1st International Research Conference

Theme:
“Enhancing Innovation for Sustainable Development in the 21st Century & Beyond”

29th – 31st Oct., 2014
in
Chuka University, Kenya

Partners:
- Kenya Wildlife Service
- National Commission for Science, Technology & Innovation (NaCoSTI)
- Hon. Kiraitu Murungi Foundation

Proceedings of the First International Research Conference, 29th to 31st October, 2014

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Proceedings

of the 1st International Research Conference held on the Main Campus from 29th – 31st October, 2014

Theme:
“Enhancing Innovation for Sustainable Development in the 21st Century and Beyond”

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CHUKA UNIVERSITY

Knowledge is Wealth (Sapientia divitia est)

Philosophy
Education and training for social cohesion, human and economic development

Vision
To be a Premier University for the provision of quality education, training and research for sustainable national and global development

Mission
To generate, preserve and share knowledge for effective leadership in higher education, training, research and outreach through nurturing an intellectual culture that integrates theory with practice and innovation

Core Values
1) Passion for excellence and devotion to duty
2) Integrity, transparency and accountability
3) Social fairness
4) Professionalism
5) Timeliness
6) Prudent use of resources
7) Corporate citizenship
8) Customer focus
9) Teamwork
10) Confidentiality

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PREFACE

The establishment of Chuka University was foretold way back in 1951 by a famous philanthropist and seer by the name Jerusha Kanyua. She prophesied that an academic mountain shall sprout at Ndagani. She advised the youth to take a pen like a spear and a book like a shield. Subsequently in 1956, the Chuka community built a Craft Centre to train school leavers to acquire skills that could be useful in nation building. The Centre was upgraded to a Youth Polytechnic in 1969. In 2003, the community members felt that they needed an institution that could provide higher education and training access for the people of eastern region and Kenya at large. At that time no institution in the eastern part of Kenya had the capability of educating and training students at diploma and degree levels. As a result, education and training opportunities were limited in the region. During the same time, Egerton University was planning to open a Campus in eastern Kenya. The community then approached Egerton University who found Chuka to be centrally placed in eastern Kenya and suitable for establishment of a university campus.

In an effort to acquire land for the Campus, the Chuka community donated the Ndagani Youth Polytechnic and Sports Stadium. In addition, the Presbyterian Church donated more land from institutions forming the Ndagani Educational Complex, which included the Ndagani Secondary, Primary and Nursery Schools. The Chuka community also added a further 500 acres at Kairini in Meru South to make the total land area 550 acres. On 21st August, 2004, when His Excellency President Mwai Kibaki visited Chuka area and held a meeting at Ndagani (the present location of Chuka University), the Chuka community through their leaders informed him of their desire to establish a university in the area. Among the dignitaries who attended the meeting were Members of Parliament from the Greater Meru and Senior Government officials. The President supported the aspirations of the people of Chuka and Meru and pledged Government’s support to establish a university at the site. Due to the goodwill of the Government, Egerton University Council approved establishment of a Campus, named Egerton University Eastern Campus at Ndagani in Chuka area.

The Campus was then launched on 1st August, 2005. The Youth Polytechnic was then relocated to another site. On 23rd August, 2007, H.E. President Mwai Kibaki elevated the Egerton University Eastern Campus to Chuka University College through Legal Notice Number 161. On 10th October, 2007, H.E. President Mwai Kibaki visited and inaugurated Chuka University College. After about five years, H.E. President Mwai Kibaki visited again and chartered Chuka University on 8th January, 2013, making it the 2nd public university to be chartered and the 9th full-fledged public university in Kenya. The University is located in Chuka Division in Meru South Subcounty, Tharaka-Nithi County at approximately 186 km from Nairobi City along the Nairobi-Meru Highway on the slopes of the snow-capped Mt. Kenya at an altitude of 1,500 m above sea level. The area provides a cool climatic environment, with temperatures ranging from 16°C to 24°C and annual rainfall averaging 1,000 mm. This serene environment is excellent for learning because it is devoid of the mundane hustle and bustle activities found in big cities.

The University is designated as a centre of excellence in Environmental and Renewable Energy Studies and offers diverse university education, training and research at Certificate, Diploma, Bachelor’s, Master’s and Doctorate degree levels in the Faculties of Education and Resources Development; Business Studies; Agriculture and Environmental Studies; Arts and Humanities; and Science, Engineering and Technology. Chuka University is an ISO 9001:2008 Certified, Chartered and full-fledged public University in Kenya. It has triple core Missions of Education, Research and Extension. Great strides have been made in delivery of higher education. Impressive strides have been made in pursuit of research and delivery of extension services in the region. The University endeavours to strengthen and sustain these noble strides by organizing International Research Conferences since application of scientific research breakthroughs stimulates development of nations.

The First International Research Conference was held from 29th to 31st October, 2014. The Conference provided a forum for sharing findings of the various researches conducted by stakeholders. The exchange was expected to contribute to realisation of Chuka University’s Vision: “To be a Premier University for the provision of quality education, training and research for sustainable national and global development”. 
The theme of the Conference was: **Enhancing Innovation for Sustainable Development in the 21st Century.** The sub-themes were:

1. Agriculture, Food & Nutrition Security
2. Climate Change Mitigation and Adaptation
3. Devolution, Governance and Management Interrogation
4. Innovations and Creations for Entrepreneurship
5. Information Communication Technology Advances
6. Engineering, Science and Technology Developments
7. Education and Human Health for Visions Realisation
8. Arts, Humanities & Social Sciences for Development
9. Gender and Disability Mainstreaming Enhancement

**The objectives were:**

1. To share and publicise current innovations to spur development.
2. To gather researchers, scholars, professionals and policy makers together to interact and network.
3. To encourage industries to exhibit their capacity and uptake recent innovations.
4. To provide a forum for staff and students to exhibit and market their creations and innovations.


The Conference took place over three days, from 29th October 2014 (Thursday) to 31st October 2014 (Saturday). On 29th, all participants attended the official opening ceremony. Thereafter, participants proceeded to parallel breaker sessions organised in three rooms, according to subthemes. Papers of a wide range were presented in the breaker sessions to give participants a chance to update and share their knowledge. Participants viewed exhibits during break time. In the evening of 30th, all participants attended the official closing ceremony and a reception dinner. On 31st, participants proceeded for picturesque tour of eastern Kenya to experience the serene countryside neighbouring Chuka University, including Mt. Kenya. The Conference ended on 31st October, 2014 in the evening.

The Conference was educative, enriching, informative, inspiring and memorable. Subsequently, manuscripts presented in it were compiled into these proceedings.

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*Deputy Vice-Chancellor (Academic, Research & Student Affairs)*
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Prof. Dorcas K. Isutsa, Ph.D.
<table>
<thead>
<tr>
<th>CONTENTS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>COVER PAGE</td>
<td>................................................................. i</td>
</tr>
<tr>
<td>PREFACE</td>
<td>................................................................. iii</td>
</tr>
<tr>
<td>DISCLAIMER, ACKNOWLEDGEMENTS, COPYRIGHT, CITATION</td>
<td>................................................................. v</td>
</tr>
<tr>
<td>CONTENTS</td>
<td>................................................................. VI</td>
</tr>
<tr>
<td><strong>AGRICULTURE, FOOD &amp; NUTRITION SECURITY</strong></td>
<td></td>
</tr>
<tr>
<td>Potato Production under Irrigation in Hot Conditions: A Reality or a Mirage?</td>
<td>1</td>
</tr>
<tr>
<td>Muthoni, J, Owilla, B.P. and Kabira, J.N.</td>
<td></td>
</tr>
<tr>
<td>Contribution of Multi-Purpose Pumpkin (<em>Curcubita moschata</em> Duch.) to the Economy of Kenyan Small-scale Households</td>
<td>6</td>
</tr>
<tr>
<td>Kiharason, J.W., Isutsa, D.K. and Ngoda, P.N.</td>
<td></td>
</tr>
<tr>
<td>Transformation of Kenya’s Agriculture</td>
<td>12</td>
</tr>
<tr>
<td>Senator Kiraitu Murungi EGH, MP, Chairman, Senate Committee on Agriculture, Livestock and Fisheries</td>
<td></td>
</tr>
<tr>
<td>Njiru, E.N., Ghelle, F.O. and Mutisya, D.L.</td>
<td></td>
</tr>
<tr>
<td>Characterization and Evaluation of Pumpkin (<em>Curcubita moschata</em> Duch.)</td>
<td>19</td>
</tr>
<tr>
<td>Kiramana, J.K., Isutsa, D.K. and Nyende, A.B.</td>
<td></td>
</tr>
<tr>
<td>Acceptability of Napier Grass, <em>Tithonia</em> (<em>Tithonia diversifolia</em>) and <em>Sapium</em> (<em>Sapium ellipticum</em>) as Forages for Sheep in Kenya and their Nutritive Content</td>
<td>30</td>
</tr>
<tr>
<td>Maragara, E.N., Wahome, R.G., Badamana, M.S., Musalia, L.M. and Njoka, E.N.</td>
<td></td>
</tr>
<tr>
<td>Digestibility of Diets Based on Napier Grass, <em>Tithonia diversifolia</em> and <em>Sapium ellipticum</em></td>
<td>34</td>
</tr>
<tr>
<td>Maragara, E.N., Wahome, R.G., Badamana, M.S., Musalia, L.M., Bundi, R.M. and Njoka, E.N.</td>
<td></td>
</tr>
<tr>
<td>Exploitation of Indigenous Chicken from Tharaka-Nithi County for Global Markets</td>
<td>39</td>
</tr>
<tr>
<td>Nyaga, S., Odhiambo-Ochiewo, J., Muthoni, E., Menyi, I. and Mati, M.</td>
<td></td>
</tr>
<tr>
<td>Emerging Solutions to Nematode and Plant Nutrition Challenges in Greenhouse Tomato Production</td>
<td>44</td>
</tr>
<tr>
<td>Otieno, P.C., Mulwa, R.M.S. and Ogweno, J.O.</td>
<td></td>
</tr>
<tr>
<td>Amaranth Pigweed Beetle Damage Level Correlates to Environmental Temperature Regimes</td>
<td>54</td>
</tr>
<tr>
<td>Mutisya, D.L., Ghelle, F.O. and Njiru, E.</td>
<td></td>
</tr>
<tr>
<td>Effect of Tomato <em>Lycopersicon esculentum</em> (Mill) Varieties on Development Time Fecundity and Longevity of Red Spider Mite <em>Tetranychus evansi</em> (Baker &amp; Pritchard)</td>
<td>59</td>
</tr>
<tr>
<td>Matika, M.S., Kamau, A.W. and Macharia, M.</td>
<td></td>
</tr>
<tr>
<td><strong>CLIMATE CHANGE MITIGATION &amp; ADAPTATION</strong></td>
<td></td>
</tr>
<tr>
<td>Climate-Smart Agro-Pastoral Practices: A Case Study of Narok County, Kenya</td>
<td>65</td>
</tr>
<tr>
<td>Githae, E.W.</td>
<td></td>
</tr>
<tr>
<td>Effects of Sea Water Intrusion and Surface Water Salinity on Irrigation Water Quality in Ramisi</td>
<td>69</td>
</tr>
<tr>
<td>Chalala, A. and Chimbevo, L.M.</td>
<td></td>
</tr>
<tr>
<td>Farmer Groups’ Characteristics Influencing Application of Soil Fertility Technologies in the Central Highlands of Kenya</td>
<td>78</td>
</tr>
<tr>
<td>Mwebia, E.W., Mucheru-Muna M.W., Mugwe J.N. and Mugendi, D.N.</td>
<td></td>
</tr>
</tbody>
</table>
Farmer Groups Members’ Household Factors Influencing Selection of Soil Fertility Technologies in the Central Highlands of Kenya ................................................................. 87
Mwebia, F.W., Mucheru-Muna, M.W., Mugwe, J.N. and Mugendi, D.N.

Adapting to Climate Change: Evaluating the Implementation of Water Resource Management Strategies in Hotels within Lake Naivasha Environs................................................................. 97
Kinyanjui, D.N., Kieti, D. Ipara, H. and Kariuki, J.M.

Role of Religious Studies in the Environmental Resource Management for Mitigation of Climate Change toward Realization of Vision 2030 ................................................................. 106
Mwangi, J. and Maingi, N.W.

Planning and Management of Natural Resources in Sub-Saharan Africa .................. 113
Ngocho, E., Kyalo, J.N. and Muli, D.

Zai Pits Adoption & Utilization for Improved Farm Productivity in Tharaka-Nithi County, Kenya.... 122
Muchai, S.W.K. Baaru, M., Ngetich, F. and Muna, M.W.M.

Smallholders’ Perceptions of Climate Change Impact on Biodiversity: A Case Study of Farmers in Varied Agroecological Zones in Kenya................................................................. 127
Kariuki, S.T., Mungai, N., Ngigi, M., Kamuru, S., Lelo, F., Bebe, B. and Chiuri, W.

Effect of Development and Human Settlement on Bird Species Richness, Abundance, Diversity and Distribution: A Case of Chuka University and Surrounding Areas........................................ 143
Waweru, M. and Soi, B.C.

Consequences of Large-Scale Land Use Changes on Environment, Livelihood and Food Security in the Yala Swamp Ecosystem, Kenya, East Africa................................................................. 151
Nthenge, A.M. and Romulus, A.R.

---

DEVOLUTION, GOVERNANCE & MANAGEMENT INTERROGATION

Corporate Social Responsibility for Sustainable Development in Africa: A Review .................. 160
Kebati, R.K. and Onyancha, E.O.

The Role of Peace Committees in Peace Building & Conflict Management: A Case of Transmara Sub-County, Kenya.................................................................................. 168
Kokeno, V. and Lutomia, G.

Contribution of New Constitution in Promoting Kiswahili Use in Mass Media .................. 175
Mugambi. A.

Role of Language in Peace Building: A Case of Kenya’s 2008 Coalition Government .............. 182
Barasa, M.N. Ndambuki, J.M. and Telewa, V.K.

Reconstructionist Analysis on Relevance of Secondary School Curriculum Content in Promoting National Cohesion of Students in Machakos Town Sub-County, Kenya.................................................. 192
Mwanzia, R.M., Ogola, F.O. and Muthaa, G.M.

Effectiveness of Performance Contracting on Service Delivery in Public Universities in Kenya........ 197
Elias, E.M., Muthaa, G.M. and Muriungi, P.K.

Lost Opportunity: Peace Building Initiatives in Conflict Prone Areas.................................. 204
Njoroge, M.P. and Muraya, M.W.
University Graduates’ Employability Skills Preparedness in Kenyan Economic Sectors……………. 216
Rintari, N.G.

Hawking University Education in Kenyan Urban Centers: Challenges and Way Forward ………….. 223
Rutere, A.M. and Mwenzwa, E.M.

Kenya’s Religious Institutions Role in Devolution for Sustainable Development………………… 228
Waithaka, M.N. and Mwangi, J.

Level of Community Engagement in National Agriculture and Livestock Extension Programme:
Comparison of Mugwe and Gitareni Locations, Meru South SubCounty, Kenya…………………. 234
Nyaga, S., Rwanda, C.B., Odhiambo-Ochiewo, J. and Menyi, E.M.

INNOVATIONS & CREATIONS FOR ENTREPRENEURSHIP

Invention, Innovation and Creativity Management Education for Sustainable Development
towards Attainment of Vision 2030…………………………………………………………………… 238
Mwangi, J., Mwangi, J.G., Wabore, J.N. and Maingi, N.W.

Influence of Entrepreneurship Training on Performance of Youth-Owned Small and Medium
Enterprises in Maara Sub-County, Tharaka-Nithi County, Kenya…………………………………… 244
Miriti, G.M. and Akwalu. P.

Traditional Posho Mill among the Abagusii as Indigenous Innovation in Entrepreneurship……… 252
Okebiro, G.N.

Linking Entrepreneurial Innovations from Kenyan Universities to Kenyan Market through Private
Venture Capital Financing…………………………………………………………………………………..... 259
Karanja, T.W.

INFORMATION COMMUNICATION TECHNOLOGY ADVANCES

Application of Open Source Tools and Cloud Computing Technologies in Real-Time Data Collection
and Analysis………………………………………………………………………………………………….. 267
Kirui, T.K.

Innovative Radio Based Extension for Agriculture and Livestock Producers in Kenya ………….. 274
Njuguna, J.K., Mwongela, B., Allport, R. and Irura, D.

Mobile Agent Based System for Listing Fundamental Wi-Fi Peer-to-Peer Network Details……….. 283
Gogo, K. and Barasa, P.

Development of an Interactive Web Portal for Kenyan Tea………………………………………. 291
Ngige, W.J., Kinyua, K.J., Gitonye, W.C., Kariuki, D. and Mwangi, J.

Computer Ergonomic Issues in Learning Institutions in Kenya: Case Study of Kirinyaga County… 301
Shikhuyu, J. and Mwangi, E.G.

ENGINEERING, SCIENCE & TECHNOLOGY DEVELOPMENTS

Phytochemical Screening and Evaluation of Oxytocic-like Activity of Uvariodendron
anisatum Verdec (Annonaceae) ……………………………………………………………………………. 309

Nutrient and Anti-Nutrient Content of Selected Wild Food Plants from Ithanga Division, Kenya… 313
Yield Maximization of Ethanol by Metabolism of Unfermented Substrate in Coconut Palm Sap Wine (Mnazi) .......................... 319
Okal, E.J., Chimbevo, M.L., Kahindo, J. and Agoi, L.K.

Repellence of Cattle Anal Odour Constituents & Analogues against Rhipicephalus appendiculatus… 324
Kariuki, M.W., Ng’ang’a, M.M., Hassanali, A. and Saini, R.K.

Solid Waste Generation and Composition in Egerton University Community………………………… 331
Kariuki, J.M., Moturi, W.N., Shivoga, W.A. and Kilonzi, C.M. and Kinyanjui, D.N.

Determinants of Rural Electrification Adoption and Socio-Economic Benefits among Households:
A Case of Meru-South Sub-County, Kenya……………………………………………………………….. 337
Kageni, C., Muiruri, P. and Obiero, K.

Determination of the Glass Transition Temperature and Modulus of PLA Films using Dynamic
Mechanical Analysis at 50°C and Amplitude of 10 µm……………………………………………………. 346

Long-Term Memory Effect in Stock Prices: An Empirical Study from Nairobi Stocks Market ……… 352
Mbae, D.M. and Mwaniki, I.

Morphological, Genetic and Symbiotic Characterization of Root Nodule Bacteria Isolated from
Bambara Groundnuts (Vigna subterranea L. Verde) in Soils of Lake Victoria Basin………………….. 362

Phytochemical Screening, Macronutrients Analysis and Antimicrobial Activity of Water from
Mature Coconut (Cocos nucifera) Fruit Grown in Sandy and Loam Soils in Coast Region of Kenya... 373
Siranjofu, E.M., Chimbevo, L.M., Gicharu, G.K. and Kahindo, J.M.

Study of Crude Extracts of Ajuga remota Benth (Labiatae) as Potential Anti-Malarial Drug……….. 379
Kariuki, J.M., Kariuki, S.T., Gitua, J.N. and Muchiri, D.R.

Reduction of Bacteria and Other Pollutants in Sewage Stabilization Ponds…………………………. 383
Aloo, B.N., Mulei, J., Mwamburi, L. and Ahoya, N.

Dynamic Mechanical Analysis and Thermal Properties of Bitumen-Acacia Sap Composites……….. 389
Mbithi, N.M.

EDUCATION & HUMAN HEALTH FOR VISIONS REALISATION

Improving Technical Education for Human Resource Training for the Realization of Vision 2030:
A Case of Technical Training Institutes………………………………………………………………….. 396
Muthaa, G.M.

Assessment of the Current Sources of Financing Educational Activities in Youth Polytechnics in
Imenit South District…………………………………………………………………………………….. 401
Cherui, R., Kirimi, T. and Kitainge, K.

Demystifying the Negativism of Cartha edulis (Miraa) and Focusing on its Religious-Socio-Economic
and Educational Significance: A Case of Meru North Region in Meru County, Kenya……………… 405
Bururia, D.N. and Nyaga, J.N.

Influence of Household Socioeconomic Characteristics on the Prevalence of Acute Respiratory
Infections among Children in Nakuru Town, Kenya……………………………………………………. 413
Mugambi, M.M.
An Investigation into the State of Disaster Preparedness in Schools in Kenya............................ 418
Lutomia, G.A. and Kisurulia, S.

Relationship between Psychological Intervention Requirements and Mathematics Achievement
Counselling Needs Among Secondary School Students in Maara District, Kenya......................... 424
Oundo, M.B.

Efficacy of Guidance and Counselling Services on Personal Competence Development of Students
in Kenyan Universities.................................................................................................................. 432
Nyaga, V.K.

Mathematical Analysis of a Comprehensive HIV/AIDS Model: Treatment versus Vaccination...... 438
Okongo, M.O.

Emergence of Non-Communicable Diseases and their Economic Impact: A Case Study of Kenya... 448
Odhiambo, B.O., Menyi, E.M. and Njoroge, L.

| ARTS, HUMANITIES & SOCIAL SCIENCES FOR DEVELOPMENT |
| Creating the Need and Awareness for GIS in Education through University Outreach and Collaborative Partnerships: An Assessment of Geography Action Week, ESRI’S GIS Day and GIS Education User Conferences........................................................................................................... 454 |
| Kibetu, K. and Rima, P. |

Cultural Diplomacy as Soft Power: A Comparative Study of China and South Africa 1990-2010.... 458
Wamuya, J.

A Critical Discourse Analysis of Key Newspaper Headline Stories on Ideological Conflicts in Kenyan Politics...................................................................................................................... 471
Karuri, M.

| GENDER & DISABILITY MAINSTREAMING ENHANCEMENT |
| Gender Mainstreaming: Perspectives and Insights in Kenya......................................................... 481 |
| Kaimenyi, C.K. and Muriungi, C.K. |

Kavulavu, L.

Taming Patriarchy: The Tower of Babel in Feminist Discourse..................................................... 494
Mwenzwa, E. and Rutere, A.
POTATO PRODUCTION UNDER IRRIGATION IN HOT CONDITIONS: A REALITY OR A MIRAGE?

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ABSTRACT
In Kenya, potato is the second most important crop after maize in terms of production and consumption. It is grown in the highlands (1500 and 3500 m above sea level). Traditionally high potential areas are becoming drier due to effects of climate change. Over 80% of Kenya’s landmass is hot and dry and therefore unsuitable for arable farming especially for production of cool season crops like potato. Kenya is endowed with fresh water bodies mostly rivers which have traditionally been used for production of paddy rice under irrigation. Rice has traditionally been rotated with maize in these irrigation schemes. Maize necrotic virus disease has recently led to huge losses in maize. The disease has no cure and maize production in the country is becoming a gamble. Maize takes a long time to mature; an alternative short-duration crop such as potatoes could fill in the gap. A study was undertaken at National Irrigation Board Perkerra station to evaluate the performance of local potato germplasm under irrigation in hot conditions. The study was carried out between 6th November 2013 and 21st February 2014. The experimental materials consisted of 33 potato genotypes; 12 advanced clones from CIP and 21 released/farmers’ varieties that are already being grown by farmers in the country. Generally, locally released/farmer varieties had higher % plant survival and stand establishment than the advanced clones from CIP. All varieties had lower yields than they do when grown in the cool highlands. The older varieties introduced into the country long ago had lower yield reduction compared with recently released varieties; possibly the older varieties have become adapted to local climatic conditions. The study needs to be repeated to validate these results.

Key words: Advanced clones, Hot Conditions, Irrigation, Potatoes

INTRODUCTION
In Kenya, potato is the second most important crop after maize in terms of production and consumption. The crop is grown mainly by small scale farmers as a cash and food crop and therefore plays an important role in food and nutrition security (MoA, 2005, 2008). Potato is grown by about 800 000 farmers, on 158 000 hectares per season, with an annual production of about 1 million tonnes in two growing seasons (Riungu, 2011). Potato is a cool season crop and grows best between 15°C and 18°C (Haverkort et al., 1990) and soil pH of 5.5 (Kanyanjua and Agaya, 2006). The potato has been grown traditionally in the high potential areas of the country which are characterized by cool temperatures with high rainfall of at least 1000 mm per annum and are situated at altitudes between 1500 and 3500 meters above sea level. With the increasing population and consequent diminishing land sizes in these areas, there has been migration to the lower, warmer and drier areas, where the migrants have moved with their cropping systems including the potato. Over eighty percent of Kenya’s landmass is hot and dry and therefore unsuitable for arable farming especially for production of cool season crops like potato (FAO, 2008). Luckily, the country is endowed with fresh water bodies mostly rivers which have traditionally been used for production of paddy rice under irrigation. Rice has traditionally been rotated with maize in these irrigation schemes. However, the maize necrotic virus disease has recently led to huge losses in maize. Currently, the disease has no cure and maize production in the country is becoming a gamble. In addition, maize takes a long time to mature; an alternative short-duration crop such as potatoes could fill in the gap. Although irrigation may mitigate the problems of low and erratic rainfall, high temperatures and high soil and water pH may limit the production of potatoes in these areas. This calls for development of locally adapted potato varieties that may tolerate heat without compromising on tuber yield and quality. In any successful breeding programme, identification of potential parents through screening of the available germplasm is crucial. Against this background, a study was undertaken at National Irrigation Board Perkerra station to evaluate the performance of local potato germplasm under irrigation in hot conditions.

MATERIALS AND METHODS
Site Characterization
The study was carried out at the National Irrigation Board at Perkerra irrigation scheme. The station is situated about 100 Km north of Nakuru in Marigat township, Baringo County, in the former Rift Valley Province. It lies at an
altitude of 1067 meters above sea level, latitude 0° 28’ 30” N and longitude 35° 56’ 20” E. The average annual rainfall is 654 mm with a bimodal distribution and potential evapotranspiration is 1360 mm. A long rainy season occurs between March and May while a short rain season is between October and December (Jaetzold et al., 2006a). The mean temperature ranges from 16.8 to 32.4°C with an average of 24.6°C. The station is situated in agro ecological zone 5 and the major land uses are irrigated and dryland farming, pastoralism involving rearing of cattle, goats, sheep, and camels and beekeeping. The soils are volcanic fluvisols of sandy/silty clay loam texture; they are slightly acid to slightly alkaline, fertile with adequate P, K, Ca and Mg but low in N and C (UNESCO, 1977).

The study was carried out for one season between 6th November 2013 and 21st February 2014. The experimental material consisted of 33 potato genotypes (Table 1). The advanced clones from CIP have high heat tolerance.

<table>
<thead>
<tr>
<th>Genotypes</th>
<th>Genetic type</th>
<th>Source of experimental material</th>
</tr>
</thead>
<tbody>
<tr>
<td>300046.22</td>
<td>Advanced clones</td>
<td>CIP</td>
</tr>
<tr>
<td>392079.4</td>
<td>Advanced clones</td>
<td>CIP</td>
</tr>
<tr>
<td>393077.159</td>
<td>Advanced clones</td>
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<tr>
<td>Tigoni</td>
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The experiment was laid out as a randomized complete block design replicated three times. Furrows, 75 cm apart were dug and potatoes were planted 30 cm apart on the shoulder of the furrows. Each plot measured 6.75 m² and consisted of 30 plants. During planting, DAP (18%N: 46%P₂O₅) was applied at the recommended rates of 500 kg ha⁻¹ in furrows before planting. Watering was done through furrow irrigation by gravity when need arose. Weeding, earthing-up and
spraying against pests and late blight were carried out as per recommendations for potato production in Kenya (KARI, 2008).

Data Collection and Analysis
During plant growth, data collected included number of emerged plants per plot (taken 21 days after planting) and number of plants that survived until harvest. This data was used to calculate % stand establishment and % plant survival, respectively. When the plants were mature (genotypes matured at different times) all the plants that survived in a plot were harvested. Data collected on plot basis included number and weights of tubers of different sizes i.e. <30, 30-60 and 60< mm in diameter. This data was used to calculate total yields (ton/ha) and % ware potato yields.

Data was analysed using Genstat statistical package, 14th edition (Payne et al., 2011) and means separated using Fisher’s Protected LSD Test at 5% (Steel and Torrie, 1980).

RESULTS AND DISCUSSION
The Perkerra site was generally hot throughout the study period (Table 2).

<table>
<thead>
<tr>
<th>Table 2. Weather data at Perkerra during the study period</th>
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<td>Min. Temp.</td>
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<tr>
<td>Max. Temp.</td>
</tr>
<tr>
<td>Mean. Temp.</td>
</tr>
<tr>
<td>Total rainfall (mm)</td>
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<tr>
<td>No. rainy days</td>
</tr>
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</table>

The soils in the study area were slightly basic (Table 3).

<table>
<thead>
<tr>
<th>Table 3. Soil characteristics at Perkerra</th>
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<tr>
<td>pH</td>
</tr>
<tr>
<td>Soil</td>
</tr>
</tbody>
</table>

There were significant differences (P<0.05) among the potato genotypes in terms of % stand establishment and % plant survival (Table 4). Most of the advanced clones from CIP had poor stand establishment and low plant survival. Among the locally released/farmer varieties, Romano, Kenya Sifa, Roslin Bvumbwe, Kenya Furaha, Pimpernel and Asante yielded better than the advanced clones 30046.22 and 393077.159 (Table 4).

Generally, locally released/farmer varieties had higher % plant survival and stand establishment than the advanced clones from CIP (Fig.1). This could be due to the fact that the locally released/farmer varieties have been in production locally over time and have somehow become adapted to the local environmental conditions especially the high temperatures. This could also explain the similar yields between advanced clones and locally released/farmer varieties despite the fact that the former are reported to be heat tolerant.

This yield reduction was mainly due to poor stand establishment and low survival rate of the emerged plants. The recently-released late maturing CIP-derived varieties such as Kenya Karibu, 398208.219, Kenya Sifa, 398193.511, 393077.159 and 398190.89 experienced high yield reduction at Perkerra (Table 5). This yield reduction could be due to shorter time to maturity the genotypes underwent at Perkerra probably due to the high temperatures (Table 3). For some older CIP-derived varieties such as Kenya Mavuno and Asante, the yield reduction was less. The case was the same for the older European varieties such as Dutch Robyn. Because this old European variety has been grown in Kenya over a long period of time, it is likely that is has become adapted to the local conditions.

Generally, the low yields realised from this study could be attributed to the high temperature, high soil pH or both. High temperature leads to faster crop maturity and hence low yield due to shorter dry matter accumulation duration. Potato is a C3 crop and excessively high temperatures are likely to lead to inefficiency in photosynthesis due to high photorespiration (Monteith, 1973). High soil pH is responsible for phosphorus fixation to form the insoluble calcium phosphate; this leads to low availability of phosphorus to the plant (Ochapa, 1984). Phosphorus fixation is at a minimum at pH levels of 6.0 to 6.5 (Ochapa, 1984). Phosphorus, as phospholipids, is a constituent of all membranes. All nucleotides and nucleic acids and certain proteins contain phosphorus. It stimulates good root development.
Table 4. Potato performance at Perkerra

<table>
<thead>
<tr>
<th>Genotype</th>
<th>% stand establishment</th>
<th>Genotype</th>
<th>% plant survival</th>
<th>Genotype</th>
<th>Tuber yields (ton/ha)</th>
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<td>703580</td>
<td>0 a</td>
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<td>0 a</td>
</tr>
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<td>39906.115</td>
<td>30.00 ab</td>
<td>Kenya Karibu</td>
<td>1.68 ab</td>
</tr>
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<td>398208.219</td>
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<td>393077.159</td>
<td>39.05 b</td>
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Figure 1. Mean performance of different genotypes

Potato yields realised at Perkerra were far below the potential yields under the same conditions (Table 5).
Table 5. Potential and actual potato tuber yields at Perkerra

<table>
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<tr>
<th>Genotype</th>
<th>*Potential tuber yields (ton/ha) at Perkerra</th>
<th>Actual tuber yields (ton/ha) at Perkerra</th>
<th>% yield reduction</th>
<th>Potential yield (ton/ha) under recommended conditions **</th>
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</table>

*Assuming 100% stand establishment and 100% plant survival.

**Production under recommended temperature, altitude and management conditions in the highlands.

REFERENCES
CONTRIBUTION OF MULTI-PURPOSE PUMPKIN \((Curcubita moschata\) Duch.) TO THE ECONOMY OF KENYAN SMALL-SCALE HOUSEHOLDS

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ABSTRACT

Kenya’s agricultural sector has generally faced a blow with repeated delays in rains causing suppressed farming. Farmers should therefore grow other non-staple crops which can do well with minimal rainfall. Pumpkin is one such crop that is drought-tolerant and requires very little care and labour. Majority of households do not utilize pumpkins regularly, although it is a multi-purpose food crop capable of forming basis for various products including infant weaning foods, snacks and bakery products. The study established socio-economic status of households and extent of cultivation and sale of pumpkin. A cross-sectional survey using a semi-structured questionnaire was used among 385 households in Nyeri County of Kenya. Majority of households earned low income, with 56.3% earning less than KSh. 12,000 monthly. Pumpkin was grown by 71.4% of farmers but contributed to livelihoods of only 4.2% households. There was a high correlation between the number of pumpkin plants cultivated and amount of income received from pumpkin sale, \(r (16)= 0.510, P=0.043\). Pumpkin fruit contributes very little to income of the households and is not yet tapped to improve food security and livelihood of people in Kenya. Improving marketability of pumpkin could increase its demand, production level and sale to generate income for many poor rural households.

Key words: Pumpkin, Fruits, Income, Kenya, Households, Socio-economic

INTRODUCTION

It is estimated that more than half of Kenya’s population, approximately 40 million people, are poor, with 7.5 million of the poor living in extreme poverty (RoK, 2008). For instance, in 2007, the number of poor people in the Kenyan population was estimated at 18.2 million, rising to 19.5 million and later 20.1 million in 2008 and 2010, respectively. Especially rampant is the poverty levels in arid areas which are characterized by harsh weather conditions, which are reported to have poverty levels above 70%. The agriculture sector has been a key driver of economic growth in Kenya for the last four decades and is the main source of livelihood (employment, income and food security needs) for more than 80 per cent of Kenya’s population living in rural areas. Agriculture is the single largest sector of the economy contributing to about a quarter of the country’s GDP and accounting for 65% of export earnings (KER, 2013). It has been documented that majority of the poor (three out of four poor people) lives in rural zones. Furthermore, most Kenyans live in areas of a medium to high potential for agriculture, which comprise about 18 per cent of the country’s territory (Uwechue, 1996). Previous literature shows that low income is one of the most important correlates of...
poverty that defines the poor. In terms of the poverty gap, poor people in the rural areas have, on average, much lower incomes compared to the poverty line, and their income distribution does not seem to change much over the years. The fight against poverty remains a top priority on Kenya’s development agenda whereby the government commits to eliminate poverty by 2030. Agriculture is the largest employer in the economy and in order to realize the desired annual economic growth rate, there is need to transform smallholder agriculture from subsistence to an innovative, commercially-oriented and modern agricultural sector (KER, 2013).

he frequent food insecurity in most parts of Keya is due to over reliance on a few staple foods like maize and potatoes, and arises from repeated cultivation of the same crops at the same areas (RoK, 2001). The recent erratic weather pattern characterized by shortage of rainfall in some ecological zones especially grain growing regions have caused a deceleration in agricultural sector, which saw a drop from 4.2% in 2012 to 2.9% GDP in 2013. There was depressed production of maize, beans, coffee among other export crops (RoK, 2014). On the other hand, traditional crops including the pumpkins, which are rich in nutrients, are so far not highly regarded by the small holder farmers. Pumpkin (Cucurbita moschata Duchesne) is among the most important crops with high potential to overcome undernourishment and food poverty (Ondigi et al., 2008). It is a drought-tolerant fruit and leafy vegetable that thrives well in most parts of Kenya (Muendo and Tschirley, 2004). Previous studies have indicated a vast potential of pumpkin production and utilization in food poverty reduction in some regions of Kenya. A 2008 study by Ondigi and colleagues recorded pumpkin as being neither a priority food crop cultivated used to generate income among the communities around Kenya’s L. Victoria Basin. There is existence of favorable ecological conditions necessary for cultivation of the pumpkin yet only small portions of land are devoted to pumpkin cultivation and these are mainly cultivated as a marginal crop often on the edges of field crops or scantily scattered between staple crops such as maize or sorghum. Furthermore, research done on the crop is inadequate compared to most mainstream and exotic crops (Hamisy et al, 2002). The utilization and improvement of productivity through cultivation under-utilized crops such as pumpkin would help reduce genetic erosion of the crops (Chweya, 1997).

Pumpkin fruit has been found to be rich in carbohydrate, protein and antioxidant activities. Antioxidants are required to boost the human body immunity against cancer and other deadly human diseases. They are also rich sources of sources of vitamin A present as beta-carotene, unsaturated fatty acids and high amounts of amino acids arginine, aspartate and glutamic acid (Usha et al., 2010). They have an abundance of vitamins B1, B2, B12, C, E and minerals (zinc, niacin, iron, magnesium, phosphorus, potassium, folate, calcium). This potential is unequalled to any other single crop (Encyclopedia of foods, 2004). Pumpkin is not as bulky as other tubers such as the yam, and can be used as breakfast. It matures in only four months, can grow in any part of East Africa and can be kept for as long as 8 months without going bad (Hamisy et al, 2002). Moreover, the production is less labour intensive and more profitable compared to yam and many other staples (Oloyede et al., 2013).

MATERIALS AND METHODS
A cross-sectional survey was carried out among sample households in Nyeri County of Kenya between 11th and 22nd February 2014. The study aimed at determining contribution of pumpkin to the economy of Kenyan households. A sample size representative of study population was determined using published tables with criteria of ±5% Precision Level (e), Confidence Level of 95% and Degree of Variability at P=0.5 (Israel, 1992). Using records from agricultural offices in the county, a population of 10,000 farmers in the study population gave a sample size of 385 farmers. Purposive sampling was done to select Nyeri County for this particular study due to the presence of a farmer’s support project on the ground. The County has six Constituencies, 12 Divisions and 24 Locations. Multi-stage random sampling was applied to determine the areas to be visited, whereby the six constituencies were written down on papers, folded and any two constituencies were randomly picked. The same was done for the 12 divisions, to end up with two divisions (one division per Constituency) and two locations (one location per division). All sub-locations in each location were listed and households in the villages in each sub-location visited until the required number of households for the sub-location was attained; the number of households per sub-location was determined by Population Proportionate to Size (PPS) method, this was after population sizes being obtained from offices of the local authority (Chief). The study population involved farmers in the study area and respondents were mothers as it was assumed that they have information on both the farming activities and sale of farm produce. The mothers were therefore better placed to provide reliable information on production and marketing of pumpkin fruits.

Respondents were interviewed using a semi-structured questionnaire to establish demographic characteristics of households, cultivation levels of pumpkin and to find out pumpkin contribution to household income. A Research
Assistant well conversant with the language of the natives was trained for one day on research ethics, interviewing techniques and data collection, as well as proper translation the questionnaire. Then one-day pilot survey was done in a sample other than in the study area, among 19 households (5% of the study sample size). The data was then entered and the tool tested for reliability. The pre-testing also helped the Research Assistant get enough familiarization with the tool, understand the process of interviewing and clearly understand the research objectives. Before receiving the day’s questionnaires, they were checked for completeness and any inconsistency confirmed while disregarding the incomplete ones. The questionnaire was coded and data entry and analysis done using SPSS version 17. The data was analyzed using descriptive statistics by applying percentages or frequencies of the responses and presented as graphs and tables. Chi-square analyses were performed to determine the significant relationship between monthly income levels and a number of demographic characteristics including education level of household head. Pearson’s correlation was used to determine association level between the extent of pumpkin cultivation and income from sale of pumpkin fruits.

RESULTS

Demographic Characteristics

Prior to collecting information on agriculture and income from farming, a number of household characteristics were established, including household size, sex of household head, occupation of household head, main livelihood source, among others; these would help in inferences and data interpretation.

A total of 385 households were sampled and the mean household size was found to be 3.9 (SD 1.77). Majority of the households (76.4%) were male headed, the rest being female headed. In terms of literacy levels of household heads, table 1 shows that majority either did not complete secondary education or dropped from upper primary school. It is also notable that majority of the households earned a livelihood through mixed farming followed by crop sale, at 30.1% and 28.3% respectively.

Table 6: Demographic characteristics of households in study area

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Percent</th>
<th>Characteristics</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education level of household head</td>
<td></td>
<td>Source of livelihood</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>12.5%</td>
<td>Crop sale</td>
<td>28.6%</td>
</tr>
<tr>
<td>Class 1-4</td>
<td>9.9%</td>
<td>Mixed farming</td>
<td>30.1%</td>
</tr>
<tr>
<td>Class 5-7</td>
<td>27.3%</td>
<td>Formal employment</td>
<td>9.4%</td>
</tr>
<tr>
<td>Completed primary</td>
<td>7.5%</td>
<td>Casual labor</td>
<td>10.9%</td>
</tr>
<tr>
<td>Secondary incomplete</td>
<td>28.3%</td>
<td>Business</td>
<td>11.7%</td>
</tr>
<tr>
<td>Completed secondary</td>
<td>5.5%</td>
<td>Sale of milk</td>
<td>4.9%</td>
</tr>
<tr>
<td>Tertiary</td>
<td>9.1%</td>
<td>Pension benefits</td>
<td>1.0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Children assistance</td>
<td>3.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Begging</td>
<td>0.3%</td>
</tr>
</tbody>
</table>

Figure 2: Category of household monthly income (K Sh)
Socio-economic status
An assessment of household income indicated that majority of the households (29.1%) had a monthly income of between K Sh. 1000 and K Sh. 6000, and only 1.9% earned sh. 100,000 and above (figure 1). There was a significant relationship between education level of the household head and the amount of monthly income earned from all sources in the household, \( \chi^2 (N=380) =168.05, p=0.000 \).

Results indicated that households with the highest income levels were male-headed. None of the female headed households earned an income of more than K Sh. 80,000 (figure 2). There was a significant relationship between the sex of household head and the category of income earned in the household, \( \chi^2 (N=380) =28.48, p=0.001 \).

Contribution of pumpkin to livelihood
This study aimed at finding out the level at which crops contributed to the income of the households. A total of 44.7% households did not get any income from crops. Majority of those who sold some crop earned quite a small amount of money; figure 3 shows that 39% of the farmers earned between K Sh. 2,000 and 5,000 and only a negligible proportion earned above K Sh. 50,000 from sale of crops.
It is also notable that pumpkin was not among major crops cultivated for income earning in the study area, given that out of 275 (71.4%) farmers who reported growing pumpkin, only 4.2% were growing for sale. In figure 4, it is evident that the major crops grown for sale included maize, beans, tea, potatoes, cabbage, carrots, spices (tomato, dhania, onions, courgette) and french beans.

Monthly income from sale of pumpkin fruits ranged from K Sh. 150 to K Sh. 12,000. Figure 5 shows that majority of farmers earned between K Sh. 200-500. Whether a household sold pumpkin fruits or not was significantly related to the amount of money earned from sale of crops, $\chi^2$ (N=382) = 35.82, p=0.000. In addition, the number of pumpkin fruits harvested highly correlated with the monthly income from sale of pumpkin fruits: $r (15)=.650$, p=.009. As well there was a high correlation between the number of pumpkin plants cultivated by the farmer and the monthly income received from sale of fruits: $r (16)=.510$, p=.043.

**Figure 4: Crops grown for sale by farmers**

**Figure 5: monthly income from sale of pumpkin fruits by farmers**

**DISCUSSION**

The sampled households show a mean household size slightly lower than the Kenyan mean of 4.2 indicated in 2008/09 KDHS report, which was a reduction from 4.4 found in the 2003 KDHS. This concurs with the fertility report in the same survey which indicated an average of 4.6 births per woman, and projected a decline due to the trend of declining fertility rates over the decades, down from 8.1 births per woman in the late 70s. Same report is found in Kenya’s 2013 Economic report which indicates falling fertility rates (KER, 2013). Regarding literacy levels of household heads,
a significant number are regarded illiterate in that they have never had any formal education. Education level has a great impact on the socio-economic status of an individual or household. This study shows, as expected, a significant relationship between education level of household head and amount of monthly income. Normally a higher education level translates into better career opportunities hence better income levels.

Households in the study area appear to be mainly of low socio-economic class, with more than half (56.3%) of the households earning KSh. 12,000 and below. Whether a household is male-headed or female-headed has an impact on issues such as socio-economic status, which in turn determine accessibility of basic needs such as food, education, health and other wellbeing of family members. Even though majority of the households are male-headed, it is notable that none of the female-headed households (which consist of almost a quarter of the study households) are in the highest socio-economic status earning KSh. 80,000 and above. Some male-headed households earn as much as KSh. 550,000 per month while none of female-headed households earn any amount close to that.

Among agricultural zones, sale of crops plays a major role in enhancing economic status of most households, especially because majority of the population in such zones rely on farming and not on white collar jobs. In addition, whether a farmer plants just a few or a large number of plants of a given crop would have some impact, for example when considering the benefits accrued from the crop. Such benefits would include health and nutrition benefits due to adequate consumption of fresh produce from the farm, as well as economic benefits, for instance a farmer who grows just a few stems of a given cash crop would only get meager returns while one who has a large plantation will earn much more from the sale. As well, a food crop would benefit a farmer much more if they have planted many crops as opposed to planting just a few stems of the crop. The latter would not even harvest enough for the family to have adequate food to eat. Majority of farmers in the study area (30.1%) rely on mixed farming for a livelihood, while another considerable proportion (28.6%) relies on crop sale alone. It is obvious that the population in study area is largely dependent on agriculture for economic sustenance, given the small proportion of households (9.4%) who rely on formal employment. This study aimed at determining the role of agriculture, especially pumpkin farming, in promoting the economic status. Generally, almost half of the farmers do not rely on sale of any farm produce to earn a living. A good number of those who sell some crop produce earn an insignificant amount of between KSh. 2,000 and 5,000 per month. Specifically, pumpkin fruit contributes very little to households’ income whereby out of the 4.2% growing and selling pumpkin fruit, more than half of them received between Sh. 201 and Sh. 500 monthly and only one farmer reported earning Sh. 12,000 monthly from sale of pumpkin fruit. A significant relationship between the amount of income from sale of crops and if a household was selling pumpkin fruits means that pumpkin was a common crop for sale among farmers who were earning more from agricultural produce.

CONCLUSION AND RECOMMENDATION

This study concludes that pumpkin farming in the study area is not intensive because although majority of farmers (71.4%) in the study area grow pumpkins, most of them (73.1%) cultivate about 5 plants or less per year, with the highest proportion harvesting between 1 to 53 fruits. It also appears that pumpkin growing is not at all a commercial crop, considering that only 4.2% of farmers grow it for sale. It can therefore be concluded that pumpkin is neither a major crop in the study area, nor does it have any significant contribution to household income. The study found that the amount of income from sale of pumpkin fruit is highly reflected by level of pumpkin cultivation by the farmer. Improving marketability of pumpkin fruit will increase its demand hence increase the level of cultivation. Pumpkin is a drought-resistant crop which can be tapped as means of improving food security as well as creating an income source through selling the vegetable, the fruit and pumpkin fruit products. This way it will contribute to improvement of people’s nutrition and health status, as well as the economy of Kenyan households.

REFERENCES


EXECUTIVE SUMMARY

This timely conference provides an important turning point in the history of Agricultural development in Kenya. The critical responsibility of the intelligentsia is to interpret and change the world. The Senate Committee on Agriculture Livestock and Fisheries which I represent welcomes this important scientific conference as a forum for innovative and creative pragmatic thinking and rejection of old dogmas in Agricultural production and marketing. Kenya’s inability to feed itself and to significantly reduce rural poverty is a product of poor policies, lack of political will, institutional failure and failed imposed models of the past.

The Bretton woods dogmas of state withdrawal, liberalization and privatization have now reached their point of diminishing returns. Time has now come for a new independent review of these policies and bold action based on our own past successful domestic experiences of the 70’s and also useful experiences from other countries such as India and China. For radical agricultural transformation to take place, Kenya needs a strong, visionary determined political leadership committed to prioritizing agriculture as the prime mover of Kenya’s economy.

The biggest challenge in Kenya’s Agriculture is political visibility, underinvestment and official neglect. Agriculture dominates Kenya’s economy feeding over 40 million people, employing 70% of the population, contributing 45% of the total government revenue, 24% of the GDP and more than 50% of the total export earnings. Yet it is consistently ignored and marginalized in allocation of public resources. The share of government spending on Agriculture in this years budget is a meager 4% compared to education 20%, infrastructure and ICT 16.6%, national security 5.9% and health 4.2%. The question is why should the Government of Kenya (GOK) put such a low priority in public investment in such a major sector of the economy?

The answer is politics. Given the cut throat competition for budgetary resources, only well organized sectors can access a reasonable share. Unless the farmers wake up and re-organize themselves and have a strong political voice the way the teachers do, they will continue to be neglected, ignored and squeezed out of the budgetary allocations.

Successive Kenyan political elites have made biased policies and distributed public resources in a discriminatory manner that has retarded both Agricultural growth and rural development. The focus of the much acclaimed vision 2030 is to transform Kenya into a newly industrialized middle income country yet growth in Agriculture is more effective in reducing widespread poverty than growth in industry or service sectors. As leaders in Malawi have clearly...
demonstrated, what we need is a no-nonsense political leader to champion Kenya’s agricultural revolution that will lead the country to an agricultural boom and overcome our chronic food shortage and rural poverty.

The level of public resources allocated to Agriculture has been very low given the centrality of Agriculture and its contribution to Kenya’s economy. Food security requires the same commitment and public resources as National security, Infrastructure, Education and Health services. As Chinese and Indian models have clearly demonstrated, to spur rapid agricultural production, the government must reject self interested prescriptions of foreign institutions such as WTO and embark on a program of massive public investment and subsidy support program for Agriculture. The Government must prioritize the fundamental interests of our people.

Such support should sustain farmer’s interest in Agricultural production by ensuring that the farmers get maximum return from their farming pursuits. Specific government interventions should include massive expansion of arable land through irrigation. Irrigation has been the Agricultural transforming game changer both in India and China. The Government should treat construction of irrigation infrastructure with same seriousness and urgency as it is treating other public infrastructure projects such as the standard gauge railway, the annuity roads program and energy projects. The investment in irrigation is more beneficial to our people than these other projects which can be done later.

The government must also invest in increasing per unit productivity of Agricultural land through provision of subsidized scientifically produced high yielding seeds, subsidized appropriate chemical inputs such as fertilizers and pesticides, subsidized agricultural machinery and technology for planting, weeding and harvesting. Agricultural research is too important to be left to donors and farmers levies. Government must also provide adequate resources for supporting agricultural research and revitalize agricultural extension and farm outreach services.

Every year in Gujarat, a pre-planting mobilization is carried out in which hundreds of farmers are trained in village training centers on issues of soil health and fertility, best suited crops, planting methods and access to credit which has revolutionized agricultural production. The government must also encourage the private sector to invest in storage, processing and value addition as well as research and development. Companies like Monsanto should be encouraged to produce super high yield seeds. China has successfully turned Agricultural subsidy as a tool for Agricultural development modernization and transformation. The government must also remove negative effects of discriminatory taxation on Agricultural produce and provide tax incentives, price stabilization funds and access to credit to cushion farmers against exposure arising from market hazards. The government must also establish mechanisms to oversee operations of the commodity markets to ensure transparency, fairplay and protection of farmers’ interests. In appropriate cases government should set the minimum prices and become a buyer of last resort in the cases of severe market volatility or collapse. Government should invest in **Rurbanization.** That is creating urban comforts in rural areas through provision of modern public services such as good roads, schools, water, electricity and health services to promote vibrant rural development.

Lastly and most importantly, given the troubled relationships between the national and county governments, the government must establish an effective institutional framework for modernizing and transforming agriculture. Such institutional framework should take the form of an all inclusive multi-stakeholders umbrella forum e.g. The National Council of Agriculture, Livestock and Fisheries similar to the National Commission of Science, Technology and Innovation with a broad mandate for developing a comprehensive national agriculture strategy, policy, planning, coordination of various sector institutions, government subsidies, agricultural research and extension, agricultural finance, market oversight and promoting private sector investment in Agriculture.

**REFERENCES**


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TARGETING APPROPRIATE GRAIN AMARANTH PRODUCTION TECHNOLOGIES FOR IMPROVED PRODUCTIVITY, HOUSEHOLD NUTRITION & INCOME SECURITY IN SEMI-ARID EASTERN KENYA

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ABSTRACT
Grain amaranth (A. creatus L. and A. hypodriacus) is a nutritious, relatively drought tolerant high value crop, whose production in Kenya outstrips the demand. Due to its tolerance to drought it is an ideal choice for the semi-arid region especially under conditions of climate change. Amaranth production in semi-arid eastern Kenya is however, at its infancy with limited production and utilization know-how. Trials were planted in two locations in Kitui and Makueni Counties of eastern Kenya during long rain and short rain seasons of 2013 with the aim of evaluating appropriate production technologies for validation and dissemination under semi-arid conditions. Objectives of these trials were: to determine ideal amaranth plant spacing for optimal yield performance and suitable and economic fertilizer levels for production under semi-arid conditions of eastern Kenya. Treatments were two inter-row spacing (90cm and 75cm) and four fertility levels (zero, 5 t farmyard manure (FYM)/ha, 10 t FYM/ha and 20 kg P₂O₅ /ha) in a randomized complete block design. There was significant difference (P≤0.05) in yields between locations with yields being higher in Kitui in long rains 2013 than Kiboko in short rains 2013. No significant difference was found between different spacing and fertility levels within locations although highest yields were obtained at spacing of 90 x 30 cm and 20 kg P₂O₅ at Kiboko and 90 x 30 cm with 10 t FYM at Kitui. More work requires to be done across locations for precise conclusions and recommendations.

Key words: Production technologies, Household Nutrition, Income security, Semi-Arid Eastern Kenya

INTRODUCTION
Grain amaranth (Amaranthus hypochodriacus) ‘manna’ is a broad leaved pseudo cereal in Amaranthaceae family (Myers, 1996; O’Brien and Price, 2008) and has multiple uses as a vegetable, nutrient rich grains and livestock feed. Amaranth is grown for its high quality grains that are used to improve nutritive values of other cereals (Tung, 2010; Svirskis, 2003). Once established amaranth is relatively drought tolerant (Mnkeni et al., 2007) and gives reasonable yields under good management making it an ideal crop in semi arid lands (ASALs) especially under the conditions of climate change (Allemann et al. (1996). Amaranth is a relatively new crop in Kenya, and demand outstrips supply with most of the processors importing the grain from Uganda and India. This makes amaranth a high value crop with a kilogram of the grain retailing at between KES 75-100 depending on the buyers. Production of amaranth is picking up in lower eastern Kenya due to awareness created by Kenya Agricultural and Livestock Research Organization (KALRO) Katumani research centre.

Despite the increased interest in amaranth as a crop in the ASALs, there are no appropriate agronomic packages for its production. Only limited information is available on fertility requirements especially from studies conducted in the wetter western part of the country (Nyankanga et al., 2012, Wekesa F.S., 2010). Although reports indicate that amaranth can withstand low soil fertility (Mnkeni et al., 2007) its general performance and ultimate yields will be influenced by existing soil conditions and available soil fertility, just like any other crop. In semi-arid lands of eastern Kenya, little is known about fertilizer requirements for optimum grain amaranth yields. Information on plant spacing in the ASALs is also lacking. Such lack of information and the growing interest in production formed the basis of this study.

MATERIALS AND METHODS
Study site
This study was conducted at Kiboko field station, a sub-centre of KALRO–Katumani in Makueni County and Kitui Agricultural Training Centre (ATC) in Kitui County both in semi-arid eastern Kenya. Kiboko is on Agro-ecological zone V and has a mean annual rainfall of 670 mm and average temperatures of 27°C. Kitui ATC lies in the transitional zone between agro-ecological zones III and IV. It is generally wetter than Kiboko with mean annual rainfall of 1021 mm and average temperature of 21.4°C (27.1°C mean maximum and 15.7°C mean minimum temperatures). Both areas exhibit variable rainfall with a bimodal pattern. These rains occur from March to May and from October to December. March to May rainfall is referred to as the long rains (LR) and usually has a peak in April. This is followed by an extended dry period which lasts until mid-October before the October to December rainfall season which is also known as the short rains (SR) with a peak in November. Dominant soils are the chromic Luvisols which are low in fertility
(0.5–1.0% carbon and 0.07–0.09% nitrogen). The main agricultural production enterprise in the surroundings of the trial locations is mixed crop-livestock production systems with varying degrees of integration.

Experimental design and treatments
Performance of grain amaranth was evaluated in a factorial experiment consisting of two plant spacing (S1 and S2) and four fertility levels (F1, F2, F3 and F4) in a randomized complete block design (RCBD) with three replicates. The trial was planted in two locations during long and short rain seasons of 2013. Grain amaranth was used as the test crop.

Treatments
Treatments consisted of combinations of two inter-row plant spacings of 90 cm (S1) and 75 cm (S2) and application of four fertility levels (0 kg fertilizer (F1), 5 tons farmyard manure (FYM) ha⁻¹ (F2), 10 tons FYM ha⁻¹ (F3) and 20 kg P₂O₅ ha⁻¹ (F4) as listed in Table 1. The intra-row spacing was kept constant at a distance of 30 cm. Treatments were randomly applied to plots of 3 m x 3 m in each of the three replicates.

Land preparation and planting
Land was ploughed and harrowed by tractor drawn plough and harrow before the soil was broken to a fine tilth and leveled using the hand hoe. Shallow furrows were opened using hand hoes at row spacings of 75 or 90 cm according to treatment allocation in the field. Soil samples were collected at the beginning of the first season of the trial before application of treatments at 0-30 cm layer for initial nutrient characterization. Farmyard manure used in the trials was purchased from Katumani research farm due to availability of information on its nutrient composition from earlier studies. Inorganic fertilizer Di-Ammonium Phosphate (DAP) was used as the source of P₂O₅. The fertilizers were applied along the prepared furrows in the specific plots before planting. Amaranth seed was mixed with dry sand at a ratio of 1:10 for easy of sowing and the mixture drilled along the furrows before covering lightly with soil. Planting was done at the onset of the rains at both locations.

Table 1: Treatments used for evaluation of performance of grain amaranth

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Inter-row spacing (cm)</th>
<th>Fertilizer applied (units ha⁻¹)</th>
<th>Number of plants ha⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1F1</td>
<td>90</td>
<td>0</td>
<td>37,037</td>
</tr>
<tr>
<td>S2F1</td>
<td>75</td>
<td>0</td>
<td>44,444</td>
</tr>
<tr>
<td>S1F2</td>
<td>90</td>
<td>5 tons FYM</td>
<td>37,037</td>
</tr>
<tr>
<td>S2F2</td>
<td>75</td>
<td>5 tons FYM</td>
<td>44,444</td>
</tr>
<tr>
<td>S1F3</td>
<td>90</td>
<td>10 tons FYM</td>
<td>37,037</td>
</tr>
<tr>
<td>S2F3</td>
<td>75</td>
<td>10 tons FYM</td>
<td>44,444</td>
</tr>
<tr>
<td>S1F4</td>
<td>90</td>
<td>20 kg P₂O₅</td>
<td>37,037</td>
</tr>
<tr>
<td>S2F4</td>
<td>75</td>
<td>20 kg P₂O₅</td>
<td>44,444</td>
</tr>
</tbody>
</table>

Trial management and data collection
The crop was thinned to an intra-row distance of 30 cm two weeks after emergence. Trials were monitored throughout the growing period and kept free of weeds by hand weeding. Insect pests were controlled by spraying with Lambdacyhalothrin 50 g/l (Duduthrin). Grain yields were determined by harvesting crop in the net plots at physiological maturity. A net plot area of 3 rows and 2.4 running metres (6.48 m²) was harvested for the 90 cm plots and 4 rows and 2.4 running metres (7.2 m²) for 75 cm plots by leaving out one row at each end of plot and one plant from each side of the harvested rows. Amaranth heads were harvested and dried before threshing and recording dry weights per plot. The grain was further dried and final dry weights recorded for calculation of yields per hectare.

Statistical analysis
Data was entered and organized in Excel spread sheets before being transferred for analysis of variance (ANOVA) and determination of significant differences (P ≤0.05) in GenStat 14th edition (VSN, 2011).

RESULTS AND DISCUSSIONS
This paper highlights results obtained during March-May (long rains) 2013 season.

Soil and manure characterization
Results of initial soil nutrient characteristics have not been included. Analysis of farmyard manure from the research station indicated the qualities shown in Table 2.
Table 2: Chemical characteristics of farmyard manure on dry matter basis

<table>
<thead>
<tr>
<th>Nitrogen</th>
<th>Phosphorous</th>
<th>Potash</th>
<th>Calcium (CaO)</th>
<th>Magnesium oxide</th>
<th>Manganese</th>
<th>Zinc</th>
<th>Copper</th>
<th>Iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.62%</td>
<td>1.15%</td>
<td>1.62%</td>
<td>0.36%</td>
<td>1.49%</td>
<td>500 ppm</td>
<td>200 ppm</td>
<td>30 ppm</td>
<td>15,000 ppm</td>
</tr>
</tbody>
</table>

Grain yield results

Kiboko location

At Kiboko grain yields were generally low during the season with an overall mean of 112 kg ha\(^{-1}\). No significant differences (P ≤ 0.05) were found between spacing, fertility levels or interaction between spacing and fertility. The highest grain yields (146 kg ha\(^{-1}\)) were however, obtained with application of 20 kg P\(_2\)O\(_5\) ha\(^{-1}\) and the least (73 kg ha\(^{-1}\)) with no fertilizer application. Addition of farmyard manure or inorganic fertilizer resulted in an increase in grain yields in an almost linear pattern. Thus, application of 5 and 10 tons FYM increased yields from those of the zero fertilizer application plots by 40% and 70%, respectively, whereas 20 kg P\(_2\)O\(_5\) ha\(^{-1}\) doubled the yields.

Highest grain yields (153 kg ha\(^{-1}\)) came from plots with 20 kg P\(_2\)O\(_5\) ha\(^{-1}\) and a spacing of 90 cm (Figure 1). This was followed by 20 kg P\(_2\)O\(_5\) ha\(^{-1}\) at 75 cm (139 kg ha\(^{-1}\)), 10 t ha\(^{-1}\) at 90 cm (131 kg ha\(^{-1}\)), and 10 t ha\(^{-1}\) at 75 cm (121 kg ha\(^{-1}\)). The least yields (78 and 68 kg ha\(^{-1}\)) came from treatments of 90 cm and 75 cm, respectively, with no fertilizer application. Yield difference between the two spacings was not significant.

Kitui location

Grain yields at Kitui ATC showed no significant difference (P ≤ 0.05) in fertility or spacing, or the interaction between spacing and fertility (Figure 2). Higher yields (532 kg ha\(^{-1}\)) were obtained from the 90 cm spacing treatment plots compared to 468 kg ha\(^{-1}\) from the 75 cm spacing plots (lsd = 104.3). Generally, with the exception of application of 5 t FYM ha\(^{-1}\) yields were always higher at 90 cm than 75 m (Figure 2).
Figure 2: Effect of spacing and different fertility levels on amaranth grain yield at Kitui

Plots with 10 t FYM ha⁻¹ gave the highest yields (577 kg ha⁻¹) followed by those with 20 kg P₂O₅ ha⁻¹ (564 kg), 5 t FYM (451 kg) and zero fertilizer application (406 kg ha⁻¹). A combination of 10 tons FYM and 90 cm spacing gave 652 kg of grain ha⁻¹. These were followed by 574 kg ha⁻¹ from 20 kg P₂O₅ ha⁻¹ at 90 cm and 555 kg ha⁻¹ from 20 kg P₂O₅ ha⁻¹ at 75 cm. Least yield (364 kg/ha) was harvested from 0 kg fertilizer at 75 cm spacing.

Across location analysis

Results of analysis across the two locations are illustrated in Table 3. Significant difference (P <0.001) was found in the general yield performance across the two locations with highest yields realized from the wetter location (Kitui ATC) compared to Kiboko. No significant difference was found in spacing, interaction between spacing and fertility or spacing, location and fertility interactions.

Table 3: Amaranth grain yield across locations (Kiboko and Kitui ATC) during long rains 2013 season

<table>
<thead>
<tr>
<th>Location</th>
<th>0 kg</th>
<th>5 t FYM ha⁻¹</th>
<th>10 t FYM ha⁻¹</th>
<th>20 kg P₂O₅ ha⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>75 cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kiboko</td>
<td>68</td>
<td>106</td>
<td>121</td>
<td>139</td>
</tr>
<tr>
<td>Kitui</td>
<td>364</td>
<td>450</td>
<td>501</td>
<td>555</td>
</tr>
<tr>
<td>90 cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kiboko</td>
<td>78</td>
<td>100</td>
<td>131</td>
<td>153</td>
</tr>
<tr>
<td>Kitui</td>
<td>449</td>
<td>452</td>
<td>652</td>
<td>574</td>
</tr>
</tbody>
</table>

However, there was significant difference (P<0.009) in the effect of fertility across the two locations (Figure 3). Grain yields from application of 10 t FYM ha⁻¹ (351 kg ha⁻¹) and 20 kg P₂O₅ ha⁻¹ (355 kg ha⁻¹) were significantly different (LSD = 108.1) from zero application of fertilizer (240 kg ha⁻¹).
DISCUSSION

Inter-row spacing of 90 or 75cm did not significantly affect grain amaranth yields at Kiboko or Kitui ATC and only minimal increments were recorded at 90 cm spacing. This partially indicates the need to adopt the wider spacing for ease of operations. Kauffman and Weber (1990) reported that although few growers have grown amaranth successfully in a 25 cm row spacing, weeds can become a serious problem with narrow row spacing if soil surface moisture promotes weed germination. Narrow row spacing provides good early season weed control, but excessive self-competition leads to reduced plant height, earlier flowering and maturity, and reduced yield (Weber, 1987).

Significance of fertilizer application on grain amaranth production in the ASALs was emphasized by the increase in grain yields in plots that received fertilizer either in organic or inorganic form. This is indicative of the poor soil fertility status of the soils, a factor that requires to be confirmed by the analysis of the soil samples. Addition of fertilizer also resulted in an increase in grain yields in an almost linear pattern. Such a linear relationship between fertilizer amounts and yield was also reported by Guierrez et al. 2002 in a similar study in Bolivia. Similarly, increases in yields with increase in fertilizer application have also been reported in studies of amaranth production in Western Kenya (Nyankanga et al., 2012, Wekesa F.S., 2010). In another study in Arkansas, a two-fold yield increase was reported at the N rate of 100 kg/ha (Endres 1986). No yield advantage was noted at the higher N rate and no response to N was noted in the second year of study.

Grain yield response to fertilizer levels was different at the two locations with highest yields being recorded from plots that received 20 kg P₂O₅ ha⁻¹ at Kiboko and 10 t FYM ha⁻¹ at Kitui ATC. These differences require to be confirmed with further studies and soil analysis. Higher yields from the wetter location may be attributed to availability of more moisture for crop use. This needs to be studied further since earlier studies suggest that grain amaranth is drought tolerant at later stages of growth although some residual soil moisture is needed to assure that emergence occurs (Mnkeni et al., 2007, Weber et al. 1988). Studies also indicate that grain amaranth water requirement is 42-47%, 51-62% and 79% that of wheat, maize and cotton respectively (Mwangi, 2003). More work is required in the semi-arid conditions of Kenya to establish these facts.

CONCLUSION

• Generally, application of fertilizer is important for improving yields of grain amaranth in semi-arid Kenya. Emphasis on fertilizer amendment in amaranth production will therefore enhance its productivity in the ASALs.
• There is need to consider using different fertilizer types for the two locations when planting amaranth. Further studies are necessary in order to establish the types and precise amounts to be applied by farmers at the different locations in the ASAL. However, this needs to be accompanied by studies on initial soil nutrient status as a guide on proper application at specific locations.
ACKNOWLEDGMENT
The authors acknowledge the European Union (EU) through the ASAL APRP project for availing funds for the study and Dr. C. W. Kariuki (KALRO-Katumani) for his support. Our special gratitude to Mrs Mary M. Kamau, Messrs. R. Mokua and C. Magondu who were vital in management of the experiments and data collection. We also sincerely thank Mr. S. Mutali, officer in-charge Kiboko su centre and the Principal Kitui ATC for availing land for the research.

REFERENCES

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CHARACTERIZATION AND EVALUATION OF PUMPKIN (Cucurbita moschata Duch.)

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ABSTRACT
Pumpkin is an emerging important indigenous vegetable in Kenya. However, its potential remains unexploited. This study collected, characterized and evaluated pumpkin germplasm accessions in Kakamega and Nyeri Counties. The 155 accessions collected consisted of 70 and 85 from Kakamega and Nyeri Counties, respectively. Morphological characterization and evaluation was done on-farm in completely randomized design, replicated three times. Morphological characterization and evaluation data were subjected to analysis of variance using the SAS program. Means were separated at P=0.05. Molecular characterization was done by extracting DNA, and polymerase chain reaction was done on 139 accessions using SSR and ISSR primers. Molecular characterization data were scored and phylogenetic analyses conducted using DarWin software. Significant variation (P<0.05) resulted among 146 accessions.
morphologically. Fruit length to width ratio and fruit weight ranged from 0.7-2.1 cm and 0.5-19.25 kg/accession, respectively. Predominant mature fruit skin colour ranged from green to orange; secondary fruit skin colour from speckled to striped; fruit surface from smooth to warty; and internal flesh colour from white to yellow. Main colour of inner flesh and of outer flesh ranged from yellow to pink-red. Molecular characterization revealed that accessions were varied with amplifications on different loci ranging from 100-500bp for SSR with band ranges of 1 to 4. ISSR primers were more polymorphic with accessions amplified between 200-2000 bp with band ranges of 2 to 7. A total of 526 alleles were identified with 5 SSR primer pairs and 509 alleles with 7 ISSR primers. The Unweighted Pair Group Method of Arithmetic Mean based on Euclidean genetic distance with 1000 bootstraps constructed the dendrograms. There is great variation in pumpkins in Kenya. Cultivars are interbreeding a lot. Conservation of naturalized germplasm needs to be expedited to save it from further distortion and extinction.

Key words: Characterization, Dendrograms, Genetic erosion, Mother trials, Pumpkin genotype, Pumpkin phenotype, Plant Biotechnology

INTRODUCTION
Pumpkin is an emerging important indigenous vegetable in Kenya; Fruit, leaves and the flowers are edible (Robinson & Decker-Walters, 1997). Seeds are used as a vermifuge, and contain fatty acids and phytosterols for treating benign prostatic hyperplasia (Dvorkin & Song, 2002). Crushed, fresh seeds inhibit helminthes, skin infections and inflammations (Guha & Sen, 1998). Pumpkins supply calcium, iron, vitamin A, oil, and protein (Oswell et al., 2007). Pumpkin fruits can be stored for up to 6 months (Mendlinger et al., 1991). Pumpkin diversity contributes to stability and sustainability of farming systems, and products of cultural and socioeconomic importance (Virchow, 2003). Diversity is the main source for current crop improvement and adaptation to changing environmental conditions. Loss of biodiversity presents serious threat to agriculture and livelihood of mankind (Mohamed & Zakri, 2001). Numerous germplasm has already disappeared or is threatened with extinction due to absence of concerted efforts to collect, characterize, evaluate, document and conserve (Mohammed & Zakri, 2001). Therefore, germplasm collection, characterization, conservation and improvement deserve priority (Grubben & Chigumira, 2004). The major task, however, is to search for unique genetic traits that will provide the future breakthroughs for agricultural and industrial use of plant germplasm resources (Thomas & Mathur, 1991).

The challenge in agriculture today is to develop seed production and delivery systems that encourage wider use of quality seed throughout the marketing chain (Ayieko & Tschirley, 2006). Currently the indigenous pumpkins are on high demand because consumers have become increasingly aware of the nutritional and medicinal values of pumpkins, and the demand has been on the rise especially in major urban centres in Kenya. This has created demand especially in both formal and informal markets in the urban centres (Ngugi et al., 2007). The major hindrance to the production of pumpkins is lack of quality seed (Abukutsa Onyango and Onyango, 2005), coupled with the inability of the formal seed system to meet the demand by farmers (Nyoro & Ariga, 2004). With increasing demand for local pumpkin particularly in urban and peri-urban, there is a need for increased production and this call for good quality seed for increased pumpkin yields (Abukutsa-Onyango, 2007).

Statement of the Problem
Agricultural production has lost about three-quarters of its genetic diversity in the past century (Ekese, 2009). Conventional agriculture has, to a large extent, concentrated on conserving the genetic resources of exotic rather than indigenous vegetables (Keding et al., 2007). Consequently, the latter are threatened with extinction (Keding et al., 2007). Indigenous knowledge on production methods, preservation, use and nutritive value is no longer transmitted systematically from one generation to another (Keding et al., 2007). Limited grassroots surveys have been undertaken to collect the valuable indigenous knowledge with the farmers on productivity and use (Chweya, 1994; Onyango, 2002a), occasioning pumpkin landraces to remain under-exploited and poorly documented (Hamisy et al., 2002). In Kenya, improvement of pumpkin is constrained by lack of evaluation, characterization and selection for desirable traits. This is because pumpkins have been neglected by researchers, policymakers and funding agencies. Consequently, naturalized pumpkins are threatened with extinction and erosion through cross pollination with introduced exotic cultivars. Most of the naturalized pumpkins are not easily available as users now gather them with great drudgery and difficulty from the few stands left in the wild (Adebooye et al., 2003).

The informal seed sector lacks official interventions, oversight, research and sophisticated infrastructure for quality control. Seed scarcity contributes to low pumpkin productivity. Introduction of exotic pumpkins in mainstream agriculture has seen these naturalized ones only used minimally during famine and by the poor (Mnzava, 1997).
Consequently, their potential remains unexploited, contributing to micronutrient malnutrition, especially among resource-poor families (Muthoni et al., 2010). The overall major constraints facing production of pumpkins in Kenya include low awareness of their potential, lack of quality seed, information on utilization and documentation of the priority landraces, among others (Maundu et al., 1999; Onyango, 2002b). These constraints notwithstanding, Kenya is endowed with great diversity of conditions suitable for pumpkin production. The study was aimed at contributing to solving some of these constraints by gathering pumpkin germplasm for characterization, evaluation, multiplication and conservation of seeds of preferred cultivars for commercial pumpkin production in future.

Research Justification
Pumpkins have an advantage over other vegetables in that the fruits can be stored for up to 6 months and can play an important role in poverty alleviation and maintenance of nutritional levels during the long dry seasons, when fresh vegetables are not available. In Kenya, primary agricultural production has neglected AIVs and is dominated by mixed farming of a few commodities (Nyangito, 1998). Pumpkins could contribute to reversing these narrow trends, because they have a considerable potential as income earners (Onyango, 2002a), particularly for the smallholders who account for over 65% of the total agricultural output. Enhanced knowledge of pumpkins could play a pivotal role in food and nutrition security of the underprivileged in both urban and rural settings (Schippers, 2000 & Onyango, 2002a).

Research indicates that pumpkins are nutrient-rich, grown as intercrops and less demanding in management since their short-growing periods are favourable to mineral nutrition intervention programmes (Onyango, 2003). Initial identification and characterization of collected accessions will provide breeders with considerable amount of information concerning their value in production of new improved cultivars. Evaluation of the indigenous cultivars will facilitate development of more productive and food-value cultivars. Conservation, utilization, improvement and cultivation will save these cultivars from erosion and/or extinction for the benefit of future generations (Chweya, 1997). Availing of production ethno-knowledge and quality seeds will empower small-scale Kenyan communities economically, and in food security (Habwe et al., 2008). A collective seed supply and husbandry is possible through participatory community seed banks that will further farmers’ autonomy with regard to timely provision of seeds and conservation of agricultural biodiversity (Ekesa, 2009).

General Objective
The general objective was to identify, characterize and evaluate seeds of dual-purpose *Cucurbita moschata* accessions among smallholder farmers in Kenya.

Specific Objectives
2. Evaluate pumpkin germplasm in Kenya.
3. Characterize pumpkin germplasm in Kenya

Expected Outputs
   i. Preferred pumpkin cultivars among smallholder farmers in Kenya determined and selected.
   ii. Dual-purpose pumpkin germplasm from two recommended regions in Kenya phenotypically and genotypically characterized.
   iii. Dual-purpose pumpkin germplasm from two recommended regions in Kenya evaluated.

BEFICIARIES OF THE OUTPUTS AND OUTCOMES
1. Small-scale and resource-poor farmers will gain preferred cultivars and quality seeds.
2. Extension officers capacity will be enhanced by availing to them pumpkin information for use in promotion of production and conservation.
3. Biotechnologists and future researchers will utilize the characterization and evaluation results to make, modify, improve or develop pumpkins for specific uses.
4. Seed companies will do business in seed production and sale.
5. Entrepreneurs will benefit through bulk-buying of pumpkins from growers to enjoy economies of scale.

METHODOLOGY
Germplasm was collected in two recommended region service units (RSUs) (Western and Central Kenya). The acquisitions were planted at the Chuka University College (CU) Ndagani Research Farm to provide material for
Pumpkin germplasm collection was undertaken in Kakamega (26\textsuperscript{th} -30\textsuperscript{th} March, 2012) and Nyeri (16\textsuperscript{th} -20\textsuperscript{th} April, 2012). Initial information on germplasm was obtained from Provincial Directors of Agriculture from each region. A diagnostic survey and formal surveys were conducted in the two regions with the help of ministry of Agriculture officials in both counties. Participatory Rural Appraisal (PRA) techniques were incorporated in the surveys, and included key informant interviews and checklists. Key informant interviews were based on IPGRI collection descriptors and were used to obtain specific information on practices, problems, ethno-botanic knowledge, constraints and opportunities in pumpkin production and utilization. The key informants were selected with the assistance of Field Extension Officers (FEOs) of the Ministry of Agriculture. Seventy five farmers identified through purposive sampling with were sampled in both counties on the basis of their interest and the constraints that needed to be addressed. Known pumpkin farmers were deliberately included and helped in the identification traditional pumpkins being grown and any other pumpkin introductions. The seeds and fruits of the landraces were collected and labeled with a date, place of collection, and number of accession. In cases where there were no seed stored, Fresh seeds, were extracted from pumpkin fruits washed and air-dried under room temperature. The seeds were placed in labeled packages for easy transportation.

**Germplasm Collection**

Molecular characterization of DNA was done at the Jomo Kenyatta University of Agriculture and Technology, Institute Biotechnology Research (IBR) laboratory and each accession represented a plot. The characters measured included vegetative, stem, root, inflorescence, fruit and seed characters.

**Morphological Characterization**

The collected accessions were planted in a 2 x ‘n’ factorial arrangement in a completely randomized design on-station at CU Research Farm, whereby ‘n’ refers to the number of accessions up to a maximum of 155. The land where the accessions were planted was prepared well to a fine tilth for easy and uniform germination. Five plants per accession were selected and tagged for morphological characterization and evaluation based on IPGRI descriptors for Cucurbits. Certain characters not in the IPGRI list were added (Fruit Flesh Thickness) and others in the IPGRI list were not be measured. Planting for morphological characterization was done on 23 may, 2012 and recording of vegetative characteristics, commenced 20 days after emergence. Plants for morphological characterization were selected randomly and each accession represented a plot. The characters measured included vegetative, stem, root, inflorescence, fruit and seed characters.

**Accession Evaluation**

The collected accessions were planted in a 2 x ‘n’ factorial arrangement in a completely randomized design with three replications, both on-station and on farmers’ farms, whereby ‘n’ referred to the number of accessions. Exotic cultivars were used as controls. Evaluations were done for 2 seasons. All accessions were planted at a standard spacing of 2 m x 2 m. Land was ploughed and pulverized into fine tilth. Farmers’ practices were followed during plant management. Data recording was undertaken 20 days after planting up to maturity. At maturity different types of plants observed were harvested individually. Each plant selected and harvested in the previous season was planted again. Data on plant characteristics, leaf and fruit yields was recorded again to obtain plant characteristics, leaf and fruit yields stability. Mother trials were conducted to evaluate growth and yield. The Mother trials had all the cultivars planted in 2 locations, with 3 replicates per location. The locations were the Kakamega and Embu KALRO research stations. The entries were compared using matrix ranking through focus group discussions.

**DNA Extraction and Quantification**

Leaf samples from the tips of young and healthy actively growing pumpkin plants, 5 per accession up to a total of 139 accessions (65 and 74 Kakamega and Nyeri counties respectively), were plucked and used to extract DNA. Seven day old leaf samples were picked, labeled and placed in cool box with ice bags in it immediately and there after transported to the Jomo Kenyatta University of Agriculture and Technology, Institute Biotechnology Research (IBR) laboratory and stored in a refrigerator at -25\textdegree C. The samples were arranged in split plot factorial with counties and accessions representing main plots and subplots, respectively. Prior to DNA extraction the leaf samples were stored at -85\textdegree C refrigerator to facilitate crushing of the leaf samples to powder form instead of using liquid nitrogen. The mortar and pestles to be used for crushing were soaked in a Jik detergent for 30 minutes and thoroughly washed and first rinsed in cold water and then warm water. The mortar and pestles were then wrapped with foil paper and autoclaved for 30 minutes to sterilize them to eliminate any possible contamination which could interfere with the results validity. The leaf samples were crushed into powder form and placed in sample tubes and then stored at -85\textdegree C again to avoid any contamination.
enzymatic reaction which could interfere with DNA extraction process. A new mortar and pestle was used for every sample then Soaked in bleach water for at least ½ hour before rinsing and autoclaving. DNA was extracted using the method described by Doyle & Doyle, (1987) and quantified using the NanoDrop-1000 spectrophotometer (Beauman, 2007). CTAB DNA Extraction Protocol was used for DNA extraction.

The Agarose Gel Electrophoresis
To confirm the presence of DNA strands from the sample extract, horizontal gel electrophoresis was conducted. Gels were prepared such that it was 0.8-1% agarose by weighing out approximately 0.8-1g of the agarose powder. The amount of agarose depended on the size of the gel rig. Gels were fairly thin, approximately 1/4 to 1/2 inch. 100 mL 1X TAE or 1X TBE buffer was added to the agarose powder. Ethidium bromide 1 ug/ul (1/10th ul 10 mg/ml etBr per ml of agarose) was used. A 5 μl drop of bromophenol blue or glycerol loading dye was used to stain the DNA samples. A maximum 20 and a minimum of 12 wells were used to load the stained DNA samples. Samples were loaded and ran at constant voltage towards the anode (red) end. For a small gel, the power pack was set to about 100 volts/ ma and a large gel, about 120 volts/ma. Milliamperage/ voltage increased during the run, so it was checked periodically and stopped the run before the bromophenol blue or glycerol loading dye front exited the gel. The power pack was turned off, the gel removed and visualized with UV light (taking proper precautions!) to visualize the presence of DNA in the sample extracts and photographed with a Photo documentation camera. The gel was then disposed off properly into carcinogenic disposal tanks for further proper disposal of ethidium bromide safely. The samples which had no DNA visualized the DNA extraction and electrophoresis procedure were once repeated until DNA was visualized and then samples stored at 4°C for the Polymerase chain reaction (PCR) amplification using the simple sequence repeats (SSR) and inter-simple sequence repeats (ISSR) primers

Molecular Characterization
Plants of 139 accessions were subjected to PCR using 5 pumpkin SSRs primer pairs and 7 ISSR for the polymorphism survey (Table 1).

<table>
<thead>
<tr>
<th>Table 1: SSR Primer Pairs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primer Name</td>
</tr>
<tr>
<td>PKCT 47</td>
</tr>
<tr>
<td>PKCT 62</td>
</tr>
<tr>
<td>PKCT 111</td>
</tr>
<tr>
<td>PKCT 122</td>
</tr>
<tr>
<td>PKCT 133</td>
</tr>
</tbody>
</table>

Length variation was the source of polymorphisms in SSR loci and could be identified by the PCR using primer pairs specific to the flanking SSR regions. The SSRs were distributed throughout a genome, and were proven to be useful as genetic markers and for cultivar identification (Watcharawongpaiboon and Chunwongse, 2007). Seven ISSR primers based on dinucleotide, tetrancleotide or pentanucleotide repeats was used in ISSR analysis (Table 2).

<table>
<thead>
<tr>
<th>Table 2: ISSR Primers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primer Name</td>
</tr>
<tr>
<td>ISSR 814A</td>
</tr>
<tr>
<td>ISSR 844A</td>
</tr>
<tr>
<td>ISSR 844B</td>
</tr>
<tr>
<td>ISSR 17898A</td>
</tr>
<tr>
<td>ISSR 17898B</td>
</tr>
<tr>
<td>ISSR 17899A</td>
</tr>
<tr>
<td>ISSR 17899B</td>
</tr>
</tbody>
</table>

ISSR, which depend on PCR, rapidly differentiated closely related individuals. The method called ISSR was based on the amplification of DNA region located between two microsatellites locus. When the primers successfully located two microsatellite regions within an amplifiable distance away on the DNA strands, the PCR reaction generated a band of
a particular size for that locus (Heikal, et al., 2008). PCR amplifications was performed with a Gene-Amp PCR system 9700 in a 10 μL final volume containing a PCR mixtures Primers were tested and optimized with 2 randomly selected accessions (KAPAP/CU/JKK/NY-135 for SSR and KAPAP/CU/JKK/KK-95) by PCR amplification. PCR reactions were performed with a stock solution containing 30ng/μl of DNA, 10X PCR buffer, 2.5 mM dNTP, 10 mM MgCl2, 5.0 pmoles /μl of each of forward and reverse primers and 5 U/μl of Taq polymerase. The PCR per reaction was 0.5μl of DNA, 0.5 μl PCR buffer, 0.4 μl dNTP, 0.4 μl MgCl2, and 0.5μl each of forward and reverse primers, 4.2 μl of Taq polymerase making a total volume of 10 μl. 3.0μl H2O for SSR and 3.5μl H2O for ISSR. The micro tubes were placed in a thermal cycler (a Gene-Amp PCR system 9700 and the thermo cycling reactions done in the following scheme: Initial denaturing at 94°C for 3 minutes, 30 cycles of 30 seconds at 94°C, 1 minute for 55°C, and 2 minutes at 72°C, elongation at 72°C for 20 minutes and a final hold at 4°C for SSR and Initial denaturing at 94°C for 3 minutes, 35 cycles of 30 seconds at 94°C, 1 minute for 47°C, and 2 minutes at 72°C, elongation at 72°C for 20 minutes and a final hold at 4°C for ISSR.

Data Collection and Analysis
Photographs were taken during all stages of collection, characterization and evaluation. The collected data was arranged in nominal, ordinal and continuous categories. Nominal and ordinal data was expressed as modes, whereas the mean was used for continuous data. Measures of dispersion were used to express diversity within accessions for each character. Standard deviation and the range were used to express the accession diversity and variability. Frequency of the mode was used as an indication of variation within accessions. Data was scored as the presence (1) or absence (0) of SSR and ISSR bands. Only sharp and precise bands were scored to generate a data matrix.

Bands present in all accessions were scored as 1 for present and 0 for absent of bands. Distance matrices for all pairs of genotypes were constructed from the SSR and ISSR data matrix using the Euclidean distance method (Rousseeuw & Kaufman, 1990). Cluster analysis was performed using UPGMA and the genetic distance matrices generated by the Euclidean distance method with 1000 bootstraps to reveal the patterns of genetic relationships among genotypes. Cluster analysis results were presented in dendrograms to infer relationships among genotypes, with 1000 bootstrap replicates (Felsenstein, 1985). Morphological characterization and evaluation data were subjected to analysis of variance using the SAS program. Means were separated at P=0.05. Molecular characterization data were scored and phylogenetic analyses conducted using DarWin software (Perrier and Jacquemoud-Collet, 2006).

RESULTS AND DISCUSSION
Germplasm Collection: Kakamega and Nyeri Counties.
Collection was conducted from 26th to 30th March and 16th to 20th April, 2012 in Kakamega and Nyeri counties respectively. Purposive sampling was used and first collected germplasm was labeled: KAPAP/CU/JKK/KK-1-14 and up to last collected accession KAPAP/CU/NY/JKK/155. A total 155 accessions were collected from Kakamega and 85 Nyeri counties. The collection itinerary was as listed in Table 5 in that order.

Table 3: Germplasm Collections Target Areas Description per Sub County

<table>
<thead>
<tr>
<th>No.</th>
<th>Sub county</th>
<th>Altitude M)</th>
<th>Agroecological Zones (AEZs)</th>
<th>Accessions Codes</th>
<th>No. of Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kakamega Central</td>
<td>1441-1547</td>
<td>UM 0, UM 1, LM 1, LM 2</td>
<td>KAPAP/CU/JKK/KK-1-14</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>Kakamega East</td>
<td>1522-1562</td>
<td>UM 0, LM 1, LM 2</td>
<td>KAPAP/CU/JKK/KK-15-30</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>Kakamega South</td>
<td>1478-1534</td>
<td>UM 1, LM 1, LM 2, LM 3</td>
<td>KAPAP/CU/JKK/KK-31-53</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
<td>Butere</td>
<td>1383-1417</td>
<td>LM 1</td>
<td>KAPAP/CU/JKK/KK-54-57</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Khwisero</td>
<td>1466-1556</td>
<td>LM 1</td>
<td>KAPAP/CU/JKK/KK-58-70</td>
<td>13</td>
</tr>
<tr>
<td>6</td>
<td>Mathira East</td>
<td>1687-1843</td>
<td>LH 1-3, UM 1-3, UH 0, UH 1</td>
<td>KAPAP/CU/JKK/NY-71-97</td>
<td>27</td>
</tr>
<tr>
<td>7</td>
<td>Mathira West</td>
<td>1649-1817</td>
<td>UM 2-4, LH 2-3</td>
<td>KAPAP/CU/JKK/NY-98-108</td>
<td>11</td>
</tr>
<tr>
<td>8</td>
<td>Nyeri Central</td>
<td>1767-1858</td>
<td>UM 2-4, LH 1-3</td>
<td>KAPAP/CU/JKK/NY-109-129</td>
<td>21</td>
</tr>
<tr>
<td>9</td>
<td>Tetu</td>
<td>1772-2128</td>
<td>UH 1, UM 1-3, LH 1-2</td>
<td>KAPAP/CU/JKK/NY-130-143</td>
<td>14</td>
</tr>
<tr>
<td>10</td>
<td>Nyeri South</td>
<td>1870-1950</td>
<td>UH 1, LH 1, UM 1-2</td>
<td>KAPAP/CU/JKK/NY-144-155</td>
<td>12</td>
</tr>
</tbody>
</table>

UM—Upper Midland, LM—Lower Midland, LH—Lower Highland, UH—Upper Highland and 0—Perhumid, 1—Humid, 2—Sub humid, 3—Semi humid, 4—Transitional. Agro-Ecological Zones LH 1-4, UM 1-5 and LM 3-4 occurs at descending altitudes, the zones UH 2, 3 and LH 2, 3, 4, 5 indicate decreasing rainfall already in higher altitudes.

The traditional landraces collected were 105 and exotic 50. The traditional (105) were always associated with the place and the community, 45 exotic were introduced but the date not known, 2 were borrowed from the neighbours around the county and 3 were introduced by a Non-Governmental Organization (NGO). Ninety collections were from
seed, 65 from fruits, and seeds extracted, processed, air dried and packaged. The collections had varied characters for the fruits and seeds. The fruit shapes were ovate (12), Globular/round (18), Elliptical (11), Pyriform /pear-like (6), Flattened (6), Acorn (9) and 3 elongate in shape. The predominant fruit colour was: cream 4, 8 pale green, 16 green, 24 dark green, 5 blackish green, 2 Light yellow, 2 orange and 4 grey in colour. The seeds of local landraces were yellow-white, cream yellow and those from exotic cultivars, light brown or tan to brown colour. The farmers had indigenous technical knowledge which they used to encourage yielding and fruiting of pumpkins. Sixty two percent of the farmers interviewed sold pumpkin fruits and leaves, 37% didn’t sell any pumpkin produce.

Morphological and Molecular Characterization

Morphological data was subjected to analysis of variance using the SAS program. Means were separated at P=0.05. Out of 155 accessions collected, 8 failed to germinate and one died prematurely. The remaining 146 accessions data on vegetative, stem, root and Inflorescence characters was recorded. Only 126 accessions were able to form fruits. There was significant variation (P<0.05) among 146 accessions (Table 6).

Table 4: Summary of Morphological Traits

<table>
<thead>
<tr>
<th>Trait</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Var</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf Ratio</td>
<td>0.58</td>
<td>0.97</td>
<td>0.7673</td>
<td>0.004</td>
</tr>
<tr>
<td>Days to 1st Flowering</td>
<td>49</td>
<td>87</td>
<td>69.06</td>
<td>102.44</td>
</tr>
<tr>
<td>Pedicle Length</td>
<td>4.0</td>
<td>16.5</td>
<td>8.290</td>
<td>5.550</td>
</tr>
<tr>
<td>Fruit Flesh Thickness (mm)</td>
<td>10.5</td>
<td>42.6</td>
<td>24.987</td>
<td>41.101</td>
</tr>
<tr>
<td>Fruit L/W Ratio</td>
<td>0.6</td>
<td>3.0</td>
<td>1.148</td>
<td>0.156</td>
</tr>
<tr>
<td>Days 1st Fruit Maturity</td>
<td>107</td>
<td>141</td>
<td>127.56</td>
<td>48.760</td>
</tr>
<tr>
<td>Maturation period</td>
<td>39</td>
<td>89</td>
<td>56.91</td>
<td>145.65</td>
</tr>
<tr>
<td>Total Fruit wt/Plant  (kg)</td>
<td>0.25</td>
<td>19.25</td>
<td>8.263</td>
<td>2.152</td>
</tr>
<tr>
<td>Stem Thickness (mm)</td>
<td></td>
<td></td>
<td>3.919</td>
<td>10.65</td>
</tr>
</tbody>
</table>

Morphological variation of fruits was great. Fruit length to width ratio and fruit weight ranged from 0.6-3 cm and 0.25-19.25 kg/accession, respectively. Variation of peduncle length and total fruit weight was 5.55 cm and 145.65 kg/accession, respectively. All the accessions characterized had leaf veins, their leaf size was large, leaf pubescence density-adaxial was dense while leaf pubescence density-abaxial intermediate, leaf lobes were shallow, leaf base shape was cordate. Leaf shapes were pentalobate and all accessions had roots at their internodes. Leaf outline of 108 accessions was broadly ovate compared to 38 accessions with very broadly ovate leaf outline. Most accessions (101) had variable leaf colour i.e. green with silvery strips. 45 accessions had one colour either green or dark green with no silvery strips. Accessions (88) showed moderate senescence when fruits matured with 44 accessions portraying Conspicuous concurrent senescence. In all the accessions the sex type was monoecious male and female, with most flowers being mostly male. Most male flowers were early compared to female flowers. Only 9 accessions had female flowers appearing before the male flowers. Flower colour was variable with most accessions (101) having orange colour flowers. Predominant qualitative fruit characteristics were fruit shape with 38 accessions exhibiting globular shape. Most accessions (42) had an average fruit size averaging 1.2 kg. One accession matured within the range of 91-110 days, 125 their fruit matured above 110 days. The delay in fruit maturity could have been attributed to the long dry spell experienced during the growing period. Accessions (99) showed the ability to regenerate second fruit cycle as they continued to produce leaves and male flowers even after harvest. Accessions (27) had no signs of second fruit cycle as most of the vegetative part had dried up and showed no signs of regeneration even after watering. Predominant fruit skin colour at maturity, ranged from green to orange, secondary fruit skin colour pattern varied from speckled to striped, fruit surface ranged smooth to skin surface with warts, and internal flesh colour from white to yellow. Main colour of flesh and flesh colour of outer layer ranged from yellow to salmon (pink-red). All the accessions had fruit vein tracks and the peduncle abscised when overripe. Deep fruit ribbing was only in 40 accessions and 69 had small blossom scars. The minimum and maximum total fruit weight 0.25 and 19.25kgs respectively. The mean fruit weight was 3-9 kg.

Molecular Characterization

The 5 SSR markers (loci) were able to detect a total of 437 alleles for all the accessions. A total of 258 bands were not amplified by the SSR markers. The Number of bands amplified by the ISSR primers were 510 with 464 not amplified respectively. DNA band sizes were measured with 1.5% gel agarose 5µL per lane bioline DNA ladder [50-2000 base pairs-(bp)]. The SSR amplified band size range was between 100 to 500 bp. Primer PKCT-62 and PKCT-111 had the lowest amplified band sizes. The band sizes for the ISSR were more polymorphic with the lowest band size ranging between 200-500 bp and the highest range between 1200 to 2000 bp. ISSR 17898B and ISSR 17899A had the highest band range. ISSR 814A had band sizes within the range of 500-1200bp with the rest of the primers with a lower range of 200-500bp.
Primer Polymorphism
The number of alleles per locus ranged from 1 for markers PKCT-47, PKCT-62, PKCT-111 and PKCT-133 to 2 for marker PKCT-111 and PKCT-122, 2 and 3 for PKCT-62, 3 to 4 for PKCT-47. There was observed heterozygosity for marker PKCT-47, PKCT-62, PKCT-111 and PKCT-122, and homozygosity for marker PKCT-47, PKCT-62, PKCT-111 and PKCT-133 for the accessions in both counties. SSR marker PKCT-122 had the most polymorphic bands in all the accessions. All the ISSR bands were polymorphic ranging from 1 to 7 bands. ISSR 17898A all the bands were polymorphic. ISSR 814A had the most Monomorphic bands, with ISSR 17899A having the most polymorphic bands.

Polymorphic Information Content (PIC)
Polymorphic information content (PIC) is the value of a marker for detecting polymorphism within a population. It measures the usefulness of a marker and Informativeness in specific families. Polymorphic information content (PIC) depends on the number of detectable alleles and the distribution of their frequency (El-Awady et al., 2012). Marker PKCT-47 revealed the highest polymorphic information content (PIC). The PIC value for SSR primers was 0.62 (PKCT-47) and 0.38 (PKCT-62), with a PIC mean value of 0.5. A total of 526 polymorphic alleles were generated using the SSR primers with a polymorphism rate of 21.3%. ISSR analysis generated a total of 509 alleles, and the polymorphism rate was 74.01%. The PIC value for ISSR primers was 0.50 (ISSR 844B and ISSR 17899B), 0.53 (ISSR 814A), 0.66 (ISSR 17898A), 0.60 (ISSR 17898B), 0.67 (ISSR 17899A) and 0.72 (ISSR 844A), with a PIC mean of 0.597.

Dendogram based on Morphological and Molecular Characters
Morphological variations constructed dendograms based on quantitative and qualitative characters. Accessions with missing data were not included. Clustering of quantitative and qualitative characters was done using the Unweighted Pairs Groups Method of Arithmetic Averages (UPGMA) based on morphological similarity. The dendrograms revealed 3 main cluster groups from the cultivars evaluated based on either quantitative or qualitative characters. Combining the quantitative and qualitative characters 2 main clusters formed (Figure 4).

Figure 4: Dendrogram of Hierarchial Clustering for Quantitative and Qualitative Morphological Characters Based on Euclidian Distance Method by UPGMA With 1000 Bootstraps.
The presence (1) and absence (0) of PCR DNA amplicons were used to construct a dendogram. The Dendrogram resulting from UPGMA hierarchial cluster analysis revealed 3 clusters based on SSR or ISSR primers. SSR and ISSR primers combined also revealed 3 main clusters (Figure 5).

![Dendogram](image)

Figure 5: Dendogram of Hierarchial clustering for SSR and ISSR based on Euclidean Distance Method by UPGMA with 1000 Bootstraps.

**Yield evaluation**

Pumpkin accessions were planted for 2 seasons in three replications at Kakamega and Embu KARI Research stations for yield evaluations. The Plants were rain fed and when there were no rains irrigation was applied at 2 litres per plant. First season was planted on 21st June and 29th September 2012, and second season on 8th April and 13th April 2013 at Embu and Kakamega KARI respectively. Comparing both seasons it took longer for germination and fruit maturity to take place in season two 7 and 89 days compared to season one 6 and 86 days with a mean of 6.94 and 88.23 days in both seasons respectively (Table 5).

**Table 5: Summary of Yield Evaluation for Seasons 1 and 2 at Embu and Kakamega KALRO Stations**

<table>
<thead>
<tr>
<th>Days to Germ</th>
<th>Days to Flowering</th>
<th>Days to Fruit Maturity</th>
<th>Average Fruit Wt</th>
<th>Total Fruit wt / plant</th>
<th>Number of fruits/plant</th>
<th>100 seed wt</th>
<th>Fruit Length</th>
<th>Fruit Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>5</td>
<td>26</td>
<td>29</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>5.56</td>
<td>7.0</td>
</tr>
<tr>
<td>Max</td>
<td>15</td>
<td>122</td>
<td>120</td>
<td>4.2</td>
<td>15.9</td>
<td>9</td>
<td>32.86</td>
<td>35.1</td>
</tr>
<tr>
<td>Sum</td>
<td>5675</td>
<td>53427</td>
<td>51790</td>
<td>791.5</td>
<td>1857.5</td>
<td>1369</td>
<td>7737.9</td>
<td>10848</td>
</tr>
<tr>
<td>Mean</td>
<td>6.94</td>
<td>66.70</td>
<td>88.23</td>
<td>1.353</td>
<td>3.175</td>
<td>2.34</td>
<td>13.227</td>
<td>18.54</td>
</tr>
<tr>
<td>Var</td>
<td>2.318</td>
<td>290.363</td>
<td>176.320</td>
<td>.330</td>
<td>5.699</td>
<td>2.184</td>
<td>24.569</td>
<td>44.06</td>
</tr>
</tbody>
</table>

Days to first flowering were shorter in season two. There was no significant difference in female flowers in both seasons. Total fruit weight (2.9), number of fruits per plant and average fruit weight (1.5) was higher in season two on average compared to season one. Season one had higher number of leaves per plant (182), weight on 100 seed weight (14.9 gms), Biological yield (344.8 gms), longer period of vegetative period (217 days) and a higher germination percentage. In season two there was higher number of seeds per plant (261), Main vine length (642.5 cm), fruit length (15.5 cm) and fruit width (14.9 cm) and a lower germination percentage of 87%. Fruit weight in grams and yields in kilograms per hectare were also high in season two. Kakamega KARI accessions had higher number of female and male flowers. Average fruit weight (1.5 kgs), Total fruit weight per plant (3.99 kgs) and the average number of fruits per plant (3), number of seeds per fruit per plant (291) with low 100 seed weight (12.45 Gms), Fruit length (21.5 cm), fruit width (15.2 cm), main vine length (597.17 cm) in both seasons. Kakamega accessions had a larger number of leaves (216) and high biological yield (377.58 Gms). Embu KARI accessions had longer vegetative period (184 days).
DISCUSSION
In Kenya pumpkins are referred to as “orphaned”. Orphaned crops are those crops which have great prospective for food production and development, but whose potential is not adequately appreciated and fully exploited. Consequently, these crops remain “underutilized” in national development (Naluwairo, 2011). Introducing exotic cultivars in the main stream agriculture has replaced/reduced the population of the local varieties (Ngugi, et al., 2007). However, producing more exotic crops is not a panacea to food and economic problems faced by the farmers; instead they have resulted to loss in pumpkin diversity. The loss of pumpkin species during the last decade was derived by asking farmers directly about the history of pumpkin cultivation in each village, if there was any difference between their own landraces with those from the neighboring villages etc. In addition farmers were asked to identify the most important uses for specific pumpkins such as for selling, domestic consumption, provision of seeds, medicinal and/or folklores. These questions were important because it was thought that if a crop had a wide range of uses then its cultivation may have been sustained for longer (Davari, et al., 2013).

From this point of view the threat of genetic erosion was not a serious problem in target areas. It was determined that most pumpkin species in both counties were cultivated for selling and that there was a negligible number of species cultivated for other reasons such as domestic consumption or for seed provision. In terms of medicinal use, there were no results for researched species (Davari, et al., 2013), but farmers believed the local landraces could cure stomach worms. Thus, economic objectives were clearly identified as the main reason for cultivating specific pumpkins in some of the target areas. This highlighted the threat of existence to the local pumpkins because it means that only those that could fetch high market prices were selected for cultivation. Some farmers used cultural values and indigenous knowledge to discourage leaf harvesting and disturbance of pumpkin plants to encourage yielding and fruiting. These and other social cultural values attached to pumpkins tended to safeguard the growth and development of pumpkin fruits (Ondigi, et al., 2008). These helped in preserving the genetic diversity in some of target areas.

One hundred and forty six pumpkin accessions from Kakamega and Nyeri counties were characterized for morphological and yield attributes. The range of first flowering was 49-87 days. The range of variability was distinct for leaf ratio, days to first flowering, fruit flesh thickness, Fruit length/width ratio, days first fruit maturity, Maturation period and Total fruit weigh per plant. The qualitative characteristics of these pumpkin accessions showed variation in fruit color and flesh color. The variation in traits of the various accessions shows the diversity in the accessions. This diversity can be used to improve, modify and create new cultivars which are high yielding and more adapted to the changing climatic conditions.

The genetic diversity among the accessions was evaluated using SSR and ISSR markers. SSR PKCT-47 primer pair identified more fragments (4 alleles /primer) than any of the other primer pairs. The second most polymorphic SSR was PKCT-122, with 2 alleles /primer. The mean number of total alleles amplified per SSR primer pair was 105.2. PKCT-111 and 122 were biallelic and PKCT-133 monoallelic hence they had zero PIC. The number of alleles amplified per locus ranged from 3 to 4 for PKCT-47, 2 and 3 for PKCT-62. The number of fragments produced by each ISSR primer varied from 2 to 7 (ISSR 844B and ISSR 17898A), with an average mean of 72.7 of amplified alleles. ISSR 17899A was more polymorphic (89.02%) with ISSR 814A being lowest in polymorphism (50.59%). The number of amplified fragments was dependent on individual Accessions.

Morphological and molecular characters generated dendrograms showing similarity in the number of clusters. The quantitative, qualitative characters, SSR and ISSR scores all produced 3 main clusters separately. The fact that 3 clusters can be observed is an indication of a high diversity, but it should be noted that the accessions are not all from the same Genera. Genera that cluster together may be a basis of possible introgressions between the genera in the field, as these are normally grown side by side (Xolisa, 2002).

Kakamega accessions were high yielders in both seasons, and could be attributed to the large number of average fruits produced per accession. Embu accessions had longer vegetative period (184 days) these was due to the prolonged growing period facilitated by the short rains in October, 2012. In both seasons the local accessions yielded more than the exotic cultivars. Introducing exotic cultivars to the main agriculture farming systems is not a panacea to economic and food security. The Embu accessions were collected from Nyeri County which had the highest number of exotic introductions. There could be some introgression and hybridization in these accessions than those from Kakamega.

CONCLUSION
The diversity of pumpkins is under serious threat due to exotic introductions brought in for economic reasons. Farmers
who are the custodians of genetic diversity should be encouraged and supported to preserve the local landraces. The local landraces not only provide the required genetic material for crop improvement but also serve as food security crops during drought, maintain good health of the farmers and notwithstanding they have medicinal value important to the mankind. Despite the local landraces being important in social economic values they have a significant role in food security for the poor and under privileged. Collection, characterization and preservation of the local landraces therefore should be given uttermost priority and be expedited to capture maximum variation useful for crop improvement before there is too much loss of diversity and/ or extinction.

REFERENCES


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ACCEPTABILITY OF NAPIER GRASS, TITHONIA (Tithonia diversifolia) AND SAPIUM (Sapium ellipticum) AS FORAGES FOR SHEEP IN KENYA AND THEIR NUTRITIVE CONTENT

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ABSTRACT

There is limited information on acceptability of Tithonia (Tithonia diversifolia) and Sapium (Sapium ellipticum) as forages to sheep in Kenya. This study compared the acceptability of Napier grass, Tithonia and Sapium as forages for...
sheep. It had five (one and half year old male sheep) selected on the basis of uniformity in live weight, averaging 23 kg. The sheep were housed in individual pens (metabolic unit), measuring 1.5mx1.5mx2.0m and mounted on the concrete floor at Kenya Agricultural Research Institute, Embu. The feeding period lasted for 10 days. Data were collected and recorded for 5 days. A sample of each offered and refused experimental diet was collected and recorded for 5 days and oven-dried for determination of moisture content, crude protein, ash content, neutral detergent fiber, acid detergent fiber and acid detergent lignin. The neutral detergent fibre levels for wilted Napier grass, Tithonia and Sapium fodder were 80.1%, 33.57% and 39.52% respectively. The acid detergent fiber levels for wilted grass, Tithonia and Sapium hay were 43.58%, 27.98% and 22.4%, respectively. The acid detergent lignin levels for the diets 1, 2 and 3 were 6.12%, 11.3% and 8.87%, respectively. Napier grass, Sapium and Tithonia forages were found to be preferred by the sheep in this order, with an average daily intake in kg/DM of 0.26, 0.11 and 0.18, respectively. Knowing acceptability of the forages could assist in their utilization in improvement of sheep nutrition and productivity.

Key words: Ruminant animals, Corriedale sheep, Neutral Detergent fiber, Acid Detergent fiber, Acid Detergent Lignin

INTRODUCTION

Ruminants such as goats and sheep may be fed with a wide variety of plant material differing in nutrient content and quality. Free choice is used to determine palatability of feed. This measured as the difference between the amount feed offered and the amount of refusal. Palatability may be affected by (visual) appearance, taste, flavour and texture (Ngwa et al., 2003). Grazing ruminants also select to make favourable combinations of various plant materials in order to maximize their biological performance and minimize toxicosis (Provenza, 1995). An ideal alternative fodder crop for Napier grass would be one that is approximately equally productive, acceptable and of high nutritive value. However, although a dry matter yield study on the two potential alternatives had been carried out (Ngwa et al., 2003), there is very little information regarding the acceptability of Tithonia diversifolia and Sapium ellipticum as fodder to focus mainly on sheep. This study was therefore carried out to compare the acceptability of Napier grass, Tithonia diversifolia and Sapium ellipticum forage fodder to sheep.

MATERIALS AND METHODS

The Study site

The study was carried out at Kenya Agricultural Research Institute, in Embu County. The center is in a sub humid Agro ecological zone, located 1490 meters above sea level at 0030’S and 37°27’E. The soils in the area are humid Nitisol derived from basic volcanic rocks and classified by USDA (United State Department of Agriculture) under humid patehumult. The region has a bimodal pattern with long rains in May to June amounting to an average of 750mm and short rains in October to December with an average of 350 mm. The monthly temperature ranges from 18 to 21°C.

Experimental animals and animal house

Five one and half year old male Corriedale sheep were selected on the basis of uniformity in live weight, averaging 23kg. The sheep were housed in individual pens (metabolic unit), with approximate sizes of 1.5m by 1.5m by 2.0m mounted on the concrete floor of the wooden animal house.

Experimental diets

Three different experimental fodders comprising of Napier grass, Tithonia diversifolia and Sapium ellipticum forages were fed to sheep. The feed materials for both Tithonia and Sapium were initially cut as green fodder and then dried under shade. After drying, the leaves and twigs were separated from the stems, and then the materials were kept in gunny bags (100 kg) and put in a well-ventilated store. The experimental diet was weighed a day before feeding using a weighing balance (Ohaus™). Tithonia and Sapium were fed as hay while napier grass was fed as wilted green chop. The three types of fodder were fed separately in three marked containers firmly fixed on the timber of the metabolic crates. All feeds were presented to all the sheep simultaneously at 8.00 am. The sheep were allowed to feed for a period of four hours in the morning (Kalio et al., 2006). The feed refusals from the three diets were then removed and emptied into labeled khaki papers and weighed using a weighing balance (Ohaus™) and a sample taken for drying in an oven set at 60°C. The feeding study lasted a period of ten (10) days. The first five days were allowed to adapt the sheep to the crates, feed samples and feeding data was collected in the last five (5) days.

Laboratory analysis

Feed on offer and refusal samples were submitted to the laboratory for proximate analysis (AOAC, 1990). Neutral Detergent Fiber, Acid Detergent Fiber, Acid Detergent Lignin, were done as described by (Van Soest et al., 1991).
Data management and analysis
The amount of each fodder type on offer to all the five Corriedale sheep and refusals was recorded over five days. The feed intake by the five sheep was determined by subtraction. The average daily feed intake for each test diet and each sheep was calculated over the five days. The intake of the three types of fodder was assessed using one way analysis of variance.

RESULTS
Chemical Composition of the fodder under test
The dry matter of a feed indicates the form in which the feed was offered. The wilted napier grass fodder was offered as green chop with a DM content of 13.6%. Sapium and Tithonia forages were fed as hay with a dry matter content of 85.2% and 89% respectively (Table 1). The Crude protein for the three fodders (wilted napier grass, Tithonia and Sapium) was 4.29%, 20.7% and 11.8% respectively. The ash content for the three fodder species, wilted napier grass, Tithonia and Sapium was 10.2%, 16.24% and 7.06% respectively (Table 1).

Table 1: Nutrient composition of napier grass, Tithonia and Sapium forage fed to sheep during the study

<table>
<thead>
<tr>
<th>Diets</th>
<th>Napier grass</th>
<th>Tithonia fodder</th>
<th>Sapium fodder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter, %</td>
<td>13.6</td>
<td>89</td>
<td>85.2</td>
</tr>
<tr>
<td>Crude Protein, %</td>
<td>4.29</td>
<td>20.7</td>
<td>11.8</td>
</tr>
<tr>
<td>Neutral Detergent Fiber, %</td>
<td>80.1</td>
<td>33.57</td>
<td>39.52</td>
</tr>
<tr>
<td>Acid Detergent Fiber, %</td>
<td>43.58</td>
<td>27.98</td>
<td>22.35</td>
</tr>
<tr>
<td>Acid Detergent Lignin, %</td>
<td>6.12</td>
<td>11.3</td>
<td>8.87</td>
</tr>
<tr>
<td>Ash, %</td>
<td>10.2</td>
<td>16.24</td>
<td>7.06</td>
</tr>
</tbody>
</table>

Table 2a: Mean Napier grass, Tithonia and Sapium fodder intake (kg/DM) over the five day preference feeding trial

<table>
<thead>
<tr>
<th>Day of intake recording</th>
<th>Wilted Napier grass fodder (13.6%DM)</th>
<th>Tithonia hay (89%DM)</th>
<th>Sapium hay (85.2% DM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.27</td>
<td>0.10</td>
<td>0.16</td>
</tr>
<tr>
<td>2</td>
<td>0.27</td>
<td>0.13</td>
<td>0.17</td>
</tr>
<tr>
<td>3</td>
<td>0.28</td>
<td>0.13</td>
<td>0.19</td>
</tr>
<tr>
<td>4</td>
<td>0.22</td>
<td>0.11</td>
<td>0.18</td>
</tr>
<tr>
<td>5</td>
<td>0.26</td>
<td>0.10</td>
<td>0.20</td>
</tr>
<tr>
<td>Average daily intake</td>
<td>0.26</td>
<td>0.11</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Table 2b: Analysis of variance of fodder and day of recording effects on fodder intake in Corriedale sheep fed three fodder alternatives

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>4</td>
<td>0.002</td>
<td>0.339</td>
<td>0.850</td>
</tr>
<tr>
<td>Fodder</td>
<td>2</td>
<td>0.113</td>
<td>23.150</td>
<td>0.000</td>
</tr>
<tr>
<td>Day * Fodder</td>
<td>8</td>
<td>0.001</td>
<td>0.267</td>
<td>0.974</td>
</tr>
<tr>
<td>Error</td>
<td>56</td>
<td>0.005</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R Squared = 0.472 (Adjusted R Squared = 0.340)

DISCUSSION
This study provided data on napier grass being low in protein and as such should be supplemented (Muia, 2000). The Crude protein of napier was quite low compared to the Crude protein of Tithonia and Sapium and this may have contributed to less preference than was expected despite the fact that it was fed as green chop in the current study. Grasses like napier grass need to be supplemented with protein rich forages because the pasture crude protein levels are usually inadequate. Crude protein contributes generally to the acceptability of a feed (Kongmanila, 2005). Indigenous fodder are known to contain high level of crude protein due to their deep rooted characteristics that stabilize crude protein levels across seasons and age unlike that of grasses, like napier (Roothaert et al., 2001). Forage intake is
modified by its quality in addition to energy demands. Intake of ruminants foraging on low quality forages (below 50% digestibility) appears to be limited by bulk fill.

Neutral detergent fiber levels of forage above 60%, causes a decrease in its digestibility and subsequently slows down the rate of passage and eventually reduces forage intake. On the contrary lower NDF content is correlated to higher forage digestibility and rate of passage allowing greater intake (Van Soest et al., 1991). In this study the NDF levels for the three fodder species, wilted napier grass, Tithonia and Sapium fodder were 80.1%, 33.57% and 39.52% respectively (Table 1).

The high NDF levels of wilted napier grass influenced a decrease to the rate of passage which limited its preference. Feeds that are least preferred in times of abundance and variety, such as Tithonia forage, could be relished during periods of scarcity and severe feeds shortages, based on animal survival instinct (Ngwa et al., 2003). The intake of all the three diets fluctuated during the five days of the sample collection probably because the sheep aimed at balancing their protein requirements which were different each day.

The Acid detergent fiber levels for the three diets, wilted grass, Tithonia and Sapium hay were 43.58%, 27.98% and 22.4% respectively (Table 1). ADF reflects the fibrous portions of the feed resistant to acid hydrolysis. It represents the cell wall materials that also account for the lignin and silica and imply a limitation to nutrient availability to the animal. The difference between the NDF and ADF of a feed may show the proportion of the cell wall material that is degradable by the ruminants. The digestibility of forage is negatively related to both increases in ADF and lignification’s levels. Forages at advanced maturity are characterized by high content of acid detergent fibers and lignin and low total nitrogen content. High proportions of the previous fractions are bound within the indigestible vascular bundles resulting to low digestibility, low nutrient intake and consequently low animal performance (Van Soest et al., 1991).

The ADL levels for the diets 1, 2 and 3 were 6.12%, 11.3% and 8.87%, respectively. Though the DM intake of roughages is inversely proportional to the filling capacity and NDF concentration, this does not seem to be the case when ruminants are offered more than two feeds that vary in chemical composition as was the case in this study (Ngwa et al., 2003).

Ruminant’s dry matter intake level depends on parameters which are related to the animal or to the diet. Independent of the quality of the forages, ruminants prefers vegetable fractions with a high leaf to stem ratio, with a low fiber and high nitrogen content. It has been observed that they are sensitive to substances such as tannins. The most important factor influencing performance of ruminant animals consuming forages diets is dry matter intake (Wilson et al., 1991). The average daily intake for wilted napier grass fodder, Tithonia and Sapium hay in kg/DM was 0.26, 0.11 and 0.18 respectively. Each sheep was taking an average of 0.56kgs DM per day which was about 2.4% of their body weight (Wilson et al., 1991). The sheep took two times more napier than Sapium and three times more than Tithonia. The difference of napier taken was not significant (Table 2a and 2b). All the three forages were accepted by the sheep although at different acceptance levels.

The effect of past experience did not contribute much to the preference since the sheep had been allowed to adapt to the other two fodder species for five days. The daily intake increased from the first day of recording upto the third day. Thereafter the daily feed intake decreased possibly due to the satiety process of ruminants (Smith et al., 2001). The preference for the three fodder species by the sheep in a decreasing order was wilted napier grass, Sapium and Tithonia (Kario et al., 2006). The fact that Tithonia was the least preferred in this study agrees with the findings of KARI, Embu research results of 1996 but contrast with Premaratne, et al (1998) when comparing the use of T. diversifolia and L. leucocephala and G. sepium on ewes. Premaratne found out that Tithonia was the best preferred.

The physical form in which a fodder is offered to the ruminants is important. Ruminants will generally discriminate dry and brittle fodder materials when they are given a chance to do so. Napier grass in the experiment was offered as a succulent green chop compared to the other two fodders which were offered as hay. The experimental animals probably found it easier to consume the former as compared to the later two. Ruminants will discriminate dustiness in the feed. Tithonia and Sapium forages had some levels of dustiness which probably denied the sheep quick acceptance as compared to napier grass which was relatively soft (Ngwa et al., 2003).
Ruminant’s animals select some pasture plants and leave others. Some forage has been described as being more palatable than others. However, if variety and availability of forages is limited even the relatively unpalatable forages may be eaten (Saskatchewan University Agriculture specialists, 2008). The sheep apparently selected more napier grass than Tithonia and Sapium since the former one was more succulent than the later two fodder species. The apparent ability of the ruminants to select the more digestible components of a diet is well known. The NDF and ADF levels of the three diets highly influenced the preference with wilted napier grass being affected most although its succence status caused a bias in the choice.

CONCLUSION

Napier grass, Sapium and Tithonia forages were preferred by the sheep in that order with an average daily intake in kg/DM of 0.26, 0.11 and 0.18 respectively. However the sheep consumed constant proportions of both Sapium and Tithonia probably to balance their protein requirements. This indicated that the two indigenous fodder species could be suitable supplements for napier grass particularly during the dry season.

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Saskatchewan Agriculture specialists. 2008. Feeding Livestock During Feed Shortages University of Saskatchewan feed and animal scientists.


DIGESTIBILITY OF DIETS BASED ON NAPIER GRASS, Tithonia diversifolia AND Sapium ellipticum,

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ABSTRACT

*Tithonia diversifolia* and *Sapium ellipticum* fodder species are widespread in Central, Western Province and the wetter areas of the coastal and Rift Valley regions. They could be used to supplement Napier grass fodder. However, there is little documentation on digestibility of diets that include varying proportions of either *Tithonia* or *Sapium*. This study compared the digestibility of diets consisting of varying proportions of *Tithonia* and *Sapium* forages with Napier grass fodder. Fourteen Corriedale rams aged 18 months selected for uniformity of live weight at 20±3 kg were used in the experiment. The weight of the sheep was determined at the start and at the end of each feeding period. The sheep were fed seven different experimental diets comprising of varied proportions of Napier grass, *Tithonia diversifolia* and *Sapium ellipticum*. The dry matter content varied with diet one having the lowest percentages 136 g/kg, diet four highest dry matter 639 g/kg. Napier grass fodder (control diet) lowest CP of (43 g/kg), while 75% *Tithonia* mixture had CP of 189g/kg. *Tithonia* based diets had lower NDF-ADF proportion of 276 g/kg, 258 g/kg and 229.5 g/kg than those of *Sapium* based diets with 296 g/kg, 282 g/kg and 256 g/kg. Diets 1, 5 and 7 reflected a negative N balance. These were the Napier grass control diet and the 25% and 75% supplementation of *Sapium* diets. *Tithonia* based diets yielded positive nitrogen balance. Inclusion of both *Tithonia* and *Sapium* forages decreased feed intake, total faecal and urine output for all the diets, although proportionately to intake, the faecal and urine output increased.

**Keywords:** Ruminant animals, Nitrogen Balance, Neutral and Acid Detergent fiber.

INTRODUCTION

Ruminant animals are usually fed on napier grass as a basal diet. Napier grass is the most widely grown and popular fodder plant for the small-scale farmers in Kenya. Overdependence on napier grass for fodder needs is risky and alternative fodder species need to be sought. In Kenya both *Tithonia diversifolia* and *Sapium ellipticum* are widespread in Central, Western Province and the wetter areas of the Coastal and Rift Valley regions. *Tithonia diversifolia* is a robust shrub with fast growth to a height of three meters, while *Sapium ellipticum* is an evergreen indigenous tree growing to fifteen meters tall with drooping branches. There is very little documentation on digestibility of diets that include varying proportions of either *Tithonia* or *Sapium*. This study compared the digestibility of diets consisting of varying proportions of *Tithonia* and *Sapium* forages with napier grass fodder.

MATERIALS AND METHODS

Study Site

The study was carried out at the KALRO Embu Research Centre, Embu district, Eastern Province of Kenya. The center is in a sub-humid agro ecological zone and is located 1490 meters above sea level at 0°30’S and 37°27’E. The deep, well weathered with friable clay texture soils in the area are humid Nitosol derived from basic volcanic rocks and classified by USDA under humid patehumult. The rainfall is moderate, an average of 1200-1500 mm (Jaetzold and Schmidt, 1983). It follows a bimodal pattern with long rainy season from March to June amounting to an average of 750mm. The short rain comes from October to December and average 350 mm and month temperature averages 18-21°C.

Study design

Experimental animals and housing

Fourteen (14) Corriedale rams aged 14 months selected for uniformity of live weight at 20±3 kg were used in the experiment. The weight of the sheep was determined at the start and at the end of each feeding period. The 14 male Corriedale sheep were housed in individual wooden slatted pens. The metabolic units was wooden with raised and slatted floor subdivided into individual pens measuring approximately 1.5m by 1.5m by 2m mounted above a cemented floor.

Experimental Diets

Seven different experimental diets comprising of varied proportions of napier grass, *Tithonia diversifolia* (*Tithonia*) and *Sapium ellipticum* (*Muthatha*) were fed. Feeding was done over four, fifteen (15) day periods. The sheep were adapted to the diets in question during the first ten (10) days of each feeding period for the adaptation, and samples were collected in the last five (5) days. The seven diets were randomly allocated to two sheep at the beginning of each period resulting in a completely randomized design (CRD). Each diet was assessed with eight (8) animals during the feeding trail. During the five day collection period, daily feeds intakes and leftovers were measured and samples of feed on offer and refusals for each sheep were taken.

Laboratory Analysis

The feed and refusal samples taken were dried at 60°C for 48 hours and milled to pass a 1mm screen and stored in clean
grass containers for future analysis. Total daily faecal output was measured for each sheep, pooled, mixed thoroughly and a 10% sample taken and stored as separate samples in a freezer (-20°C) for each experimental period. The five days samples for each sheep were pooled at the end of the experiment and a composite sample taken for each experimental period. Sub-samples of the faeces were taken, oven dried at 60°C to constant weight and ground (1mm mesh) for later chemical analysis.

The 24 hours urine output from each sheep was measured, recorded, mixed and a 10% sample taken and stored as separate samples in a freezer for each experimental period. The DM for feed offered, refusals and faeces were obtained by oven drying at 105°C to constant weight. Ash of the feed offered was determined by igniting samples in the muffle furnace at 600°C for 5 hours (AOAC, 1990). The feed, faecal and urine nitrogen contents were determined by the standard micro Kjeldal method (AOAC, 1990). Neutral detergent fiber (NDF) and Acid detergent fiber (ADF) were determined by the procedures described by Goering and Van Soest (1970).

**Data management and analysis.**

Intake, faecal and urine outputs were recorded daily during the five day sampling period. The DM and the CP contents of the seven diets were established using proximate analysis. The DM of the dried samples was calculated after further drying the samples in the oven at 60°C and 105°C. NDF, ADF and ADL levels of the seven diets was established using the Van Soest analysis. Ash content was calculated by drying sample in the oven set at 105°C and burning the samples in the muffle furnace at 600°C.

Apparent digestibility was calculated using the equation formula below:

\[
\text{Apparent digestibility} \% = \frac{100 \times \text{Nutrient intake} - \text{Nutrient in faeces}}{\text{Nutrient intake}}
\]

**RESULTS**

**Chemical composition of the diets.**

The dry matter content of the seven diets varied; with diet one having the lowest percentages 136g/kg while diet four had the highest dry matter 639g/kg. The DM content depended largely on the proportion of napier grass fodder fed. The dry matter content of the substitute diets increased with the level of inclusion of other feedstuffs. *Tithonia diversifolia* forage produced diets that had greater dry matter content than *Sapium ellipticum*. Napier grass fodder (control diet) had the lowest CP percentages of (43g/kg) while 75% Tithonia mixture (diet 4) had the highest CP of 189g/kg. The CP levels for the diets increased with increase of either Tithonia or Sapium forages as the hay had higher levels of CP than napier grass. Leaves and twigs from trees and shrubs have crude protein content ranging from 12-30% which is usually higher than that of mature grasses 3-10% (Le Houerou, 1980). Crude protein value of 8% is considered absolute minimum needed to maintain ruminant function. The nutritive value of browse trees and shrubs varies with soil type, location, plant part (leaf and stem), age of leaf and season. The latter factors influence the forage chemical composition, palatability, intake, the extent and the rate of degradation, digestibility and the nutrient utilization by ruminants (Kaitho, 1997).

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**RESULTS AND DISCUSSION.**

**Chemical composition of the diets**

The dry matter content of the seven diets varied; with diet one having the lowest percentages 136g/kg while diet four had the highest dry matter 639g/kg(table 1). The DM content depended largely on the proportion of napier grass fodder fed. The dry matter content of the substitute diets increased with the level of inclusion of other feedstuffs. *Tithonia diversifolia* forage produced diets that had greater dry matter content than *Sapium ellipticum*. Napier grass fodder (control diet) had the lowest CP percentages of (43g/kg) while 75% Tithonia mixture (diet 4) had the highest CP of 189g/kg(table 9).

The CP levels for the diets increased with increase of either Tithonia or Sapium forages as the hay had higher levels of CP than napier grass. Leaves and twigs from trees and shrubs have crude protein content ranging from 12-30% which
is usually higher than that of mature grasses 3-10% (Le Houerou, 1980). Crude protein value of 8% is considered absolute minimum needed to maintain rumen function. The nutritive value of browse trees and shrubs varies with soil type, location, plant part (leaf and stem), age of leaf and season. The latter factors influence the forage chemical composition, palatability, intake, the extent and the rate of degradation, digestibility and the nutrient utilization by ruminants (Kaitho, 1997).

<table>
<thead>
<tr>
<th>Table 1: Nutrient composition for the seven diets containing 3 three levels of Tithonia and Sapium fodder g/kg DM (Dry matter basis).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet Mixture</td>
</tr>
<tr>
<td>All Napier grass fodder diet (D1)</td>
</tr>
<tr>
<td>25% Tithonia hay-75% napier grass fodder (D2)</td>
</tr>
<tr>
<td>50% Tithonia hay-50% napier grass fodder (D3)</td>
</tr>
<tr>
<td>75% Tithonia hay-25% napier grass fodder (D4)</td>
</tr>
<tr>
<td>25% Sapium hay-75% napier grass fodder (D5)</td>
</tr>
<tr>
<td>50% Sapium hay-50% napier grass fodder (D6)</td>
</tr>
<tr>
<td>75% Sapium hay-25% napier grass fodder (D7)</td>
</tr>
</tbody>
</table>

Fiber and ash proportions of the diets
NDF has been shown to be negatively correlated with dry matter intake in that as it increases, animals tend to reduce their dry matter intake. NDF levels increase with the advancing maturity of the forages (Van Soest et al., 1991). Grasses with content of NDF above 60% DM for grasses are classified as poor in quality (Van Soest et al., 1991). Tithonia-based diets had lower NDF-ADF proportion of 276g/kg, 282g/kg and 229.5g/kg than those of Sapium based diets with 296g/kg, 258g/kg and 256g/kg. The ADF levels decreased with increase in substitution of napier grass with either Tithonia or Sapium. The ADF component has been shown to be negatively correlated with the digestibility of forages (Van Soest et al., 1991). Tithonia-based diets had higher Ash content than the other four diets, originating from the high ash content in Tithonia and were possibly an indication of high concentrations of minerals desired by animals (Kwabiah et al., 2003).

Feed Intake
Diet 2 had the highest intake with 0.6kg DM while diet 7 had the least intake with 0.4kg DM per sheep per day. Intake decreased with substitution of napier grass fodder with either Tithonia and Sapium hays.

Faecal material output and urine output
The average faecal output per sheep per day decreased as the level of napier grass decreased in all the six diets (table 9). However proportionately, faecal output increased with substitution of napier grass with either Tithonia or Sapium to the effect that diets with lower intake had proportionately higher faecal output. The differences in N intake observed between animal species and level offered are largely due to fodder species differences in N content, since animals consumed most of the leaves on offer.

<table>
<thead>
<tr>
<th>Table 2: Average Dry matter feeds intake (kgs), faecal output (kgs) and urine (Litres) for sheep offered.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed Intake/sheep/day</td>
</tr>
<tr>
<td>All Napier grass fodder diet (D1)</td>
</tr>
<tr>
<td>25% Tithonia hay-75% napier grass fodder (D2)</td>
</tr>
<tr>
<td>50% Tithonia hay-50% napier grass fodder (D3)</td>
</tr>
<tr>
<td>75% Tithonia hay-25% napier grass fodder (D4)</td>
</tr>
<tr>
<td>25% Sapium hay-75% napier grass fodder (D5)</td>
</tr>
<tr>
<td>50% Sapium hay-50% napier grass fodder (D6)</td>
</tr>
<tr>
<td>75% Sapium hay-25% napier grass fodder (D7)</td>
</tr>
<tr>
<td>SED</td>
</tr>
</tbody>
</table>

Means with different superscript in the same column differ significantly (P<0.05)
DISCUSSION

Average digestibility coefficients for the seven diets are presented in (table 3a) and the summary ANOVA of their comparison in (table 3b). The digestibility of the dry matter for all diets decreased with an increase in the level of inclusions of the substitution diets. Diet two had the highest digestibility coefficient for dry matter (72.3%) amongst the seven diets while diet seven had the lowest (56.5%). The digestibility coefficient of the CP was lowest in diet 1 (52.6 %) while the digestibility coefficient for CP was highest in diet 2 (81.6%). A number of factors are known to influence digestibility. Among them are such feed factors as chemical composition, feed preparation and level of feeding. Among the animal factors are animal age, metabolic needs and water. The arrangements in this study strategized to minimize selection. Diets 1, 5 and 7 reflected a negative N balance (table 4). These were the napier grass control diet and the 25% and 75% supplementation of Sapium diets. Tithonia based diets yielded positive nitrogen balance. Loss of N through urine was low for all the treatment diets. Muia, (2000) suggested that protein supplementation improves growth and nitrogen balance in animals. Therefore the positive balance experienced in the diets of Tithonia was occasioned by the high protein content (20.7%) of *Tithonia diversifolia* foliage.

Sapium constituted diets only diet six yielded a positive nitrogen balance confirming the fact that the CP level was the major factor in determining the nitrogen balance. The negative nitrogen balance experienced in the diet one could have been caused by the low CP of 4.29% that was below the limiting level of 6-8% and consequently a low apparent digestibility coefficient of 52.6%. The negative nitrogen balance experienced in Sapium diets five and seven could be as result of low CP levels (6.29% and 9.98%) respectively. These two diets had CP levels considerably lower than those of Tithonia. The drying effect of Sapium forage could have affected the Sapium diets probably more negatively than the Tithonia forages since Sapium is reported to have higher tannin levels than Tithonia forages (Sekatuba et al., 2004). However, Tithonia masked the effect of drying because it is very low in tannins. The implication of negative nitrogen balance is that the experimental sheep would break down tissue protein to meet demand of amino acids required for normal metabolism.

Table 3a: Mean apparent digestibility coefficients (%) and nitrogen balance (g/day) for the different components analyzed for the seven diets

<table>
<thead>
<tr>
<th>Dig. Coefficients</th>
<th>Diets 1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM</td>
<td>69.8</td>
<td>72.3</td>
<td>67.5</td>
<td>60.8</td>
<td>69.0</td>
<td>66.3</td>
<td>56.5</td>
<td>2.1</td>
</tr>
<tr>
<td>CP</td>
<td>52.6</td>
<td>81.6</td>
<td>77.4</td>
<td>74.9</td>
<td>80.9</td>
<td>78.0</td>
<td>55.2</td>
<td>3.6</td>
</tr>
<tr>
<td>NDF</td>
<td>69.8</td>
<td>70.2</td>
<td>65.0</td>
<td>58.3</td>
<td>67.7</td>
<td>62.8</td>
<td>49.1</td>
<td>2.5</td>
</tr>
<tr>
<td>ADF</td>
<td>67.9</td>
<td>68.6</td>
<td>58.9</td>
<td>52.0</td>
<td>66.9</td>
<td>62.4</td>
<td>38.2</td>
<td>2.6</td>
</tr>
<tr>
<td>ASH</td>
<td>60.5</td>
<td>69.8</td>
<td>64.2</td>
<td>50.4</td>
<td>54.5</td>
<td>58.6</td>
<td>28.9</td>
<td>3.5</td>
</tr>
<tr>
<td>N balance</td>
<td>-4.64</td>
<td>4.26</td>
<td>4.77</td>
<td>8.61</td>
<td>-3.82</td>
<td>6.48</td>
<td>-3.24</td>
<td>1.45</td>
</tr>
</tbody>
</table>

Table 3b: Analysis of variance for Mean apparent digestibility coefficients for the different components analyzed for the seven diets

<table>
<thead>
<tr>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM</td>
<td>243.7</td>
<td>6.78</td>
<td>0.000</td>
</tr>
<tr>
<td>CP</td>
<td>1157.8</td>
<td>10.05</td>
<td>0.000</td>
</tr>
<tr>
<td>NDF</td>
<td>454.8</td>
<td>8.65</td>
<td>0.000</td>
</tr>
<tr>
<td>ADF</td>
<td>966.0</td>
<td>15.92</td>
<td>0.000</td>
</tr>
<tr>
<td>ASH</td>
<td>1397.7</td>
<td>11.37</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Table 4: Nitrogen Balance (g/day) for sheep fed seven diets in four periods of a feeding trial

<table>
<thead>
<tr>
<th>Chemical component</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dietary crude protein</td>
<td>4.29</td>
<td>12.41</td>
<td>14.34</td>
<td>18.92</td>
<td>6.29</td>
<td>9.98</td>
<td>14.32</td>
<td>0.000</td>
</tr>
<tr>
<td>Dietary Nitrogen</td>
<td>0.69</td>
<td>1.99</td>
<td>2.29</td>
<td>3.03</td>
<td>1.01</td>
<td>1.6</td>
<td>2.29</td>
<td>0.000</td>
</tr>
<tr>
<td>Total nitrogen in faeces and urine</td>
<td>11.50</td>
<td>15.60</td>
<td>18.17</td>
<td>21.67</td>
<td>13.88</td>
<td>16.4</td>
<td>19.21</td>
<td>1.47</td>
</tr>
<tr>
<td>Nitrogen balance</td>
<td>-4.64</td>
<td>4.26</td>
<td>4.77</td>
<td>8.61</td>
<td>-3.82</td>
<td>6.48</td>
<td>-3.24</td>
<td>1.47</td>
</tr>
</tbody>
</table>

Nitrogen balance Means with different superscript differ significantly (P<0.05)

CONCLUSION

Tithonia forage has a CP and ADF value of 20.7% and 27.98%, while Sapium and napier grass have 11.8% and 4.29%,
and 22.35% and 43.58% respectively. Inclusion of both Tithonia and Sapium forages caused a decrease in feed intake, total faecal production and total urine output for all the diets although proportionately to intake, the faecal and urine output increased. DM, CP, NDF and ADF digestibility decreased for all the diets with increased supplement fodder. Tithonia constituted diets indicated positive nitrogen balance while all supplementation with Sapium caused sheep to have a negative nitrogen balance. Finally, replacing 25% of napier grass fodder in sheep diets with Tithonia and 50% with Sapium will constitute the best ratio in taking advantage of their availability for protein supplementation.

REFERENCES

EXPLOITATION OF INDIGENOUS CHICKEN FROM THARAKA-NITHI COUNTY FOR GLOBAL MARKETS

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ABSTRACT
Indigenous chicken are found in virtually every rural household in the world as important source of livelihood. They are staple food for many communities, ceremonial species and key economic activity. However, production has remained at the household level and nearest market centres, leaving many consumers craving for this delicacy. Tharaka-Nithi County’s Agriculture Sector Development Support Program is developing a poultry value chain, identified by stakeholders using the value chain prioritization tool matrix. This study investigated the socio-economic hurdles that the enterprise has to overcome to penetrate global markets. The challenges were poor attitude to the enterprise, labelled as local in contrast to exotic, belittling the enterprise as being only “meaningful” to the resource-poor and enterprise ownership by women. The economic “hurdles to jump” include low production levels due to poor management of the flocks, low investment into the enterprise, lack of a well-developed value chain, exploitation by the middlemen and global market standards. Addressing the challenges may require establishment of resource ownership rights, strengthening market structures, management and providing production incentives so as to avail them to the global dining table.
Keywords: Culture, Value Chain, Food security, livelihood
INTRODUCTION

Indigenous chicken production represents an important source of livelihood for the growing human population of Tharaka Nithi County. They are also a source of high quality protein and provide additional income to resource-poor small farmers, especially women (Guèye, 2009). According to FAO (2002), the increasing human population pressure, the need for high quality versatile foods especially protein, increasing levels of income and standards of living have created a tremendous demand for poultry products. According to Perry et al (2002) and Moreki et al (2010) chickens are the most widely kept livestock species in the world and also the most abundant. Indigenous chickens play an important role in income generation and food production. They are widely distributed in rural and peri-urban areas (Thornton et al. Moreki et al., 2010). They make up to 70 % of all chicken kept in Africa (FAO, 1986). About 90% of the small-scale farmers in Kenya rear indigenous poultry, majority of which are indigenous chicken (Gichohi and Maina, 1992). In 2013 indigenous chicken comprised of over 90% of all the poultry kept in Tharaka Nithi County. Eggs and meat from indigenous chicken contribute to the protein nutrition of various household in the country. Sale of poultry products increase and diversify revenue in the livestock sector. For instance in 2013 indigenous chicken produced over 8.5 million eggs and almost 200 metric tonnes of meat in the County (Livestock Annual reports 2013). Poultry sub-sector creates employment and promotes overall economic development. Indigenous chicken have been used in cultural activities such as traditional medicine and for various rites (King’ori, 2004).

Compared to other livestock species, chicken production has quick returns to investment even with limited management practices. Chicken has many market outlets for their products. Sale of products especially eggs in low value units make chicken products affordable to the lower income brackets (Say, 1987; FAO, 1997). Tharaka Nithi County has an estimated poultry population of 0.7 million. Of these, about 90 % are free-ranging indigenous chickens (Livestock Department 2013). Poultry keeping is especially attractive to poor households as they require low start-up capital and have low maintenance costs. Besides, increasing landlessness occasioned by the high population growth means that poultry production has become the investment of choice due to its low space requirements. The productivity of indigenous poultry is normally low due to genotype, poor feed conversion efficiency and low adoption of modern technologies. In an endeavour to improve indigenous chicken production in Tharaka Nithi County, the Agriculture Sector Development Support Program, a SIDA funded program under the Ministry of Agriculture, Livestock and Fisheries is trying to assist in the development of the indigenous chicken value chain. The poultry value chain was identified by stakeholders using the value chain prioritization tool matrix. This study was motivated by the need to contribute to knowledge about value chain development for indigenous Chicken in Tharaka-Nithi County. The main objective was to map and analyze the challenges facing indigenous chicken value chain actors in Tharaka-Nithi. The factored considered were production, marketing and social.

Conceptual framework

This study employs a Value Chain Analysis (VCA) framework to understand the challenges facing indigenous chicken industry in Tharaka Nithi County. The value chain describes all the activities which are required to bring a product or service from the beginning, through the different stages of production delivery to final consumers and final disposal after use. The VCA seeks to understand the various factors that drive the incentives, growth, and competitiveness within a particular industry and identify opportunities and constraints to increasing benefits for stakeholders operating throughout the industry. This feature of VCA lends to its completeness as a strategic tool in exploring different alternative strategies for poverty reduction. The purpose of analysing the value chain for indigenous chickens is to identify key points of intervention along the chain and to recommend specific policy directions to enhance the competitiveness of the indigenous chicken sub-sector.

METHODOLOGY

The data for this study were collected from both primary and secondary sources. Secondary data included published and unpublished literature in the public domain. Data collection was guided by checklists based on the terms of reference above. The report relies heavily on proceedings of various stakeholder meetings held under the ASDSP from the Livestock Department, particularly the 2013 annual report in an endeavour to support the indigenous chicken value chain in the county. It is relies on Annual reports.

In addition, informal interviews with key stakeholders in the poultry sector were conducted from various stakeholders identified during the value chain mapping by ASDSP. The data collected was collated with the information available from secondary data sources. Respondents included key participants in the poultry value chain such as indigenous Chicken keepers, middlemen involved in the business, retailers, hoteliers and even individual consumers. The
respondents were asked their views on challenges facing the indigenous poultry industry in the county. Data was analysed qualitatively with an emphasis on descriptive analysis.

RESULTS
Indigenous chicken are the most widely kept birds in the County. From Figure 1 below it evident that indigenous chicken population is far much above the population of exotic broilers and layers. Indigenous chicken are well spread over the County. However, most of them are found in Tharaka South Sub County.

![Figure 1: Population of various chicken types in Tharaka-Nithi County](image)

**Figure 1: Population of various chicken types in Tharaka-Nithi County**
*Extracted from County Summaries for Livestock Population 2013*

Indigenous poultry value chain in Tharaka-Nithi County
The value chain map for indigenous chicken in Tharaka-Nithi is simple and under developed with no infrastructure except small market segments set aside for chicken traders in the main trading centres such as Chuka, Kaanwa and Kathwana. The main actors along this value chain are smallholder farmers, primary collectors and live bird traders and retailers. There are a few wholesalers in larger markets like Kathwana. The main marketing channels are from farmer to trader or consumer (informal marketing). The other marketing channel is from farmer to retailer and then to consumer (primary marketing). Some farmers sell directly to restaurants while others sell to middlemen who take their chickens either to secondary markets and urban markets (wholesalers). The final end market of indigenous chickens is domestic consumption through hoteliers.

![Figure 2: Indigenous chicken population by Sub-county](image)

**Figure 2: Indigenous chicken population by Sub-county**
*Source: County Summaries for Livestock Population 2013*
Challenges affecting the indigenous chicken in Tharaka-Nithi are diverse. These challenges occur at every part in the value chain. They include:

**Production challenges**

1. **Types of indigenous chicken kept**
   Like in most developing countries indigenous chicken populations kept in Tharaka Nithi County are the result of uncontrolled cross breeding programmes between various lines of local and exotic breeds. However, there are distinct indigenous chicken types such as frizzled feathered, naked neck and barred feathered. These types vary in body size, conformation, plumage colour and performance. Therefore the indigenous chickens kept are a heterogeneous population with no standardized characteristics and performance and hence cannot be gauged on the same standards.

2. **Type of production system**
   In most parts of Tharaka Nithi County indigenous poultry are kept either under free range or in semi intensive production system. In the free range system, birds are let out during the day and are confined at night. They scavenge for insects, green leaves, food wastes, scattered grains, leafy vegetables. The birds are sometimes supplemented with grains during times of abundant food. Birds of all ages live and scavenge together. Drinking water may or not be provided. Housing is not developed and only seeks to protect the birds from extreme weather and predators. In semi-intensive system of production birds are let to scavenge during the day and they are housed during the night. They are supplemented with various feeds such as grain and they do get water and veterinary. The production systems outlined above pose two major challenges. There are heavy losses to predators and sometimes birds are not able to get adequate feed. This slows their growth rate as well as their productivity. Disease outbreaks also become a major challenge. To overcome this hurdle, housing of the indigenous chicken needs to be tremendously improved. Fencing of the walking area with chicken wire goes a long way in ensuring the birds safety.

3. **Feeds and feeding**
   Birds are normally let out to scavenge for food in the morning where they pick whatever is available including insects, food wastes, green grass, leafy vegetables and scattered grain. Availability for food for the scavenging birds is dependent on the cropping season with food being abundant during the harvest season and least just before the planting season. Feed availability is also dependent on the area available for the birds to scavenge. Where there are large tracts of land and lower bird population then there may be more abundant feed. In addition the birds may not always attain the required nutritional requirement. However deliberate effort to feed the birds is imperative if meaningful profits have to be realised. Feeds and feeding greatly affect the level of output of the chicken including both eggs and meat.
iii. Diseases, pests and predators

Diseases are major constraint to not only the indigenous poultry production but also the exotic poultry. Expenditure on disease control is minimal and chick mortalities are high over the first 8 weeks. Newcastle Disease (NCD) is the most prevalent and fatal in the County. The control of NCD is possible through vaccination and vaccines are available from local chemists. Very few farmers vaccinate their poultry since many of them are not aware that NCD can be controlled by vaccination. The vaccine requires being stored under refrigeration and is packaged in doses for 100 chickens. This packing poses a limitation to the use of vaccines for NCD. Other common diseases include fowl pox, fowl typhoid and coccidiosis. Fowl pox is prevented by vaccination. Fowl typhoid and coccidiosis are prevented by proper hygiene in the chicken house and routine administration of antibiotics. Pests also pose challenges but losses due to pests are relatively small compared to diseases such as NCD that can wipe away whole flocks. Predators are a threat to scavenging birds and especially chicks and pullets.

Marketing challenges

From the value chain actors analysis it is clear that the industry is not well developed as there are no or very few traders of the product from outside the county. In addition, there are no market structures such as wholesaling or assembling for collective marketing. There are no markets sheds for poultry marketing and the County lacks poultry slaughter slabs and cold storage. There is no evidence of an established relationship among value chain actors and the industry lacks sound institutional support systems not only in marketing but also efficient extension services which is easily accessible by rural chicken producers. There is also lack of reliable market information to rural poultry producers and difficult urban markets access due to poor infrastructure. The apparent lack of a centralised market information system easily accessible by rural poultry producers means that their pricing decisions may not necessarily be reflective of the market situation and could negatively affect their incomes from the indigenous chicken business. Difficult markets access characterised by high transportation costs due to poor infrastructure increases production costs and weakens returns from the indigenous chicken business. On the other hand, the middlemen add some price mark-up for commercial gain, hence the end market price for indigenous chickens in the tertiary market becomes significantly high.

Social Challenges

Despite its enormous potential in rural livelihood development, chicken keeping is still largely considered a women enterprise. According to the ASDSP baseline survey conducted in 2013, it is the only livestock enterprise where women are the main decision makers. It also emerged that women enterprises get the lowest allocation of the family resources for investment. In addition, the Tharaka Nithi County Integrated Development plan of 2013-2017 does not mention indigenous chicken and this is a challenge as the enterprise is not on the County development agenda to propel the enterprise, there needs a mind shift towards the enterprise to facilitate it achieve the full potential.

**CONCLUSION**

The system of production and productivity of indigenous chickens in Tharaka-Nithi County is similar to other regions in Kenya and indeed to other African countries. Indigenous chickens contribute significantly to the county egg and meat production. They are very important in the improvement of the protein nutrition of the rural population and a common feature in the diets of many urban dwellers. The low productivity of indigenous chickens is mainly due to poor nutrition, housing and lack of proper health care. In addition there is little investment towards the enterprise and poor altitude towards the same. Growing indigenous chickens in the free-range system require daily supplementation.
with balanced chicken feed. Vaccination against NCD reduced mortality, increased eggs per hen per year and increased cash flow income from sale of chicken and eggs. Indigenous chicken production is a way of increasing rural incomes and also economic empowerment of the rural women and youth. The indigenous chicken enterprise holds promise for integrating women into markets due to the existence of a number of opportunities such as the growing demand and preference for indigenous chicken due to changing dietary habits that are driven by the need to have healthy diets. Of supreme importance is the need to invest in innovative interventions to address the systems challenges which have held back the indigenous chicken industry from realising its potential.

References
Ministry of Agriculture, Livestock and Fisheries. 2013. Livestock Production Department Annual Report

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EMERGING SOLUTIONS TO NEMATODE & PLANT NUTRITION CHALLENGES IN GREENHOUSE TOMATO PRODUCTION

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ABSTRACT
Tomato (Lycopersicon esculentum Mill.) is a high-value vegetable. However, nematode infestation and nutrient depletion are major constraints in greenhouse tomato production, causing 35% to 40% losses. Chemical control options in Kenya compromises environmental safety. This study investigated the impact of soil amendments with fresh biomass from Lippia kituensis Vatke (LK) and Ocimum gratissimum L. (OG) on Meloidogyne sp., tomato growth, yield and quality. Unbalanced pot experiment in factorial format, embedded in RCBD, with 4 levels of plant biomass replicated 3 times was used. Biomass rates were 0, 2%, 4% and 8% in 10 kg potted soil mixes, singly and in all possible combinations. Neem extract (Azadirachtin 0.3 w/w) was used as positive control. Nematode population reduced by 82.2% at 8% of both Lippia and Ocimum combined, compared to 91.4% of Azadirachtin. Gall numbers reduced by
98.3% in roots compared to 98.7% recorded in Azadirachtin. Total root volume of 308.7 cm³ was recorded in 8% LK + 8% OG compared to 69.33 cm³ and 89 cm³ for non-amended and Azadirachtin treatments, respectively. Means on leaf numbers were 29.90 compared to 22.67 and 28.13 of non-amended and Azadirachtin, respectively. Shoot and root dry weights of 53.17 g and 100.85 g were recorded compared to 24.17 g and 46.12 g and 51.75 g and 86.23 g for non-amendment and Azadirachtin, respectively. The yields were 2.71 kg per plant at 8% LK + 4% OG compared to 0.53 kg of non-amended treatment. Thus, L. kituensis and O. gratissimum L. are potential nematicides and can be used in tomato nutrition for sustainable production in the greenhouse.

**Key words:** Plant biomass, *Lippia kituensis, Ocimum gratissimum, Meloidogyne sp.*

**INTRODUCTION**

Tomato is the leading greenhouse vegetable crop grown in both soil and soilless media. Soil based media often require appropriate amendments with compost and other additives to be effective. Under soil based greenhouse tomato production, nematode infestations become a serious constraint leading to yield reductions of 35-40%. Root-knot nematodes (*Meloidogyne spp.* ) are the most damaging nematodes in tomatoes grown in the tropics (Walker, 2007). Control of nematodes in the greenhouse is largely done with chemicals - nematicides, which are costly and tend to persist in the soil after harvest, causing contamination of ground water. Consequently, several nematicidal compounds have been withdrawn from the market. There is growing interest in use of a wide variety of plant based amendments and cover crops for the management nematodes (Walker, 2007). Olabiyi et al. (2007) reported significant reduction in the soil population of *Meloidogyne spp.*, *Helicotylenchus* sp. and *Xiphinema* sp in field grown with cowpea after application of high levels of organic plant based manures. Use of composted dry cork, dry grape marc and a mixture of dry olive marc has been reported to significantly reduce root galling and populations of *Meloidogyne incognita* and *M. javanica* in plots planted with tomato compared to controls (Andres et al, 2004). Similarly, Garcia et al. (2006) reported effective control of root knot nematodes using pepper crop residues within 20 days of application.

It has also been suggested that reduction of nematodes and associated damages in fields treated with plant biomass wastes results from improved soil structure and fertility, alteration of plant resistance from release of nematode toxins, or increased population of fungal and bacterial parasites or other nematode antagonistic agents (McSorley, 2011). Apart from nematode control, these biomass based also provide essential nutrients (such as N and P), help rebuild soil organic matter contents, and aid in the re-establishment of beneficial microbial populations (Suresh et al., 2004; EPA, 2007; Dauda et al., 2008). Although these organic materials provide plant nutrients in small quantities compared to inorganic fertilizers, they also complement plants by releasing other growth factors such as hormones thereby improving overall plant productivity (Sanwal et al., 2007). Additionally, higher organic matter content increases soil water holding capacity and supports thriving communities of decomposers and predators in the soil system.

The nematicidal properties of plants may be a contributed from extracted biomolecules resident in the plant bodies. The major classes of compounds with proven nematicidal activity include alkaloids, fatty acids, glucosinolates, isothiocyanates, phenols, diterpenes and a variety of essential oils (Chitwood, 2002). Neem cake, known to be rich in azaderachtin is also associated with strong nematicidal activity (Riga and Lazarovits, 2001; Abbasi et al., 2004). Laboratory extracted essential oils have also been reported to affect development of nematode eggs and second juvenile stage under *in vitro* conditions (Onifade, 2007). Other extracts with strong pesticidal properties include rotenone, nicotine and pyrethrins (Berger, 1994).

Control of nematode infestations in soil based greenhouse tomato production using fresh plant derived biomass from species known to be rich in essential oils has not been reported. In this study we report results of a greenhouse pot experiment to evaluate management of root knot nematodes using fresh plant derived biomass soil amendments with *Lippia kituensis* Vatke. (Verbenaceae) and *Ocimum gratissimum* L. (Lamiaceae).

**MATERIALS AND METHODS**

*Site Description*

The study was conducted for two growing seasons at the Horticulture Research and Teaching Field, Egerton University, Kenya in 2012. The field is located on latitude 0 23°S, longitude 35 35°E in the lower highland III (LH3) agro ecological zone at an altitude of 2238 m a.s.l. (Jaetzold and Schmidt, 1983). The site receives a mean rainfall of 1012 mm with a mean day temperature of 22°C and night ranges of 5 - 10°C. The pot experiment was conducted in a polytunnel greenhouse measuring 8 m wide × 60 m length and 3 m height, covered with UV stabilized polythene sheet gauge 200μm.
**Biofumigant plant materials preparation**

Leafy twigs of *L. kituensis* Vatke. and *O. gratissimum* L were collected in the wild around Egerton University from flowering plants. The materials were chopped into aggregates approx. 0.5 cm to enable proper mixing with soil and to increase the surface area for decomposition activity. The chopped aggregates were incorporated into 10kg of potted solarized forest soil at four levels (0% (control), 2%, 4% and 8% w/w), singly and in all possible combinations. A positive control treatment of a commercial organic nematicide from a neem extract (Azadirachtin) was also included.

**Crop establishment and maintenance**

Tomato seedlings were raised in a protected nursery bed for four weeks and transplanted into plastic sleeves (8 cm x 14 cm x 14 cm), Gauge 300, filled with the various plant biomass and solarized soil mixtures. The pot soil/biomass mixtures were single rate treatments (0% (control), 2%, 4% and 8% w/w) of the two plant species and all possible combinations of the rates. To each pot 10 grams of diammonium phosphate (DAP- 18:46:0) was added as basal fertilizer, an equivalent of 200 kg/ha DAP. On attaining a height of 30 cm, plants were trained on to a binding wire trellis placed 150 cm above the pots. Top dressing with calcium ammonium nitrate (CAN, 26% N) at the rate of 10 g per pot was applied 21 days after transplanting (DAT). Plants were pruned to maintain two stems per plant and watering was done continuously during the growing period with rates being adjusted according to plant growth phases. In the first 30 DAT, 2 litres of water was applied per plant per day and thereafter, the rate was increased to 3 litres per day as the plants developed. Weeding and pest and disease control were performed as required.

**Nematode augmentation, extraction and inoculum preparation**

Nematodes were collected from a field previously grown with infested tomatoes and augmented on two weeks old potted tomato seedlings established in a greenhouse following the method of Siddiqui and Akhtar, (2007). Specifically, Galls were extracted from the roots of infested tomatoes, chopped and mixed with the native soil. The mixture was added to pots planted with 2 week old tomato seedlings and the inoculum allowed to infest and multiply for 8 weeks.

After augmentation, nematode egg masses were extracted from the heavily galled tomato roots by chopping the roots to lengths of 0.5 cm and macerating the tissues to release egg masses. These were placed in 15 cm diameter sieves of 1 mm pore size, lined with cross–layered tissue papers and incubated at 27°C to hatching in glass petri-dishes containing distilled water. After hatching, the second instar juveniles (J2) were transferred into 2 litre conical flasks. Quantification of juveniles was done under a stereoscope with gridded petri dishes. Ten ml replicate samples were drawn from the well mixed suspensions to establish the average number of juveniles per ml. The determined quantity was 20 juveniles per ml. Finally, the nematode inoculum suspension samples were adjusted to contain approx. 1000 juveniles in 50 ml of distilled water.

**Nematode inoculation and determination of infestation parameters**

The 50 ml J2s inoculum suspensions were added to pots containing the various plant biomass amended media planted with 28 day old tomato transplants. The inoculum was allowed to develop under normal tomato culture conditions in a polytunnel greenhouse. Destructive sampling of tomato plants to determine nematode infestation was conducted 100 DAT. Four plants from each replicate were sampled at the peak of flowering.

**Nematodes population:** To determine the nematode population in the biomass amended pot soil treatments, second stage juveniles (J2) were extracted from 100 cm³ composite sample of soil from each replicate, using the method described by Kimenju et al., (2010). Specifically, at 100 DAT, the soils from each of the four pots were sampled by taking 100 cm³ of sample. The samples were placed in 9 cm diameter sieves with pore diameters of 1 mm lined with double layered tissue paper. The sieves were half immersed in metallic troughs containing 250 ml of distilled water to allow nematode migration into the water underneath for 24 hours. Nematode counts were determined in 10 replicate samples of 1 ml for each soil sample as previously described.

**Gall numbers and galling index:** For gall assessments, plants were gently uprooted and their roots thoroughly washed under tap water to remove all the adhering soil. Galling was determined by counts of galls size 1 mm diameter and above. The galling index was scored on a scale of 1-10, where 0= no gall, 1= 1-50 galls, 2= 51-100 galls, 3= 101-150 galls, 4= 151-200 galls, 5= 201-250 galls, 6= 251-300 galls, 7= 301-350 galls, 8= 351-400, 9= 401–450 and 10= 451 and above (Kimenju et al., 2010). The scores were converted into numerical entries and their means worked out for analysis of variance.
Experimental design and data analysis
The experimental design was an unbalanced factorial in a Randomized Complete Block Design (RCBD) with a total of 17 treatments. Each replicate treatment consisted of 6 pots which represented a plot. Treatments were replicated three times including the positive control treated with 0.3% w/w Azadirachtin. The pots were arranged in rows spaced at 60cm X 40cm. Data was analysed by analysis of variance (ANOVA) and means separated by the Tukey’s LSD using The SAS statistical program version 12e.

RESULTS
Effect of soil organic amendment on nematode population
Different levels of amendments with *Lippia kituensis* Vatke and *Ocimum gratissimum* L. biomass significantly influenced nematode populations in the amended soils (Table 1). At 100 DAT in season 1 and 2, the various rates of the two plant organic amendments indicated suppression of juvenile populations in the soil compared with the control. In season 1, single treatments of *Lippia* and *Ocimum* at 200g, 400g and 800g reduced nematode population in the soil by 14%, 61.3%, and 67% and 4.7%, 14% and 47.7%, respectively, compared with the control (Table 1).

A combination of *Lippia* and *Ocimum* at rates of 800 each produced the best nematode population reduction of 82.2%. This effect was not significantly different from treatment with Azadirachtin recorded a 91.4% population reduction. Similarly, no statistically significant differences in nematode population reduction were observed when *Lippia* and *Ocimum* were applied in combinations of 800LK + 400OG (81.5%) and 400LK + 800OG (79.8%), respectively. Similar observations were made in season 2. Figure 1 shows a general trend of nematode reduction with the increasing rates of organic amendments, used singly or in combinations.

<table>
<thead>
<tr>
<th>Season 1</th>
<th>Lippia levels (g)</th>
<th>Ocimum levels (g)</th>
<th>Ocimum means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>53.42a**</td>
<td>39.25c</td>
<td>19.42fg</td>
</tr>
<tr>
<td>200</td>
<td>46.33b</td>
<td>39.50c</td>
<td>17.08gh</td>
</tr>
<tr>
<td>400</td>
<td>35.83d</td>
<td>34.67d</td>
<td>16.50h</td>
</tr>
<tr>
<td>800</td>
<td>29.50</td>
<td>28.425e</td>
<td>10.58ij</td>
</tr>
<tr>
<td>Lippia means</td>
<td>41.25a</td>
<td>35.46b</td>
<td>15.90c</td>
</tr>
<tr>
<td>Ocimum means</td>
<td>41.27a</td>
<td>33.90b</td>
<td>15.67c</td>
</tr>
<tr>
<td>Azadirachtin</td>
<td>4.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Season 2</td>
<td>0</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>51.58a</td>
<td>38.50b</td>
<td>19.17f</td>
</tr>
<tr>
<td>200</td>
<td>48.43a.</td>
<td>36.92bc</td>
<td>17.92f</td>
</tr>
<tr>
<td>400</td>
<td>33.33cd</td>
<td>31.92cde</td>
<td>15.42fg</td>
</tr>
<tr>
<td>800</td>
<td>31.75de</td>
<td>28.25e</td>
<td>10.17b</td>
</tr>
<tr>
<td>Lippia means</td>
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<td>33.90b</td>
<td>15.67c</td>
</tr>
<tr>
<td>Azadirachtin</td>
<td>4.08</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Means followed by the same letter series within a column and a row per season are not significantly different according to Tukey’s LSD at P ≤ 0.05.

Effect of organic amendments on gall numbers and galling index
Gall numbers and galling index were destructively determined 100 days after transplanting (DAT). Gall numbers and galling index were significantly influenced by organic amendments in both seasons I and 2 (Table 2). There was a general decrease of gall numbers in the roots of tomato with increased levels of *Lippia* and *Ocimum*. In season 1, application of *Lippia* alone at rates of 4% and 8% reduced the galls in the roots by 89.8% and 93.8% respectively, in comparison to the non-amended soil. *Ocimum* applied at the same rates had a lower response in root galls, registering reductions of 35.5% and 41.1%, respectively. Similar result trends were observed in season 2, only that gall numbers were higher in season 2. Combination treatments of *Lippia* and *Ocimum* were most effective in terms of reducing gall numbers but no significant differences were evident among the various combinations. The combination treatments were also comparable with Azadirachtin treatment (Table 2). The root-knot galling of tomatoes generally varied according to the rates of *Lippia* and *Ocimum* applied. As with gall numbers, the galling index also showed a reducing trend with increasing levels of the two soil organic amendments (Figure 2).
Table 2. Effect of fresh organic amendments on gall numbers

<table>
<thead>
<tr>
<th>Amendments* (%)</th>
<th>Season 1</th>
<th>Season 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>200 OG</td>
</tr>
<tr>
<td></td>
<td>718.33a**</td>
<td>773.00a</td>
</tr>
<tr>
<td>200 OG</td>
<td>671.33a</td>
<td>585.00b</td>
</tr>
<tr>
<td>400 OG</td>
<td>463.00b</td>
<td>435.67b</td>
</tr>
<tr>
<td>800 OG</td>
<td>423.00b</td>
<td>334.00c</td>
</tr>
<tr>
<td>200 LK</td>
<td>54.33c</td>
<td>449.00b</td>
</tr>
<tr>
<td>400 LK</td>
<td>73.00c</td>
<td>280.00cd</td>
</tr>
<tr>
<td>800 LK</td>
<td>47.00c</td>
<td>143.00c</td>
</tr>
<tr>
<td>200LK + 200 OG</td>
<td>97.33c</td>
<td>470.67b</td>
</tr>
<tr>
<td>200LK + 400 OG</td>
<td>57.33c</td>
<td>271.33b</td>
</tr>
<tr>
<td>200LK + 800OG</td>
<td>20.33c</td>
<td>210.00d</td>
</tr>
<tr>
<td>400LK + 200 OG</td>
<td>52.33c</td>
<td>246.00d</td>
</tr>
<tr>
<td>400LK + 400 OG</td>
<td>14.67c</td>
<td>17.33d</td>
</tr>
<tr>
<td>400LK + 800 OG</td>
<td>15.33c</td>
<td>72.67cd</td>
</tr>
<tr>
<td>800LK + 200 OG</td>
<td>27.33c</td>
<td>45.00d</td>
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<tr>
<td>800LK + 400 OG</td>
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<td>99.00cd</td>
</tr>
<tr>
<td>800LK + 800 OG</td>
<td>12.00c</td>
<td>36.00d</td>
</tr>
<tr>
<td>Azad.</td>
<td>9.00c</td>
<td>8.67d</td>
</tr>
</tbody>
</table>

**Means with the same letter within a column are not significantly different according to Tukey’s LSD at P ≥0.05.

In season 2, the highest weight of marketable fruits from single treatments was harvested from treatment of Ocimum at 8%OG with 2.16 Kg per plant while non-amended treatment yielded the lowest weight (0.53 kg) per plant. The result was similar in season 2. The single Lippia treatment at 8% LK produced 1.65 kg of tomatoes per plant, which was
significantly ($P \leq 0.05$) lower than those from Ocimum at the same rate of amendment. In the combination of the two amendments, 8% LK+ 4% OG produced the highest weight of tomatoes per plant (2.72 kg), while from Azadirachtin treatment 2.23 kg per plant was harvested.

Non-marketable fruit yield trends were opposite to those of marketable fruit weight. In both seasons, the highest number of non-marketable fruits was obtained from Azadirachtin and non-amended treatments. However there were no significant difference between the single rates and non-amended treatments on weight of non-marketable tomatoes in seasons 1 and 2. The combination with the lowest non-marketable weight was 4%LKi + 8%OGi (0.14 kg) per plant and this was not significantly different from other various combinations of treatments (Table 3). Generally, for any given treatment there was very little significant variation on non-marketable weights in both seasons (Plate 2). On marketable quality, significant relationship was also observed between nematode population and marketable yield ($P= 0.0001$). Analysis revealed that increase in nematode population resulted to a decrease in marketable tomato fruit weight as explained by the equation \{Marketable yield (kg/plant) = 2.4019876 - 0.0320059*Nematode population (no./plant)\} (Figure 4A). The relationship between nematode population and fruit was also significant ($P= 0.0001$). Firmness of tomato fruit decreased with increase in nematode population as explained by the equation; Fruit firmness (KgF) = 4.4193861 - 0.0405667*Nematode population (no. / plant) (Figure 4B).

![Figure 1. Trends of nematode populations against fresh plant biomass treatments.](image1)

![Figure 2. Gall index trends against soil amendment treatments](image2)
DISCUSSION

Use of various indigenous plants and botanical extracts as sources of organic soil amendments has become an important option in pest management option. Apart from direct toxicity, plant derived soil amendment acts in various ways against plant parasitic nematodes. For instance, increased microbial activity in the soil amended with certain plant materials may enhance enzymatic activities, accumulation and decomposition of organic matter and also microbial metabolites which are deleterious to nematodes (Kagai et al 2012). This study has revealed positive effects of *Lippia kituensis* Vatke and *Ocimum gratissimum* L. fresh biomass for the control of nematodes (*Meloidogyne* spp.) in greenhouse tomatoes. Overall, the results indicated effective nematode control in the tomato crop treated with the plant biomass compared to the control treatments where no amendments were applied. Additionally, it was generally observed that combination biomass treatments of the two species at the higher rates tested (i.e. 400g and 800g) were more effective than the single treatments. Oka et al. (2007) reported that sensitivity of plant-parasitic nematodes to plant derived nematicides, however, indicated that the effect varied with the nematodes species targeted and the rates applied. He further reported that the second instar juveniles (J2) of *Meloidogyne* spp were more susceptible to the treatments. Proliferation of the second instar juveniles, which is the more destructive stage of the nematode, was effectively suppressed when growing soils were treated with the fresh biomass of the two plant species tested.

Several postulations on the mechanisms of action of these fresh biomass materials have been put forward. One of them is that during the decomposition of organic materials, volatile fatty acids, ammonia and hydrogen sulphide gases are released (McSorley, 2011) and these enhance nematode control. In this study *L. kituensis* and *O. gratissimum* biomass additions to soil proved toxic to *Meloidogyne* spp. under greenhouse conditions. These treatments effectively reduced the nematode J2 population in the soil to tolerable levels by these plants derived soil amendments (Table 2). Similar results have been reported by Kagai et al. (2012) with selected plant biofumigants in the management of plant parasitic nematodes in *Asclepias tuberosa* L. Claudia et al. (2004) reported that essential oils from Argentine...
**Lippia** (*L. juneliana* and *L. turbinata*), has effect on nematodes control in the laboratory condition. The same has been confirmed by Onifade, (2007) using essential oils from basil (*Ocimum basilicum*) to have nematicidal effect on parasitic nematodes, especially RKN *Meloidogyne* spp and root lesion nematode *Pratylenchus penetrance*. In this study, *Lippia* and *Ocimum* decomposition and mineralization probably released essential oils that were effective in RKN control. Other possible mechanisms for nematode suppression by these organic amendments include direct inhibition or reduced infectivity of nematodes on the plant host. In the present context, it may be that the use of *Lippia* and *Ocimum* as fresh soil organic amendment increased antagonism in the soil mixes by increasing the abundance of other competing beneficial organisms as also reported by Akhtar and Alam (1993a).

**Plate 2. Differences in the quality of tomatoes produced with different rates of Lippia and Ocimum amendments.** A=4 LK+4% OG; B= 0 LK+2%OG; C= 8% LK+8% OG and D= Non- amended soil.

A number of other mechanisms have been proposed to explain the beneficial effects of organic amendments on plants infested with nematodes (McSorley, 2011). These include the release of nematicidal compounds from decomposing materials, stimulating the natural enemies of nematodes and improving plant tolerance to nematodes. Chen et al., (2000) reported that breakdown of plant organic material releases nematicidal substances that contribute to nematode control. Akhtar and Malik (2000) further reported that crops and weeds release biochemicals that counteract the activities of nematodes. *Lippia* and *Ocimum* have been reported to yield essential oils of diverse nature (Atuboyedia et al, 2010). In particular, *Lippia* has been reported to possess piperitenone oxide, limonene, camphor and spathulenol, piperitenone oxide (Claudia et al., 2004). Analysis of *Ocimum* yielded eugenol, citrol linalol, charvicol, thymol, gerianol, triterpenoids, saponins and alkaloids (Matasyoh et al., 2007; Ogendo, 2008). Based on the findings of the present investigation, it is may be plausible to suggest that these biomolecules would have been extracted during decomposition of the plants biomasses to inhibit nematode activity in the amended soil.

The efficacies of soil amendments in this study increased with the dosage of application. This is consistent with the work of Ogwulumba et al. (2010). Similarly, Faruk et al. (2011) reported similar results of the effect of plant organic amendment for controlling RKN *Meloidogyne incognita* on country bean. Further observations by Onifade (2007) indicated that use of essential oils of *O. gratissimum* and *O. basilicum in vitro* at rates ranging from 25-100 µg mL⁻¹ completely inhibited egg hatching and larval survival of nematodes. Attacks by RKN can significantly limit tomato production worldwide particularly in green house production. Based on the findings from the current studies, the
organic soil amendment is a nematode management option, and numerous aspects of this research have practical applications in commercial agriculture for the solution of the pest problems. Management of nematode population and reduction of gall numbers, were contribution from Lippia kituensis Vatke and Ocimum gratissimum L. applied at different rates. L. kituensis Vatke and O. gratissimum L. significantly reduced the nematode population in the soil and the gall numbers in the roots (Table 2); hence they have the potential to manage RKN Meloidogyne spp. From this study, L. kituensis Vatke and O gratissimum L. combined, or as single rates at the range of 400 g to 800 g of either of the plant biomass, was the most suitable rate for nematode management in the greenhouse. Based on the findings of the present investigation, different levels of fresh plant biomass from Lippia kituensis Vatke and Ocimum gratissimum L. have significant effect on the management of root knot nematodes in greenhouse produced tomatoes.

Besides direct toxicity to RKN, Lippia and Ocimum influenced tomato yield in terms reducing plant photosynthate’s sinks (giant cells), which formed root galls. These root galls are feeding sites in the plant that attracts plant photosyntates down to the roots at expense of other plant parts, thus reducing the growth and yield. Reduction of the RKN population and consequently gall number (Table 2), also meant reduced photosynthate sinks in the root, which increased tomato marketable yield (Table 3). Volvas et al. (2005) reported that parasitism by RKN involves the establishment of permanent feeding sites called giant cells in the root cortex, endodermis, pericycle and vascular parenchyma which is sinks for photosynthates, leading to impaired growth of plants low productivity of Chick pea. The effect of biomass of the two plants Lippia and Ocimum may have probably reduced the sink sites in roots leading to better yield in amended soil treatments.

The biomass used caused increase in plant growth vigor and yield by suppressing nematode population and increasing the growth through the nutrients available in Lippia and Ocimum amendments. Similar observation was reported by Walker (2007) in the study on the effect of organic amendments, fertilizers and fenamiphos on parasitic and free-living nematodes on tomato, where growth and yield were increased on amended soil. This is further supported by the studies of Claudius-Cole et al. (2010) who evaluated plant extract in the management of Meloidogyne incognita on cow pea Vigna unguiculata (L) Walp. In their work the boost on yield was connected with nutrient derived from O. basillicum, used as organic amendment. In earlier study by Hasabo and Noweer (2005), it was reported that the extract of Ocimum reduced nematode population on eggplant, which resulted in higher yields. In the current investigation, it was apparent that those plants established in higher rates of Lippia and Ocimum produced fruits of better quality and marketable size, compared to those in non-amended treatment (Plate 2). From the regression equation (Figure 4A), it was evident that nematode reduced tomato fruit marketable yield. This implied that 56.6% of the reduction in marketable yield was due to the effects of nematode population. However, in tomato quality, only fruit firmness was significantly affected by nematode population at 58.2% (Figure 4B). These plant organic amendments can be used combined or as single rates at the range of 400 g to 800 g of either of the biomass, for nematode management in the greenhouse tomatoes production.

REFERENCES


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AMARANTH PIGWEED BEETLE DAMAGE LEVEL CORRELATES TO ENVIRONMENTAL TEMPERATURE REGIMES

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ABSTRACT

Pigweed beetle *Hypolixus haerens* Boheman has been cited as a major insect pest of grain amaranth worldwide. This study evaluated injury level of both foliar and stem damage pests on eight varieties of *Amaranthus hypochondriacus* (L.) during two seasons of production at Katumani (LM4) and Kiboko (LM5). Stem damage by beetle *H. haerens* correlates to environmental temperature. The hotter zone of low midlands five (LM5) was drier (43.7 ± 15.9 mm, 28 ± 2°C) than the cooler zone of low midlands four (LM4), which was relatively wetter (57.1 ± 13.8 mm, 24 ± 2°C). Beetle stem tunnel length inversely correlated with yield. The stem damage levels at the cooler zone were lower by 35, 42 and 47% in comparison to those from the hotter zone (LM5). Insect foliar damage level did not reflect direct grain loss. No variety was found resistant to *H. haerens* stem injury from the eight accessions evaluated. The wetter and cooler zone (LM4) was found to influence lower stem damage and subsequently 5-9 times higher grain yield than the hotter zone. In conclusion, considerations of the environmental factors in each agro-ecological zone would lead to right time of insecticide spray for management of the pests of grain amaranth to prevent yield loss.

Key words: Amaranth; Agro-ecological zones; Low midlands; Foliar damage; Tunnel length; Pigweed beetle

INTRODUCTION

*Amaranthus hypochondriacus* L. belongs to the grain group of Amaranthaceae and is increasingly being grown in Kenya after introduction from the Americas (Gupta and Thimba, 1992; Kaur et al 2010). As a grain crop amaranth has been reported to provide low cholesterol diet as staple food stuff (Berger et al, 2003; Kong et al., 2009; Escudero et al., 2011). Much research has been dedicated on the chemical composition and nutritive quality of the pseudo cereal amaranth, where several varieties of *Amaranthus* have been found superior to most other cereals (Gorinstein et al., 1991; Gonzalez et al., 2007; Milan et al., 2012). The importance of amaranth is increasingly being reported as an important food supplement for people living with HIV/AIDS in most Sub-Sahara Africa (Veetu et al., 2009; Schoenlechner et al., 2010; Kunyanga et al., 2012). The plant has been found to be a heavy feeder of nitrogen and microelements (Zhelezov et al., 1997; Skwarylo-Bednarz et al., 2011; Skwarylo-Bednarz, 2012). On pest occurrence, some sucking plant bugs and the pigweed beetle have been reported worldwide as the major agents constraining realization of variety genotype potential yield (FAO, 1988; Grubben et al., 2004). Some disease pathogens like Pythium can be a problem under some environmental conditions. Another disease fungus of Rhizoctonia genus, as well as stem canker, caused by Phormia or Rhizoctonia genus which colonizes leaves and stems and causes dieback has been highlighted in the Americas and Africa (van Rensburg et al., 2007). However, little information has been documented on the actual yield loss due to foliar and plant stem damage of specific pests. Farmers in Kenya have used various insecticides reporting no reduction of *Hypolixus haerens* Boheman, on amaranth as agro-chemical stockists experiment with farmers each season. The objective of this study was to evaluate both foliar pests and the stem damage by the pigweed beetle *H. haerens* as well as variety tolerance of other pests in two related agro-ecological zones in the low midlands region of Kenya, and the right time to spray against common pests was tested using Beta-cyfluthrin-Chlorpyrifos insecticide.

MATERIALS AND METHODS

Site Plot Establishment

Eight variety plots of amaranth were established on tractor ploughed and harrowed plots. The eight varieties were planted on the onset of the short and long rain seasons in April-June (2013) and January-March (2014). Using Jaezold et al (2007) agro-ecological zonation, the two plots were located at two low midlands ecological zone sites; at Kiboko, low midlands five (LM5) and Katumani, low midlands four (LM4) of the eastern region of Kenya. Plot design was randomized complete block design (RCBD). The eight varieties were planted in five rows of 90cm x 30cm spacing. The plot sizes were 18 plants in the five rows. Climate data (pooled) from the sites meteorological stations was analyzed for interpretation of plant development and final yield in consideration to biotic and physical factors during production periods. Kiboko site plot was drier, monthly rainfall of 43.7 ± 15.9mm at an altitude of 940m above sea level (asl). Katumani plot was within the wetter zone of monthly rainfall of 57.1 ± 13.8mm at an altitude of 1609 m asl. Site annual temperatures were 26-30°C for Kiboko and 22-26°C range for Katumani.
Treatments and Data Collection

One month after plant emergence, foliar damaging insects like bollworms and leaf miners showed windowed leaves and lamina mining. The stem pest pigweed beetle *H. haerens* damage symptoms was observed on most plant stems as pin hole-punches three weeks after plant germination. Bioassay studies on the efficacy level of Bulldock Star® 262.5 EC (pyrethroid-organophosphate) of Beta-cyfluthrin (12.5g/litre)-with-Chlorpyrifos (250g /litre) was carried out at the rate of 5ml /20-litre, 10ml /20-litre and 15ml/20-litre to determine dose effectiveness on the two pests.

Three different species of leaf miners, *Liriomyza sativae* Blanchard, *L. trifolii* Burgess and *L. huidobrensis* Blanchard were identified on amaranth leaves at the two sites. Composite manure was applied at the plots at planting at the rate of 2.7 t ha⁻¹. The variety blocks were treated with the insecticide together with the control plot treatments replicated four times at the two different field plots. Spray of Bulldock Star® 262.5 EC was carried out on the first three outer-most plant rows on all plant variety plots in two months’ intervals to crop physiology maturity. The manufacturer’s rate of recommendation of 10ml / 20-litre of water was followed. The total sprays were two at each site with the first one carried out after one month of crop emergency.

Insect foliar damage data was taken at the flowering stage (seven weeks after planting) of the crop and the pigweed stem tunnel length at harvest; nine weeks after planting (WAP). Other damage symptoms of beetle exit holes, tunnel length and number of beetles were scored for each treatment plot. This was to enable comparison of variety pest tolerance as well as insecticide efficacy under the prevailing agro-climatic conditions at the two sites. Log transformation (x +5) was carried out on the number of pests per plant to remove effect of zero values on parameter means. Analysis of variance (ANOVA) was carried out to determine significant difference of parameter mean values of plant height (cm), stem tunnel length (cm), exit holes and number of pigweed beetles (larvae) per plant stem. The analyses were carried out using General Linear Method (GLM) of Student-Newman Keuls (SNK) Post Hoc Test using SAS Version 8 (2001) at 5% significance level. Correlation (R²) trend of yield response to increase of stem tunnel length was graphed for interpretation of the relationship between the two parameters at the two sites.

RESULTS

Foliar Damage

Mean bollworm infestation densities on varieties was not significantly (P>0.05) different on the unsprayed plots at Kiboko. At Katumani, varieties KAM 201, Kisii White, KAM 105 and KAM 106 indicated significant (P<0.05) increase of plant height with insecticide application (Table 1).

Bollworm larvae density difference on the varieties was insignificant (P>0.05) among unsprayed plots at Kiboko while at Katumani where KAM 115 led with 2.3 larvae / plant. Insecticide application lowered significantly (P<0.05) pest reduction at Katumani. Leaf miner pest density was significantly (P<0.001) different amongst the different varieties at the unsprayed plots at Kiboko. Likewise, leaf miner density was significantly (P<0.05) different among varieties at Katumani on the same unsprayed plots. Insecticide application did not significantly (P>0.05) decrease leaf miner densities on the varieties at both sites.

Beetle stem damage

The *H. haerens* beetle caused highest stem damage on amaranth at the hotter Kiboko site (28 ± 2 °C) than the cooler Katumani (24 ± 2 °C). The 4 °C difference in temperatures at Kiboko and Katumani resulted to twice tunnel length increase across most varieties at the former.

Yield at the sites

On unsprayed plots, variety yield tonnage / ha was significantly (P<0.001) different among the varieties at the two sites. Highest yield was recorded at Katumani on variety Kisii White (1,524.8 kg /ha) followed by Kisii Brown (1,323.3 kg/ ha) as shown on Table 2. The least yield was on variety KAM 114 of 808.7 kg /ha at the same site. At the drier Kiboko, the highest yield was on variety KAM 201 with 238.4 kg /ha closely similar to Kisii Brown yield (237.1 kg/ha). All varieties at Katumani site had >100% yield increase in comparison to Kiboko site. Some varieties recorded over 400% (Kisii White, Kisii Brown, KAM 201 and KSC) grain yield increase.
Table 1: Mean (± SE) amaranth variety height and foliar pests’ occurrence at two different agro-ecological zones under unsprayed and sprayed treatments at flowering stage.

<table>
<thead>
<tr>
<th>Site</th>
<th>Plant height (cm)</th>
<th>No. bollworm larvae / plant</th>
<th>No. Leaf miner larvae / plant</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Variety</td>
<td>Unsprayed</td>
<td>Sprayed</td>
<td>Unsprayed</td>
</tr>
<tr>
<td>Kiboko (LM5)</td>
<td>KAM 201</td>
<td>86 ± 3.9aA</td>
<td>86 ± 5.4aA</td>
<td>0.6 ± 0.2aA</td>
</tr>
<tr>
<td></td>
<td>Kisii Brown</td>
<td>64 ± 5.4bB</td>
<td>84 ± 4.6aA</td>
<td>0.5 ± 0.3aA</td>
</tr>
<tr>
<td></td>
<td>KSC</td>
<td>78 ± 4.2abB</td>
<td>93 ± 3.6aA</td>
<td>0.4 ± 0.2 aA</td>
</tr>
<tr>
<td></td>
<td>Kisii White</td>
<td>86 ± 3.4aB</td>
<td>104 ±2.5aA</td>
<td>0.7 ± 0.4aA</td>
</tr>
<tr>
<td></td>
<td>KAM 114</td>
<td>88 ± 4.6aA</td>
<td>94 ± 4.7aA</td>
<td>0.5 ± 0.1aA</td>
</tr>
<tr>
<td></td>
<td>KAM 105</td>
<td>81 ± 2.9abA</td>
<td>77 ± 2.75aA</td>
<td>0.4 ± 0.1aA</td>
</tr>
<tr>
<td></td>
<td>KAM 106</td>
<td>89 ± 2.3aA</td>
<td>90 ± 3.6aA</td>
<td>0.6 ± 0.5aA</td>
</tr>
<tr>
<td></td>
<td>KAM 115</td>
<td>81 ± 2.5abA</td>
<td>85 ± 1.6aA</td>
<td>0.4 ± 0.1aA</td>
</tr>
<tr>
<td></td>
<td>P-value</td>
<td>0.028</td>
<td>0.727</td>
<td>0.375</td>
</tr>
<tr>
<td>Katumani (LM4)</td>
<td>KAM 201</td>
<td>125 ± 2.3ab A</td>
<td>130 ± 1.3abA</td>
<td>1.9 ± 1.3abA</td>
</tr>
<tr>
<td></td>
<td>Kisii Brown</td>
<td>127 ± 2.0abA</td>
<td>122 ± 2.3cB</td>
<td>1.3 ± 1.2abA</td>
</tr>
<tr>
<td></td>
<td>KSC</td>
<td>127 ± 3.6abA</td>
<td>129 ± 2.5aA</td>
<td>2.1 ± 1.8abA</td>
</tr>
<tr>
<td></td>
<td>Kisii White</td>
<td>127 ± 4.8abA</td>
<td>142 ± 2.9aA</td>
<td>1.1 ± 0.7abA</td>
</tr>
<tr>
<td></td>
<td>KAM 114</td>
<td>114 ± 3.4aB</td>
<td>124 ± 3.0cA</td>
<td>1.4 ± 1.3bA</td>
</tr>
<tr>
<td></td>
<td>KAM 105</td>
<td>113 ± 5.4bA</td>
<td>137 ± 3.6abA</td>
<td>0.8 ± 0.7abA</td>
</tr>
<tr>
<td></td>
<td>KAM 106</td>
<td>138 ± 5.2aA</td>
<td>142 ± 4.5aA</td>
<td>2.2 ± 2.0abA</td>
</tr>
<tr>
<td></td>
<td>KAM 115</td>
<td>120 ± 3.0abB</td>
<td>135 ± 2.9bA</td>
<td>2.3 ± 1.3aA</td>
</tr>
<tr>
<td></td>
<td>P-value</td>
<td>0.011</td>
<td>0.003</td>
<td>0.015</td>
</tr>
</tbody>
</table>

Similar lower case letters denote insignificant (P>0.05) mean value parameter difference among different amaranth varieties (SNK at 5% level). Different upper letters denote significant (P<0.05) difference between sprayed and unsprayed treatment within rows.

Fig. 1: Pigweed beetle tunnel length (cm) on different amaranth varieties at two varied site temperatures.

On the insecticide treated plots at Katumani, Kisii Brown variety had highest yield at 2,113 kg /ha with KSC recording 1,735 kg /ha as the second highest (Table 3). At Kiboko insecticide treated plots, variety KAM 201 led with 628.1 kg /ha followed by Kisii White (618.9 kg /ha). Significant (P<0.001) yield difference was realized among the different
varieties at both sites on control and insecticide treated plots. The cooler zone had 5-9 times higher yield than the hot and drier zone irrespective of treatment. The insecticide application effected significant (P<0.05) yield increase at Kiboko of between 23% (Kisii Brown) to 163% (KAM 201) but did not bring similar increase at Katumani plots as shown in Table 2. At Katumani low stem damage led to higher yield than at Kiboko plots. Grain yield (dependent variable) was influenced by other environmental factors (independent variables) besides stem damage level as Figure 2 shows at the two sites.

Table 2: Mean (±SE) amaranth variety grain yield (kg/ha) under treatments (unsprayed) plots

<table>
<thead>
<tr>
<th>Site</th>
<th>Variety</th>
<th>Unsprayed: Kg ha⁻¹</th>
<th>Sprayed: Kg ha⁻¹</th>
<th>F (df), p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiboko (LM5)</td>
<td>KAM 201</td>
<td>238.4 ± 24.9abB</td>
<td>628.1 ± 33.5aA</td>
<td>6231.2 (1,3), 0.001</td>
</tr>
<tr>
<td></td>
<td>Kisii Brown</td>
<td>237.1 ± 22.4abB</td>
<td>292.9 ± 18.3cA</td>
<td>553.9 (1,3), 0.008</td>
</tr>
<tr>
<td></td>
<td>KSC</td>
<td>155.3 ± 24.5dB</td>
<td>291.7 ± 11.2cA</td>
<td>1577.8 (1,3), 0.006</td>
</tr>
<tr>
<td></td>
<td>Kisii White</td>
<td>210.5 ± 21.9bcB</td>
<td>618.9 ± 91.5aA</td>
<td>103.3 (1,3), 0.009</td>
</tr>
<tr>
<td></td>
<td>KAM 114</td>
<td>208.2 ± 25.9bcB</td>
<td>457.7 ± 38.8bA</td>
<td>1147.8 (1,3), 0.001</td>
</tr>
<tr>
<td></td>
<td>KAM 105</td>
<td>189.3 ± 30.6bcdB</td>
<td>471.6 ± 150.8bA</td>
<td>19.9 (1,3), 0.046</td>
</tr>
<tr>
<td></td>
<td>KAM 106</td>
<td>165.4 ± 13.3c</td>
<td>441.2 ± 45.2b</td>
<td>244.3 (1,3), 0.044</td>
</tr>
<tr>
<td></td>
<td>KAM 115</td>
<td>264.3 ± 34.5a</td>
<td>349.1 ± 47.1bc</td>
<td>215.9 (1,3), 0.041</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F (df), p</td>
<td>10.2 (7,14), 0.001</td>
<td>17.2 (7,14), &lt;0.001</td>
</tr>
<tr>
<td>Katumani (LM4)</td>
<td>KAM 201</td>
<td>1,230.8 ± 30.7cDA</td>
<td>1,572.9 ± 117.6cA</td>
<td>7.1 (1,3), 0.116</td>
</tr>
<tr>
<td></td>
<td>Kisii Brown</td>
<td>1,323.3 ± 107.7bA</td>
<td>2,113 ± 112.5aA</td>
<td>3.9 (1,3), 0.184</td>
</tr>
<tr>
<td></td>
<td>KSC</td>
<td>1,279.8 ± 74.4bcA</td>
<td>1,735.0 ± 108.1bA</td>
<td>0.1(1,3), 0.835</td>
</tr>
<tr>
<td></td>
<td>Kisii White</td>
<td>1,524.8 ± 73.7aA</td>
<td>1,538.9 ± 76.7cA</td>
<td>0.1 (1,3), 0.882</td>
</tr>
<tr>
<td></td>
<td>KAM 114</td>
<td>808.7 ± 80.6gB</td>
<td>1,461.2 ± 49.6dA</td>
<td>20.6 (1,3), 0.045</td>
</tr>
<tr>
<td></td>
<td>KAM 105</td>
<td>1,168.5 ± 36.5edA</td>
<td>1,183.4 ± 104.3fA</td>
<td>0.2 (1,3),0.754</td>
</tr>
<tr>
<td></td>
<td>KAM 106</td>
<td>914.5 ± 56.6fA</td>
<td>887.3 ± 41.2gA</td>
<td>9.5 (1,3), 0.090</td>
</tr>
<tr>
<td></td>
<td>KAM 115</td>
<td>1,101.6 ± 25.9eA</td>
<td>1,265.2 ± 104.5eA</td>
<td>13.2 (1,3), 0.068</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F (df), p</td>
<td>86.6 (7,14), &lt;0.001</td>
<td>397.3 (7,14), &lt;0.001</td>
</tr>
</tbody>
</table>

Different lower case letters denote significant (P<0.05) mean value parameter difference among different amaranth varieties (SNK at 5% level). Similarly, different upper letters denote significant (P<0.05) difference between sprayed and unsprayed treatment within rows.

DISCUSSION

Pest foliar damage of the grain amaranth was found to have no significant effect to the yield as in maize stem borers (Kfir et al., 2002; Beyene et al., 2011). The drier and hotter zone at Kiboko (LM5) had lesser foliar damage of bollworms and leaf miners than the cooler zone at Katumani (LM4). The indication was that foliar damage of bollworm and leaf miner pests on grain amaranth did not appear to reduce yield loss at Katumani. The spray of pyrethroid-organophosphate insecticide reduced plant stress and led to significant (p<0.05) height gain on the different varieties at Kiboko but less same effect at Katumani. There was no significant reduction of *H. haerens* beetle development at the two sites among varieties even where insecticide spray was used. Higher beetle density was recorded at the drier Kiboko than the cooler Katumani site. The pest control of foliar damage in the low midland zones led to increased plant height and this showed improved plant health, good for higher grain yield as found in other related studies (Gimplinger, et al., 2007).

![Fig. 2: Regression of amaranth yield at Katumani (LM4) and Kiboko (LM5) vs stem tunnel length (cm)](image-url)
Bautista et al. (1997) has described a dipteran borer pest on grain amaranth in South America with close symptoms as *H. haerens*. Oliveira et al. (2012) recently presented similar tunnel length and exit holes of a moth, *Herpetogramma bipunctalis* Fabricius. The present study has analyzed the effect of *H. haerens* on grain amaranth at the two sites. Further comparison of environmental factors of rainfall amount and temperature influence to grain yield showed that higher tonnage of between 5-9 times was realized at the cooler/wetter zone (LM4-Katumani) than the hotter/drier LM5 (Kiboko) on almost all the varieties. Kunyanga et al. (2012) detailed amaranth ecological requirement for optimum production as medium soil fertility and rainfall amount of >100 mm per production season and medium pH level of 4.5-6.5. The present work has shown yield increase to over 400% with increase of monthly rainfall amount change from 43.7 mm to 57.1 mm in a higher altitude. The environmental effect to both plant development and yield was found a strong determinant to final effect of pests. Beetle stem tunnel length was found inversely correlated to yield as in maize (Beyene et al., 2011).

Further, a parallel comparable similarity damage traits of two different orders of insects; Lepidopteran and Coleoteren, respectively comes to the fore. As determined on maize recently, the tunnel length on the plant stem is the criteria for resistance on a crop variety (Bautista et al., 1997; Butron et al., 2014). All the evaluated eight amaranth varieties did not indicate resistance to *H. haerens* as they displayed high similar stem damage indicted by long tunnel lengths. Higher stem tunnel length led to lower yield tonnage on all varieties, as found in other studies (De Oliveira, et al. 2012). There was significant difference on tunnel length on the varieties where the hotter/drier zone site had higher lengths than the cooler/wetter zone on both insecticide sprayed and non-sprayed plots. Both tunnel lengths and number of beetles per stem parameters showed no significance difference between sprayed and unsprayed plots, leading to the conclusion that the insecticide pyrethroid-organophosphate was not effective in controlling *H. haerens* on grain amaranth. Being a contact insecticide no significant control was achieved on stem tunneling *H. haerens* as the beetle could lay its eggs between the one month or so period of spray application. One of the factors found to lead to high stem damage by *H. haerens* was hot-warm environment, while the wetter-cool conditions led to faster plant growth and better plant health leading to higher grain yield as reported on cereal stem borers (Abro et al., 2013; Bamaiyi and Ijeola-Joan, 2011). Nevertheless, the timing of spray could have been done every 7-14 days but not at one month interval as farmers’ were directed by agro-chemical dealers, with a systemic insecticide to protect amaranth crop from pests.

ACKNOWLEDGEMENT
We acknowledge the technical support of Messrs. Richard Omolo and Raymond Mokua for plot lay out and data collection at the sites of Katumani (LM4) and Kiboko (LM5). Dr. D. M. Mwangi of EU/KARI / Arid and Semi-arid Lands National Project Coordinator is acknowledged for timely release of funds.

REFERENCE
Food and Agriculture Organization (FAO). 1988. Traditional Food Plants. FAO, Food and Nutrition paper 42. United Nations, Rome, Italy
EFFECT OF TOMATO *Lycopersicon esculentum* (Mill) VARIETIES ON DEVELOPMENT TIME FECUNDITY AND LONGEVITY OF RED SPIDER MITE *Tetranychus evansi* (Baker & Pritchard)

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ABSTRACT

Tomato *Lycopersicon esculentum* (Mill), is an important source of income to many small scale farmers in Kenya and is a major dietary component. The production of tomatoes is however constrained by several pests with Red spider mite *Tetranychus evansi* (Baker & Pritchard) being the most important dry season pest in Eastern and Southern Africa. Control of *T. evansi* has mainly been by chemicals sprays, which has resulted in problem of pest resistance and pollution of the environment. This study was therefore an attempt to look into alternative environmentally friendly ways of controlling *T. evansi* in tomatoes. To determine the effect of tomato varieties on development time, fecundity and longevity of *T. evansi* an experiment was conducted in a convorin incubator maintained at 25 ± 2°C, 50-70% relative humidity and photoperiod 12:12 L:D a complete randomized design (CRD) arrangement replicated four times in Kenya Agricultural Research Institute, Njoro, Kenya. The tomato varieties assessed were: Cal J, Onyx, Roma VFN, Riogrande, Money maker, Eden F1, Anna F1, and Wild type. The results showed that the, mortality rate for protonymph, deutonymph and adult stages was highest in Wild type (95%) and lowest in variety Money maker (50%). In addition, the average number of eggs per female mite was significantly higher on variety Money maker (52.4) and Riogrande (48.6), while the least number of eggs was recorded on Wild type (9.1). Tomato variety, Money maker was highly susceptible and Wild tomato was most resistant. Since only eight tomato varieties were evaluated, there is therefore need to evaluate more tomato varieties to identify high yielding and less susceptible varieties that can be recommended to farmers. Varietal resistance could become an integral part of an Integrated Pest Management (IPM) programme.

**Key words**: Deutonymph, IPM, *Lycopersicon esculentum*, Protonymph, *Tetranychus evansi*
INTRODUCTION

Tomato Lycopersicum esculentum (Mill) is the world’s most popular vegetable, with an annual world production of 80 million metric tons (FAO, 2001). Kenya produces an estimated 318,639 metric tons and earning cash value of Ksh 5.1 billion (KARI, 1996). In Kenya, it is one of the most important local vegetable crops ranking second to Brassica (cabbage and kales) in quantities produced and value (KARI, 1996). The increased popularity in tomato production may be attributed to both its high yield potential, high prices and a continuous source of income (Kamau, 1985), and perhaps more than any other vegetable, it has a higher monetary return per unit area. Tomato growing is thus an important undertaking by low to moderate class earners and goes along way in supporting the fight against poverty and nutritional improvement in Kenya. In Kenya, tomato is grown in almost all arable areas including semi arid and arid areas using irrigation. However, the major tomato production constraints in Kenya are Red spider mite (T. evansi), bacterial wilt, late blight, plant parasitic nematodes, insect pests, lack of high yielding varieties and poor agronomic practices (KARI, 1996).

Red spider mite (T. evansi), is a major pest of solanaceous crops including tomato, pepper, eggplant, tobacco and nightshade (Quereshi, et al., 1969., Ramalho and Flechtmann, 1979). It is the most important dry season pest of tomatoes in eastern and southern Africa. Kamau, 1985, reported that these are serious pests of tomato crop grown in areas where the crop experience periods of hot and warm dry weather. Tetranychus evansi. causes serious damage to the tomatoes by reducing their yields and affecting quality, not to mention the cost of pesticides used by the farmers (Saunyama and Knapp, 2003). Compounding their effects is the fact that in many instances, farmers have listed Red spider mites as a disease (Yang et al., 2004) because they are unable to recognize their minute sizes on crop surfaces. Resistant tomato varieties to Red spider mites have been reported in some countries. For instance, in USA, Kalohi lines recorded high tolerance to mite injury (Varela et al., 2003). In Brazil, some promising tomato genotypes tolerant to T. evansi have been identified (Varela et al., 2003). There are many tomato varieties commercially available to growers in Kenya; however these varieties have not been screened to compare their resistance levels to Red spider mites. This study was conducted to determine the effect of tomato varieties on T. evansi development time, fecundity and longevity.

MATERIALS AND METHODS

Mite culture

A stock culture of Red spider mite T. evansi was established in greenhouse at KARI- Njoro (0°20’S 35°56’E, 2164 m above sea level). The initial culture was collected from Horticulture Department (Field 3), Egerton University- Njoro, Kenya and reared on potato plants. The reared red spider mites were later used in laboratory experiment carried out at KARI- Njoro. Red spider mite, T. evansi was identified in consultation with International Centre of Insect Physiology and Ecology (ICIPE)–Nairobi.

Development time from egg to adult

Studies on the effect of tomato varieties on the development time from egg to adult of T. evansi were done in a conviron incubator maintained at 25 ± 2°C, 50-70 % relative humidity and photoperiod 12:12 L:D (Helle and Sabelis, 1985). Small Petri dishes (100 mm diameter) were loaded half with cotton wool and kept wet by adding 5ml of clean water in the morning and evening. Ten leaf discs from each tomato variety with a diameter of 20 mm each were punched from the tomato varieties using a cork borer. The leaf discs were placed in individual Petri dishes, the underside facing up. Thin layer of vaseline was placed on the edges of the leaf disc to prevent the mite from walking a way from the leaf disc and drowning.

Ten female mites were taken from the colony, put on each leaf disc for each tomato variety separately and left for six hours to allow egg laying. Afterwards, eggs were removed (killed) using fine camel hair brush leaving only two eggs per leaf disc. Petri dishes containing leaf discs were then placed in an incubator in a complete randomized design (CRD) arrangement replicated four times. The leaf discs were checked after every 12 hours with the aid of a dissecting microscope and development time from egg to larva, protonymph, deutonymph and adult, as well as adult survival and sex were noted and recorded. Leaf discs were changed after every three days to provide fresh leaves for mites to feed on.

Fecundity and longevity

Studies on the effect of tomato varieties on fecundity and longevity of T. evansi were done in a conviron incubator maintained at 25 ± 2°C, 50-70 % relative humidity and photoperiod 12:12 L:D (Helle and Sabelis, 1985). Small Petri dishes (100mm diameter) were loaded half with cotton wool and kept wet by adding 5 ml of clean water in the
morning and evening. Ten leaf discs with a diameter of 20 mm from each tomato variety were punched using a cork borer. The leaf discs were placed in individual petri dishes, the underside facing up. Thin layer of vaseline was placed on the edges of the leaf disc to prevent the mite from walking away from the leaf disc and drowning. One female deutonymph was placed on each leaf disc for each of the ten leaf disc per tomato variety. Petri dishes containing leaf discs were then placed in an incubator in a complete randomized design (CRD) arrangement replicated four times. The number of eggs was counted and recorded using dissecting microscope after every 48 hours and killed until the mite died. The fecundity and adult longevity on each leaf disc was recorded. Leaf discs were changed after every three days to provide fresh leaves for mites to feed on.

**Data analysis**

Data collected was organized and Analysis of variance (ANOVA) was done using the General linear model (GLM) procedure of SAS 2001 version 8.02. Means were separated using Tukey’s Studentized Range Test.

**RESULTS**

There was no significant difference (P>0.05) on incubation period, and duration of larval stage in all the varieties tested (Table 1.1). However, there was significant difference (P<0.05) on duration of protonymph, and deutonymph stages and as well as adult survival among tomato varieties (Table 1.1 and Table 1.2). The mortality rate of protonymph, deutonymph and adult stages was highest in wild type with 44.4%, 70.0% and 66.7% respectively and lowest in Money maker with 15.0%, 23.5% and 23.1% respectively. The total development period (egg to adult) ranged between 8.9 to 11.0 days (Table 1.1 and 1.2). The average number of eggs laid per female mite was significantly higher on Money maker which was not significantly different (P>0.05) from Riogrande (Table 2). The least number of eggs was recorded on Wild variety which was significantly different from all the varieties.

**DISCUSSIONS**

The results on incubation period and duration of larval stage may be because the mites are not feeding on the host plant and therefore there is possibly that there is neither morphological nor chemical effect on the mite development at this stage. The significance difference in the duration of time taken on these stages (Protonymph, Duetonymph and adult) may be because at these stages the mite has started feeding on the host plant. The difference in duration may therefore be attributed to the different morphological traits such as trichomes and surface waxes as well as secondary plant metabolites on different tomato varieties (Anathakrishnan, 2001). The difference in mortality rate in the present study may be due to difference in host plant characteristics. This is similar to what was reported by Chatzivasileiadis and Sabelis, 1997,1998., Chatzivasileiadis et al., 1999., Maluf et al., 2001., Cedola and Sanchez, 2003) where compounds from tomato trichome were reported to produce exudates such as methyl ketons and zingiberene that were reported to be toxic to spider mites. High densities of glandular type IV trichomes on L. hirsutum, and non-glandular type V trichomes on L. esculentum were also found by Simmons and Gurr (2005). Glandular trichome types I, IV, VI and VII are known to release secretions on touch that are sticky and toxic (Van haren et al., 1987). Nihoul, 1993, Kennedy, 2003, Simmons and Gurr, 2005). The secretions immobilize mites or kill them. The total development period (egg to adult) ranged between 8.9 to 11.0 days.

Similar results were reported by Wesonga et al., (2005). It was noted that the period of *T. evansi* from egg to adult on tomato leaves ranged from 6.5 to 11.5 days. Meyer, (1996) also reported that the life cycle is 9 to 12 days resulting to 24-30 generations in a year. The difference in time taken for eggs to hatch and larva that completed the cycle indicated that development and population increase of *T. evansi* depends on host type. In this case Money Maker is a more suitable host compared to Wild type and other commercial varieties tested because 50% of the larvae reached the adult stage. Similar results were also reported by Isutsa et al., (2006) where it was reported that 58 % of the larvae on Money maker reached adult stage. Host plants can exert profound effects on the biology of spider mites including *T. evansi* Jeppson et al., (1975). In this study the average ratio of male to female was 1:2.6. This is less compared to what was reported by Qureshi et al (1969) that the ratio of male to female was about 1:10. These difference may be due to difference in test plant varieties used and also different laboratory conditions i.e. temperature and relative humidity. However, the results seems to be almost similar to work done by Moutia (1958) who reported that the sex ratio on tomato plants in the field was 1:3.3. The short life cycle and high ratio of female to male indicate that on suitable host and favorable climatic conditions *T. evansi* can reproduce rapidly and cause severe crop losses. In the present study, highest mortality was recorded on Wild type while lowest mortality was recorded on variety Money maker. Similar results were also reported by Snyder and Carter (1984 and 1985) where it was reported that mite survival was lower in *L. hirsutum var. hirsutum* that possessed fewer type VI trichomes than *L. esculentum*, and concluded that trichome type VI could be responsible for the high levels of resistance in this species.
The results on fecundity and longevity of *T. evansi* agree with what was reported by Isutsa *et al.*, (2006) where the highest total number of eggs laid by an individual female mite was reported on Money maker. From the results, Money maker seems to be a preferred host plant for egg laying as compared to wild type. Similar results were also reported by Murungi *et al.*, 2009 where preference to Money maker was attributed to trichome density and plant emitted volatiles. This may be attributed to the different morphological traits such as trichomes and surface waxes as well as secondary plant metabolites (Anathakrishnan, 2001). The wild type may also be releasing some chemicals that repel the mite away and therefore not laying eggs on them. These reports agree with the work done by by Wesonga, *et al.* (2005) who reported that, the wild *Lycopersicon* accessions (*L. hirsutum* and *L. peruvianum*) were found to be the most repellent to the spider mites.

### Table 1.1: Effect of tomato varieties on duration (days) of incubation, larvae and protonymph stages of Red spider mite (*T. evansi*)

<table>
<thead>
<tr>
<th>Variety</th>
<th>Incubation period</th>
<th>Larvae Total no Duration</th>
<th>Protonymph Total no Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Eggs (mean days)</td>
<td>(Mean days)</td>
<td>(Mean days)</td>
</tr>
<tr>
<td>Cal J</td>
<td>20</td>
<td>4.1a</td>
<td>18</td>
</tr>
<tr>
<td>Onyx</td>
<td>20</td>
<td>4.1a</td>
<td>19</td>
</tr>
<tr>
<td>Roma VFN</td>
<td>20</td>
<td>4.2a</td>
<td>18</td>
</tr>
<tr>
<td>Riogrande</td>
<td>20</td>
<td>4.1a</td>
<td>20</td>
</tr>
<tr>
<td>Money maker</td>
<td>20</td>
<td>4.1a</td>
<td>20</td>
</tr>
<tr>
<td>Eden F1</td>
<td>20</td>
<td>4.3a</td>
<td>20</td>
</tr>
<tr>
<td>Anna F1</td>
<td>20</td>
<td>4.2a</td>
<td>20</td>
</tr>
<tr>
<td>Wild type</td>
<td>20</td>
<td>4.3a</td>
<td>18</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CV %</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Means within a column followed by the same letter are not significantly different using Tukey HSD test, α = 0.05.

### Table 1.2: Effect of tomato varieties on duration (days) of deutonymph stage, a dult stage, sex and mortality of Red spider mite (*T. evansi*)

<table>
<thead>
<tr>
<th>Variety</th>
<th>Deutonymph Total no Duration (Egg to Adult)</th>
<th>Total no Male</th>
<th>Total duration</th>
<th>Sex</th>
<th>Sex Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cal J</td>
<td>7</td>
<td>1.3ab</td>
<td>5</td>
<td>9.9a</td>
<td>75</td>
</tr>
<tr>
<td>Onyx</td>
<td>7</td>
<td>1.8a</td>
<td>4</td>
<td>10.3a</td>
<td>2 2 80</td>
</tr>
<tr>
<td>Roma VFN</td>
<td>5</td>
<td>1.3ab</td>
<td>3</td>
<td>10.3a</td>
<td>- 3 85</td>
</tr>
<tr>
<td>Riogrande</td>
<td>12</td>
<td>1.5ab</td>
<td>9</td>
<td>10.4a</td>
<td>2 7 55</td>
</tr>
<tr>
<td>Money maker</td>
<td>13</td>
<td>1.8a</td>
<td>10</td>
<td>11.0a</td>
<td>3 7 50</td>
</tr>
<tr>
<td>Eden F1</td>
<td>9</td>
<td>1.3ab</td>
<td>5</td>
<td>10.5a</td>
<td>2 3 75</td>
</tr>
<tr>
<td>Anna F1</td>
<td>9</td>
<td>1.3ab</td>
<td>6</td>
<td>9.9a</td>
<td>2 4 70</td>
</tr>
<tr>
<td>Wild type</td>
<td>1.0b</td>
<td>1</td>
<td>8.9b</td>
<td>-</td>
<td>1 95</td>
</tr>
<tr>
<td>Mean</td>
<td>1.41</td>
<td>10.17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>0.14</td>
<td>0.14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CV %</td>
<td>31.33</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Means within a column followed by the same letter are not significantly different using Tukey HSD test, α = 0.05.

### Table 2: Effect of tomato varieties on fecundity and longevity of *T. evansi*

<table>
<thead>
<tr>
<th>Variety</th>
<th>Fecundity (mean no. of eggs laid/female)</th>
<th>Average longevity days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cal J</td>
<td>32.0b</td>
<td>7.5b</td>
</tr>
<tr>
<td>Onyx</td>
<td>23.0c</td>
<td>7.2b</td>
</tr>
<tr>
<td>Roma</td>
<td>23.9c</td>
<td>6.7b</td>
</tr>
<tr>
<td>Riogrande</td>
<td>48.6a</td>
<td>8.2b</td>
</tr>
<tr>
<td>Money maker</td>
<td>52.4a</td>
<td>12.8a</td>
</tr>
<tr>
<td>Eden F1</td>
<td>31.3b</td>
<td>7.6b</td>
</tr>
<tr>
<td>Anna</td>
<td>33.2b</td>
<td>7.4b</td>
</tr>
</tbody>
</table>
CONCLUSION AND RECOMMENDATIONS

The development, fecundity, adult longevity and survival of *T. evansi* varied with varieties. It was evident that antibiotic effect existed especially in Wild tomato variety. Tomato variety Anna F1 had higher yields in spite of high mite population and damages an indication of tolerance to mite damage. The present study did not study the mechanisms of resistance and there is a need to comprehensively study the mechanisms and sources of resistance.

ACKNOWLEDGEMENT

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CLIMATE SMART AGRO-PASTORAL PRACTICES: A CASE STUDY OF NAROK COUNTY, KENYA

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ABSTRACT
Pastoralism is described by a high reliance on livestock production systems for socio-economic wellbeing. In Kenya it is the dominant form of livelihood in the arid and semi-arid lands, which constitute more than 80% of the total land area, host about 10 million people and 70% of the national livestock herd. Despite these areas being the major meat producers in the country, production is threatened by climate related hazards as witnessed by livestock deaths, reduced daily yields and prices, degraded natural resources, and high incidences of livestock pests and diseases. The traditional coping strategies applied in terms of nomadic pastoralism, has been reduced due to fragmentation of rangelands, forcing them to transform towards sedentary lifestyles. Thus, what can be done to improve this sedentary lifestyle and how can it be sustained within the ASALs? What are the on-the-ground coping strategies that enhance environmental conservation? This study assessed the coping mechanisms applied to the changed lifestyle within the pastoral communities of Narok County that not only improve livelihoods through climate change adaptation but also contribute towards climate change mitigation. This was done using key informant and focus group discussions. Policy guidelines are provided on building capacity through participatory approaches to enhance long-term sustainable systems that will ensure food security to these vulnerable communities, while at the same time contributing to natural resource conservation and ecosystem services.

Key words: ASALs, Climate change adaptation, Environmental conservation, Mitigation, Pastoralists

INTRODUCTION
Pastoralism is described by a high reliance on livestock production systems for socio-economic wellbeing. These systems occupy about 40% of Africa’s land mass, mostly in the arid and semi-arid areas, which are characterized by erratic and unreliable rainfall (AU, 2010). Pastoralists traditionally move from one place to another in search of water and pasture in response to climatic stress. However, the increasing droughts and food insecurity has forced majority of them to completely drop out of nomadic pastoral lifestyle and engage in other forms of livelihood (Adow, 2008). In Kenya, pastoralism is the dominant form of livelihood in the arid and semi-arid lands (ASALs), which constitute more than 80% of the total land area, host about 10 million people and approximately 70% of the national livestock herd (GOK, 2007). They are the major meat producing areas in the country with an annual slaughter of approximately 1.6 million tropical livestock units (Muthee and Wahiu, 2006).

The demand of livestock products is expected to increase in future especially due to the influence of the upcoming urbanization that mainly alters the patterns of food consumption (FAO, 2009). However, climate change poses a major threat to this productivity leading to livestock deaths, reduced daily yields and prices, degraded natural resources, and high incidences of livestock pests and diseases. In addition, majority of the pastoralists especially in the Southern Kenya have lost pasture land due to the expanding population and large scale agriculture (Norton-Griffiths et al., 2007). The traditional coping strategy applied in terms of mobility, which has supported them for many years, has also been reduced. It is estimated that close to one million have already been forced to abandon pastoralism and majority transforming towards sedentary lifestyles. Proper assessment of the needs of these communities in line with the changing paradigms is therefore required that should involve their participation for development (Musimba and Nyariki, 2003). This study addressed the following questions; i) what should be done to improve this sedentary lifestyle and how could it be sustained within the ASALs? And ii) what are the on-the-ground coping strategies that improve livelihoods while simultaneously enhancing environmental conservation? The information will be essential in informing policies and strategies for improving livelihoods while at the same time conserving natural resources and ecosystem services.

MATERIALS AND METHODS
The Study Area
Narok County is situated in the South West of Kenya and covers an area of about 15000 Km². Rainfall is highly variable and increases along a gradient from the lowlands with an average of about 500 mm/yr to the highlands (with about
According to the Kenya ASAL policy, the Government strategizes to support pastoralism and agropastoralism by encouraging diversification through value addition in livestock products, introduction of other livestock such as poultry and beekeeping, irrigated crop farming, ostrich farming, mining, fishing, harvesting of non-wood forest products, eco-tourism and cottage industries and introduction of camels in areas not previously rearing them including Narok (GOK, 2005). Although the new livelihood shift had many constraints, the communities applied various natural resource based strategies in order to increase food security while simultaneously improving the environment. These strategies are examples of livestock related climate-smart production systems.

**Silvicultural practices**

Majority of the pastoralists had maintained indigenous nitrogen-fixing legume trees on their pasture land in order to provide shade, fodder and limit wind tornadoes. Shade trees reduce heat stress on animals and help increase productivity. They also improve soil fertility and enhance carbon sequestration. Forage/legume mixtures increase pasture productivity and when legumes are included in livestock feeds they increase the food conversion ratio and decrease GHG emissions (FAO, 2012). Practices that enhance soil carbon sequestration can result in greater biodiversity, improved water management in both quantity (reduced run off and evaporation or flood control) and quality (reduced pollution) and restoration of land degradation (Neely *et al.*, 2010).

**Agroforestry**

About 20% of the participants had abandoned pastoral livelihoods and adopted rain-fed agropastoralism. They maintained and or planted indigenous nitrogen-fixing trees on their farm to improve soil fertility and provide shade to crops. Agroforestry is said to be crucial for both climate change adaptation by diversifying production and mitigation through carbon sequestration, improved feed and consequently reduced enteric methane (FAO, 2013).

**Integrated crop-livestock systems**

This involved leaving crop residues after the cropping season for use as fodder while at the same time rejuvenating the land. This increased soil fertility which in turn increased crop yields and enhanced income while at the same time provided fodder for livestock. These systems increase soil organic matter and improve soil structure hence plays a major role in carbon sequestration. They are also increase crop yield, improve livestock production, enhance nutrient cycling, improve water infiltration and recharge of groundwater reserves and can therefore help reduce poverty and malnutrition and strengthen environmental sustainability (Rota and Sperandini, 2010).

**Livestock management**

About 60% of the participants had reduced the number of livestock and herd composition while simultaneously improving feed resources. They also kept more sheep and goats during the dry periods and increased their cattle numbers during the onset of the rains. Most of the respondents had maintained the traditional cattle breeds which they thought were more tolerant to drought. About 8% of the respondents were investing in improved cattle breeds that gained weight more quickly that the traditional ones and hence had a better sale.

**Grazing management**

Managing grazing lands reduce grazing pressures, enhance water retention and soil health and hence increase grassland productivity. About 40% of the participants practiced rotational grazing which conserved vegetation cover and soil organic matter. Those who practiced it were the pastoralists with very large pieces of land but with reduced number of livestock. Rotational grazing can lead to greater forage production, sustainable use of resources, enhanced profitability, land rehabilitation and restoration of ecosystem services (FAO, 2012). It also reduces and offsets GHG emissions by lowering enteric emission intensities through selecting more nutritious forage (FAO, 2009). The participants recommended the importance of mobility as a coping strategy due to the unpredictable climatic changes. Nevertheless, mobility in this area had been short and temporary and mostly towards Maasai Mara National Reserve where grazing resources were available. Neely *et al.* (2010) reported that mobility of pastoralists enables them to sustainably utilize harsh environments and therefore increase resilience of these livestock systems to climate change.

**Use of organic Manure**

All participants who practiced agriculture agreed that the use of fertilizers in their farms was very expensive. To supplement this, a few applied cattle manure as organic fertilizer on planting pits before sowing crops. They reported an increase in crop yield compared to the use of synthetic fertilizer alone. Cattle manure is reported to be a good fertilizer and presents a low risk of over-fertilization and improves soil structure by adding organic matter and nutrients.
1800mm/yr). The highlands have fertile soils suitable for intensive agricultural production hence dominated by large scale farming of wheat, barley, maize, beans and potatoes as well as production of wool sheep and dairy farming. The lowlands cover over three quarters of the county with low unreliable rainfall hence dominated by nomadic pastoralists. Most of these lands fall under trust and host large group ranches owned by local communities. Nearly 60% of the district’s households are dependent on livestock for their livelihood (PricewaterhouseCoopers 2005). The County also hosts the 7th Wonder of the world, the Maasai Mara National Reserve, which is one of the richest in biodiversity in the world. Being an ASAL, the area is most vulnerable to climate change which has been worsened by encroachment of agricultural activities associated with the increasing human population. The area is undergoing rapid changes due to fragmentation of rangelands, urbanization and associated changes in land use.

**Data Collection**

Three study sites (Mulot, Ewasong’iro and Ntulele) were purposively selected to represent pastoral areas facing massive land use changes. Within each site, semi-structured focus group discussions were carried out to provide a wide background on the concerning perceptions of change and the past and present coping mechanisms, particularly those contributing to mitigation (natural-resource based). Each group was composed of eight participants who were village elders and were all male due to cultural practices. The facilitated group discussions lasted for about 4 hrs and the information was recorded collectively as a group. Discussions were summarized according to the comments that had risen. Interviews were also conducted with key informants such as the sub-county leaders with specialized knowledge on the current challenges facing these communities. A total of three focus group discussions and nine key informants were interviewed in the three study sites.

**RESULTS AND DISCUSSION**

The focus group discussions gave an overall picture of the impacts of change of pastoral livelihoods to sedentary lifestyles. In summary of the information that was discovered across the three sites, climate change and land fragmentation due to population pressure were stated to be the main sources of vulnerability for the past five years. This led to reduced land, land degradation, decline in grazing resources causing reduced livestock yields. To cope with these challenges, pastoralists had diversified from livestock into agropastoralism with subsequent shift from communal land to land ownership. Attempts had also been made to diversify into other sources of livelihood strategies to increase food security (Fig. 1).

Income diversification was through selling food-crops such as potatoes and vegetables in the local markets. Women were generally involved in small-scale sale of dairy products such as milk and yoghurt. Others practiced bee-keeping and ecotourism. Majority were also diversifying livestock species by keeping emerging livestock such as pigs and poultry which are easily maintained with high yielding breeds. Overall, all groups accepted that most of their family members were employed within Narok town while all the participants practiced charcoal burning.

**Vulnerability**

- **Shocks**
  - Climate change
  - Land fragmentation

- **Trends**
  - Reduced land
  - Land degradation
  - Decline in grazing resources
  - Reduced livestock yields

**Transformation processes**

- Agropastoralism
- Land ownership

**Livelihood strategies**

- Income diversification
- Silviculture
- Agroforestry
- Integrated crop-livestock systems
- Reduced livestock
- Zero grazing
- Improved breeds

Increased food security
Enhanced environment

**Fig. 1 Influences of the changing pastoralism in Narok County**
It also improves productivity and allows for reductions in use of synthetic fertilizers and the associated direct and indirect GHG emissions (FAO, 2012).

**CHALLENGES AND OPPORTUNITIES**

A number of challenges and opportunities for improvement of these agropastoral livelihoods were identified. The key constraints were the limited knowledge on sustainable land management practices and post-harvest handling, inappropriate land laws and policies, limited capital and insurance and frequent crop and livestock pests and diseases. In order to improve the livelihoods of these communities, support is required in climate change adaptation and mitigation and disaster management for sustainable and resilient pastoral systems through the following areas.

(a) Providing incentives to adopt environmentally friendly practices that would result in both environmental socio-economic benefits that including payments for environmental services (PES)
(b) Raising awareness on sustainable land management practices that improve soil while simultaneously enhancing food security.
(c) Ensuring prompt and appropriate diagnostics and treatment of crop-livestock pests and diseases that should incorporate the massive indigenous knowledge.
(d) Training on fodder management techniques such as harvesting and storage, re-seeding and use of supplements in order to increase livestock productivity.
(e) Ensuring proper resource monitoring systems that fit within the ASALs in order to inform communities on pasture availability and future climate change.
(f) Promotion of drought-tolerant crops and dryland multipurpose trees
(g) Providing access to capital and markets

**ACKNOWLEDGEMENT**

This study was funded by the UK Department for International Development (DFID) through the Future Agricultures Consortium (FAC). The researcher wishes to thank all pastoral community members who were interviewed in this study for their time, cooperation and the information provided.

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EFFECTS OF SEA WATER INTRUSION AND SURFACE WATER SALINITY ON IRRIGATION WATER QUALITY IN RAMISI

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ABSTRACT
One of the major economic activities in Ramisi is cane growing. However, rain fed farming is not sustainable owing to erratic rainfall patterns and limited agricultural land. River Ramisi is saline, mineralized, unsuitable for domestic and agricultural use, and affected by seawater intrusion during high tides. KISCOL drilled 37 boreholes to bridge the water demand gap but quality is doubtful. This study determined suitability of water sources in Ramisi in terms of salinity and contaminants, risk of salt water intrusion and microorganisms levels. Water samples were collected from boreholes and Rivers Ramisi and Mkurumudzi and analyzed for organic constituents, chemical oxygen demand, dissolved oxygen and electrical conductivity physical and microbiological parameters using Standard Methods. The pH of the water ranged from 6.5-8.5 with exceeding limits for conductivity, chlorides, TDS, turbidity (25 NTU) and TDS (1,238 mg/l). Magnesium, iron, sodium and potassium and nutrients were below permissible levels for irrigation water. Thus River Mkurumudzi and groundwater sources are not at risk of sea water intrusion, but River Ramisi is not. Most surface water sources were contaminated with coliform and E. coli hence not suitable for domestic use. Further research is needed to ascertain quality of the water for both agricultural and domestic uses.

Key words: Organic constituents; Physiochemical properties; Microbiological levels; Irrigation water quality

INTRODUCTION
Kenya’s Gross Domestic Product (GDP) and per capital income depends on agriculture. Among the key agricultural activities is cane growing for sugar production. Kenya produces about 60% of sugar for her domestic consumption and the deficit is met by importing. The country, however, has the potential and capacity to produce sufficient sugar for local consumption as well as surplus for export. Owing to the steady increase in the domestic sugar demand from about 460,000 tonnes in 1988 to about 730,000 tonnes in 1998 with only a marginal increase in production within the same period, the government has adopted an economic policy of liberation, geared towards providing an enabling environment for greater investment in the sugar industry by both local and foreign investors. Among the foreign investors is Kwale International Sugar Company Limited (KISCOL), which re-established cane growing and sugar production factory at Ramisi in Msambweni district after the collapse of the former Ramisi Sugar Company in 1988 that had operated for 67 years.

A major challenge, however, is the limited agricultural land and availability of water as rain fed agriculture is not sustainable owing to erratic rainfall patterns. Koromojo Dam built to bridge the water requirements deficit for cane production served principally as a livestock watering point since 1988. River Ramisi draining the area has been found to be saline, highly mineralized and unsuitable for domestic and agricultural use (Earth view, 2009) and is affected by seawater intrusion during high tides. The only fresh water tributary of the Ramisi is the Mkanda stream, while the other streams originate from regions of active volcanic activity (Earth view, 2006).

The sandstones and shales over which the rivers flow dip to the South East lead to the groundwater directed by the bedding planes towards the Msambweni area (Tole, 1995). Further, groundwater recharge on the beach at low tides lead to springs of freshwater discharging copious amounts of freshwaters into the sea (Mwangi, 1981). Groundwater resources in coastal areas are always in danger of contamination by sea water intrusion. Although a variety of chemical buffer reactions occur at the fresh/saline interface, mixing of the two is to a large extent a combination of physical processes that are accelerated drastically by nearby abstraction (Groundwater Survey, 2009). The likelihood of sea water intrusion is further increased by the highly porous nature of the underlying coral limestone formation and reduced rates of groundwater recharge as urban centres and roads are paved (Tole, 1997). Therefore, safe yield of groundwater aquifers should allow acceptable levels of impact and protects the higher value uses that have a dependency on the water (Evans, 2002).

Salts in soil and/or water can reduce water availability to the crop affecting yields. Electrical conductivity (EC) or total
dissolved solids (TDS) measure salinity of the soil water, directly affected by the EC of the irrigation water (Compton, 2011). The infiltration rates are particularly sensitive to SAR and salinity (Ayers and Westcott, 1985; Oster, 2001) and soil solution SAR and salinity are closely linked to the SAR and salinity of the irrigation water (Oster, 2001). Thus when salt levels are too high, salinity hazard may exist if salt accumulates in the crop root zone to a concentration that causes a loss in yield (Ayer, 1985; Peterson, 1999). The microbial safety of water is of particular concern to effluent irrigation.

Previous studies in the area (Caswell, 1953; Gentile, 1965; Austrominerall, 1980; Adam, 1982; Majanga, 1987; Tole, 1997) have excluded the Ramisi area, concentrating on Tiwi, Ukunda and Msambweni parts of the Coastline. All these studies, except Gichaba et al., (1992), expressed concern of imminent sea water intrusion and recommended that groundwater abstraction should be limited and further drilling controlled. As the more easily accessed surface water resources are already being used, pressure on groundwater is growing due to the availability of cheap drilling and pumping technologies and energy subsidies distorting decisions about exploiting groundwater (Mumma, 2011). The digging of unlicensed boreholes in the area coupled with massive over abstraction, has brought into focus the need for a sober look at the sustainable use of groundwater and hence the need for conducting this study. Although groundwater exploitation has potential for boosting water supplies in Kenya, its use is limited by poor water quality, overexploitation, saline intrusion along the coastal areas, and inadequate knowledge of the occurrence of the resource (MoWI, 2009). Availability of water is critical to the overall success of KISCOL operations. It is for this reason that 37 boreholes were drilled to bridge the water demand gap. However, the suitability and quality of water produced from the bore holes for agricultural and domestic uses is uncertain. Therefore, this study was undertaken to assess the suitability of the KISCOL proposed water sources for sustainable domestic use and irrigation to produce the required volume of raw materials to fulfill the company’s demands.

**MATERIALS AND METHODS**

**Study area sampling and sample collection**

Sampling was done at the KISCOL nucleus area, straddling 15,000 acres of land and bound approximately by latitudes 3.6° and 4.6°S and longitudes 38.6° and 39.6°E and running along the Indian Ocean. River Ramisi was sampled at three representative points. Koromojo Dam, on River Mkurumudzi, was also sampled to complete surface water analysis. 11 groundwater sources within 3km of the Indian Ocean’s shores, and also within the latitudes and longitudes described were sampled. Surface water samples were collected beneath the surface in quiescent areas. The sampling container was opened beneath the water surface with the mouth directed toward the current to avoid collecting surface scum. Grab samples, as opposed to composite samples, was the only mode of sample collection. Water samples from boreholes were accessed through hand pumps that consumers utilize to draw water. However, for samples for microbiological analysis, sterilization of the draw-off points through heating with a gas stove were necessary. 1-Litre plastic sampling bottles were used for physico-chemical parameters and sterilized glass bottles for microbiological parameters.

**Analysis of the samples**

**Organic constituents’ tests**

The pH, Biological oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO) and electrical conductivity were measured using digital probes nd TDS estimated as (EC × 0.65) ppm.

**Turbidity**

Fuller’s earth method was used to estimate turbidity. 100mg of Fuller’s Earth was suspended in 100ml distilled water to give approximately 1,000 Jackson Turbidity Units (JTU). A set of dilutions of this standard were prepared to yield the desired turbidities in 10ml volumes in test tubes and compared with water samples. 10ml of well mixed sample was placed in clean test tube and compared with standards and visualized which standard was closest in turbidity to the water sample.

**Total alkalinity**

100ml of water sample was measured in a conical flask and 2 drops of Phenolphalein indicator added to the water with the appearance of a reddish pink colour. The water sample was titrated with 0.02N Sulphuric acid until the pink tinge just disappears. 2 drops of the mixed indicator was added and the sample further titrated until the pink tinge reappears. The total alkalinity was calculated using the formula below;

\[
\text{Total alkalinity mgCaCO}_3/l = \frac{A \times C \times 50,000}{\text{ml of sample}}
\]

Where: A = ml of acid used to final pinkish end point, B = concentration of acid.
Total hardness
The EDTA titration method was adopted for total hardness estimation. 50ml of sample in conical flask will be mixed with 2ml of buffer solution. 2ml of Eriochrome Black T indicator was added producing a reddish colour. The water sample was titrated with 0.01M EDTA until the reddish tinge changes to a blue colour and total hardness calculated using the formula below:

\[
\text{Total Hardness } \frac{\text{mgCaCO}_3}{\text{L}} = \left( A \times B \times 1,000 \right)/\text{ml of sample}
\]

Where: \( A \) = ml of EDTA used, \( B \) = mgCaCO\(_3\) equivalent to 1 ml EDTA titrant

Calcium hardness
50ml of sample in conical flask was mixed with 2ml of NaOH solution, 2 drops of Murexide indicator added to produce a pink colour. The water sample was titrated with 0.01M EDTA until the pink tinge changes to a purple colour and calcium hardness calculated using the formula below:

\[
\text{mgCaCO}_3/\text{L} = \left( A \times B \times 400.8 \right)/\text{ml of sample}
\]

Where: \( A \) = ml of EDTA used, \( B \) = mgCaCO\(_3\) equivalent to 1 ml EDTA titrant

Magnesium hardness
The hardness due to Mg\(^{2+}\) was simply calculated from values of Total and Calcium Hardness as follows: \( \text{mgMg}\)/l = [Total Hardness – Calcium hardness \times 0.244]

Chlorides and salinity
50ml of water sample was measured into a conical flask and 0.5ml of K\(_2\)CrO\(_4\) indicator solution added. The sample was then be titrated with AgNO\(_3\) to a pinkish yellow end point. Reagent blank value is established after the end point is reached and chloride concentration calculated using the formula below:

\[
\text{mgCl}/\text{L} = \left( A - B \right) \times N \times 35,450/\text{ml of sample}
\]

Where: \( A \) = ml of AgNO\(_3\) for sample, \( B \) = ml of AgNO\(_3\) for blank, \( N \) = Normality of AgNO\(_3\)

Salinity is calculated as a function of Chloride content as follows; \( \text{mgNaCl}/\text{l} = \text{mgCl}/\text{l} \times 1.65 \)

Free carbon dioxide
Potentiometric titration to pH 8.3 was the method used. A suitable sample was peppered into titration flasks and pH measured. If pH was above 4.0 5-mL increments of 0.02N sulfuric acid were added to reduce pH to 4 or less, electrodes removed and 5 drops of 30% H\(_2\)O\(_2\) added and boiled for 2 to 5 min. Cooled to room temperature and titrated with standard NaOH to pH 8.3. Titrated to preselected end-point pH without recording intermediate pH values. As the end point is approached, smaller additions of NaOH were made ensuring that the pH equilibrium is reached before making the next addition. Calculation:

\[
\text{mg CO}_2/\text{L} = \frac{A \times N \times 44000}{\text{ml sample}}
\]
Where: \( A = \text{ml NaOH titrant used}, \ B = \text{normality of NaOH}, \ C = \text{ml H}_2\text{SO}_4 \text{ used and} \ D = \text{normality of H}_2\text{SO}_4 \)

**Sulphates**

Turbidimetric method will be used to estimate the sulphate level. Sulphate standards of 5, 10, 15, 20, 25, ppm in 50ml will be prepared from the stock solution. The turbidity of the sample and standards will be measured in the Nephelometer. To 50ml of sample and standards, 2.5ml of conditioning reagent will be added and stirred and while stirring, a spoonful of BaCl\(_2\) crystals will be added. Solution will be stirred for further 60 seconds and turbidity measured once again for sample and standards. A calibration curve of Nepheloturbidimetric Units (NTU) against concentration of the standards will be plotted. The concentration of the water sample will then be deduced from the calibration curve using the formula:

\[
\text{mgSO}_4^{2-}/\text{l} = \text{turbidity after addition of BaCl}_2 - \text{initial turbidity} - \text{slope in calibration curve}
\]

**Metals**

Flame atomic absorption spectrometry was used. Standard solutions of known metal concentrations were prepared in water with a matrix similar to the sample. Standards that bracket expected sample concentration and were within the method’s working range were used. For samples containing high and variable concentrations of matrix materials, the major ions in the sample and the dilute standard was made similar. If the sample matrix is complex and components cannot be matched accurately with standards, use was made of the method of standard additions. All data was reported as ppm metal (i.e. milligrams metal per litre). Samples were filtered prior to use and the sample aspirated into the flame. Since the spectrometer uses a different lamp for each metal to be analysed, complete analysis of one metal was done (calibration curve and duplicate sample measurements) before commencing analysis of another metal. Metals to be determined by AAS included Manganese, Iron, Sodium, Potassium and Calcium.

**Microbiological levels**

The Petri film of E.coli/Coliform Count Plate was placed on a flat surface. The top film was lifted, the pipette held perpendicular to the plate and 1mL of sample carefully dispensed onto the centre of the bottom film. The top film was rolled down onto the liquid, avoiding the entrapment of air bubbles under the top film. The plastic all-purpose spreader was oriented with the smooth side down (ridge side up) and placed on the top film over the liquid sample. The centre of the spreader was pressed gently to distribute the sample evenly while avoiding sliding or twisting the spreader on the film. The spreader was removed and the plate left undisturbed for one minute to allow the gel to solidify. Inoculated plates were incubated in a horizontal position (clear side up) at 35°C for 24 hours. The plates were incubated for a further 24 hours at 35°C to detect any additional *E.coli* growth.

**Data Analysis**

Analysis results obtained was compared against regulatory guideline values for irrigation water to draw inferences regarding their suitability for intended purpose. Raw data acquired in the study was analysed by the MS Excel’s ANOVA function to obtain descriptive and inferential statistics.

**RESULTS**

**Physical and chemical properties of KISCOL proposed water source**

The proposed water sources had fairly good physical composition, with most parameters tested falling within the regulatory limits cited by NEMA (2006). Most surface water sources had higher turbidities compared to their ground water counterparts (Table 1).

A few of the sources returned pH values just above or just below the 6.5-8.5 guideline values, but that is not a worrying feature for utilization of the sources. Turbidity values for Koromojo Dam, Kidzumbani Spring and Gonjora well exceeded the 25 NTU permissible levels for domestic water use. Other physico-chemical properties such as salinity and sea water intrusion have a significant bearing on the focus of the study. Makambani Borehole slightly surpasses the 1,200 mg/l maximum permissible limit for TDS, while River Ramisi exceeds limits for Conductivity, Chlorides, TDS and therefore Salinity. All the other sources returned values within the bounds of the regulatory limits. Data analysis for conductivity returns a p-value of 8.43×10\(^{-4}\) and an F factor of 18.2 against an F critical figure of 4 indicate that both of these are indicative of highly significant differences between the
EC of surface water and that of ground water. Surprisingly though, it is apparent that surface water salinities are much higher than ground water salinity.

Table 1: Physico-chemical properties of KISCOL proposed water sources

<table>
<thead>
<tr>
<th>Sampling site</th>
<th>pH</th>
<th>Physical parameter ± SE</th>
<th>Turbidity (NTU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koromojo dam</td>
<td>7.670±0.5380</td>
<td>71.667±0.5380</td>
<td>125.000±44.7886</td>
</tr>
<tr>
<td>Mkurumudzi river</td>
<td>8.416±0.9804</td>
<td>63.333±4.3433</td>
<td>4.333±1.4343</td>
</tr>
<tr>
<td>Mkanda stream (Mkurumudzi)</td>
<td>8.410±0.7162</td>
<td>33.333±4.3433</td>
<td>2.667±1.4343</td>
</tr>
<tr>
<td>Ramisi river (Upstream)</td>
<td>8.630±0.8638</td>
<td>63.333±28.6865</td>
<td>20.000±15.1116</td>
</tr>
<tr>
<td>Ramisi River (Midstream)</td>
<td>8.743±0.9954</td>
<td>81.667±4.3433</td>
<td>34.000±6.5729</td>
</tr>
<tr>
<td>Ramisi River (Downstream)</td>
<td>8.280±0.0896</td>
<td>53.333±7.1716</td>
<td>3.333±1.4343</td>
</tr>
<tr>
<td>Ramisi River (Bridge)</td>
<td>8.293±0.3308</td>
<td>51.667±7.1716</td>
<td>4.667±5.1715</td>
</tr>
<tr>
<td>Vidungeni Shallow Well</td>
<td>7.440±0.2865</td>
<td>5.000±0.0000</td>
<td>3.000±2.4843</td>
</tr>
<tr>
<td>Kidzumbani Spring</td>
<td>6.620±0.5599</td>
<td>196.667±14.3433</td>
<td>80.000±4.9687</td>
</tr>
<tr>
<td>Makambani Borehole</td>
<td>7.663±1.1970</td>
<td>0.000±0.0000</td>
<td>0.000±0.0000</td>
</tr>
<tr>
<td>Milalani Pry School Borehole</td>
<td>8.596±0.5645</td>
<td>10.000±0.0000</td>
<td>0.000±0.0000</td>
</tr>
<tr>
<td>Kingwede Borehole</td>
<td>8.393±0.8349</td>
<td>1.667±7.1716</td>
<td>0.000±0.0000</td>
</tr>
<tr>
<td>Barabarani Shallow Well</td>
<td>7.280±0.6300</td>
<td>30.000±0.0000</td>
<td>0.333±1.4343</td>
</tr>
<tr>
<td>Gonjora Well</td>
<td>6.740±0.1629</td>
<td>367.000±32.8645</td>
<td>70.667±8.7247</td>
</tr>
<tr>
<td>Tuliani Borehole</td>
<td>6.446±0.0379</td>
<td>0.000±0.0000</td>
<td>0.000±0.0000</td>
</tr>
<tr>
<td>KISCOL existing Borehole</td>
<td>7.526±0.9571</td>
<td>0.000±0.0000</td>
<td>0.333±1.4343</td>
</tr>
<tr>
<td>KISCOL new Borehole</td>
<td>6.240±0.0896</td>
<td>0.000±0.0000</td>
<td>16.667±8.7247</td>
</tr>
<tr>
<td>Kibaoni Shallow Well</td>
<td>8.6967±0.5743</td>
<td>0.000±0.0000</td>
<td>0.000±0.0000</td>
</tr>
</tbody>
</table>

Table 2: Physico-chemical properties of KISCOL proposed water sources

<table>
<thead>
<tr>
<th>Sampling site</th>
<th>Conductivity (µs/cm)</th>
<th>TDS (mg/l)</th>
<th>Chlorides (mg/l)</th>
<th>Salinity (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koromojo dam</td>
<td>276.67±7.99</td>
<td>170.40±6.49</td>
<td>45.67±2.87</td>
<td>75.35±4.73</td>
</tr>
<tr>
<td>Mkurumudzi river</td>
<td>264.00±6.58</td>
<td>166.32±8.39</td>
<td>35.33±5.74</td>
<td>58.30±9.47</td>
</tr>
<tr>
<td>Mkanda stream (Mkurumudzi)</td>
<td>404.67±7.99</td>
<td>250.17±3.35</td>
<td>79.00±13.83</td>
<td>130.35±22.82</td>
</tr>
<tr>
<td>Ramisi river (Upstream)</td>
<td>5,646.67±127.49</td>
<td>3,521.48±14.91</td>
<td>1,552.33±87.35</td>
<td>2561.35±144.13</td>
</tr>
<tr>
<td>Ramisi River (Midstream)</td>
<td>5,613.33±94.06</td>
<td>3,483.68±73.80</td>
<td>1458.67±19.30</td>
<td>2406.80±31.84</td>
</tr>
<tr>
<td>Ramisi River (Downstream)</td>
<td>35,300±496.87</td>
<td>21,870.00±390.44</td>
<td>9193.33±199.26</td>
<td>15169.00±328.78</td>
</tr>
<tr>
<td>Ramisi River (Bridge)</td>
<td>33,733.33±717.16</td>
<td>20,826.00±382.20</td>
<td>10566.67±379.49</td>
<td>17435.00±626.15</td>
</tr>
<tr>
<td>Vidungeni Shallow Well</td>
<td>67.00±8.96</td>
<td>41.26±2.99</td>
<td>8.00±0.00</td>
<td>13.20±0.00</td>
</tr>
<tr>
<td>Kidzumbani Spring</td>
<td>52.00±28.65</td>
<td>25.03±4.39</td>
<td>7.67±1.43</td>
<td>12.65±2.37</td>
</tr>
<tr>
<td>Makambani Borehole</td>
<td>2,056.67±287.94</td>
<td>1,237.67±6.25</td>
<td>363.33±14.34</td>
<td>599.50±23.66</td>
</tr>
<tr>
<td>Milalani Pry School Borehole</td>
<td>495.00±31.13</td>
<td>304.10±12.99</td>
<td>18.33±3.79</td>
<td>30.25±6.26</td>
</tr>
<tr>
<td>Kingwede Borehole</td>
<td>590.33±29.11</td>
<td>363.06±29.52</td>
<td>19.33±2.87</td>
<td>31.90±4.73</td>
</tr>
<tr>
<td>Barabarani Shallow Well</td>
<td>272.67±43.76</td>
<td>171.05±3.62</td>
<td>75.33±10.4043</td>
<td>124.30±16.57</td>
</tr>
<tr>
<td>Gonjora Well</td>
<td>65.67±7.99</td>
<td>39.17±1.2922</td>
<td>7.33±1.4343</td>
<td>12.10±2.37</td>
</tr>
<tr>
<td>Tuliani Borehole</td>
<td>512.33±10.04</td>
<td>314.83±3.27</td>
<td>134.67±8.72</td>
<td>222.20±14.40</td>
</tr>
<tr>
<td>KISCOL existing Borehole</td>
<td>415.00±10.83</td>
<td>228.19±4.28</td>
<td>32.33±1.43</td>
<td>53.35±2.37</td>
</tr>
<tr>
<td>KISCOL new Borehole</td>
<td>129.00±16.29</td>
<td>61.31±3.07</td>
<td>53.88±9.46</td>
<td>88.90±15.62</td>
</tr>
<tr>
<td>Kibaoni Shallow Well</td>
<td>812.33±7.99</td>
<td>501.51±2.09</td>
<td>75.33±1.43</td>
<td>124.30±2.37</td>
</tr>
</tbody>
</table>

± = SE

Analysis of metals

Analysis results for metals indicate that most water sources would have mostly trace amounts that would not exceed the regulatory standards stipulated by NEMA, (2006). The Sodium Adsorption Ratio (SAR) figures were not calculated because whereas they are critical for irrigation water, they are outside the scope of this study.

River Ramisi surpassed guideline values for Magnesium, Iron, Sodium and Potassium. Koromojo Dam, Kidzumbani Well and Gonjora Well also exceeded the maximum permissible value for Iron while both KISCOL boreholes exceeded the Potassium levels.
Hardness and associated parameters
This set of parameters was analysed to find out the levels of water hardness, alkalinity and free carbon dioxide. The Total Hardness and Total Alkalinity have a bearing on the scaling and utility of water in plant machinery. Except for River Ramisi, all the other sources fell within the limits stipulated under irrigation water quality guidelines. The high alkalinity recorded for River Ramisi at the bridge could be due to anthropogenic point source pollution from farmlands just before the bridge.

Nutrients
Analysis of nutrients expected to be in minimal amounts in the water sources at KISCOL was undertaken. While most of these nutrients might not have a critical bearing on the irrigation water, they could serve as an indicator of future trends. Only River Ramisi returned Fluoride and Sulphate levels above the 1.5 mg/l and 2,000 mg/l permissible in irrigation water. All the other samples had levels of nutrients below the permissible levels for irrigation water.

Microbiological analysis
The water sources proposed by KISCOL had a significant level of coliform bacteria. However, all the surface water sources had fecal coliform while in the ground water sources only Milalani Primary School Borehole and Tuliani Borehole were contaminated with fecal coliform (Table 6).

There were significant differences in coliform counts between the surface and ground water sources proposed by KISCOL (p<0.05). However, the surface water had an average coliform count of 432 per 100 ml (against the regulatory standard of 1,000 per 100 ml) and E.coli count of 290 per 100 ml (against the regulatory standard of Nil per 100 ml) attesting to less than desirable quality. Ground water sources returned better figures with an average of 19 per 100 ml coliform count and only 3 per 100 ml for E.coli.

DISCUSSION
Even though fifteen groundwater sources had been targeted in the project design, only eleven could be found within the 3km distance from the shore, which defined waters likely to be affected by sea water intrusion. To obtain meaningful data that can render clear insights into the status of the samples with regard to the levels of salinity obtaining, the raw data was clustered into groups of River Mkurumudzi, Upstream and Midstream River Ramisi, Downstream and River Ramisi Bridge at the A14 Lunga Lunga Highway and Groundwater.

Electrical conductivity and total dissolved solids are the major indicative chemical parameters for irrigation water salinity (Ayer, 1985). However, due to the observed differences in the nature of surface and groundwater sources, these two were treated separately in an effort to obtain more discernible inferences. Seven surface water and eleven groundwater sampling sites had three replicate analyses undertaken. From the data, it is apparent that salinity levels of groundwater sources approximate closely to those of River Mkurumudzi while there is a huge difference for figures between Upstream and Midstream River Ramisi and Downstream and River Ramisi Bridge. It is also discernible that only the River Ramisi figures exceed the irrigation water maximum guideline value for conductivity of 3000 µs/cm.

Considering the World Health Organisation standards as described by Bauder, (2005) and Ayer and Westcot, (1985), it is evident that Ramisi River is an inappropriate source for cane irrigation. The minimum EC recorded was 5,613.3333µs/cm for Midstream Ramisi River. This is way higher than the recommended limit of 3000µs/cm. With the maximum EC at 35300µs/cm Downstream. Ramisi River should only be considered as a viable water source with interventions to radically alter its salinity levels. Further, there is a huge spike in EC as you approach the Indian Ocean (5,613.3333 to 35,300µs/cm). This can only be explained as a factor of sea water intrusion on the river water, with sea water ingress being experienced during high tides.

As feared at the onset of the study, the data collected attests to very high salinity levels for River Ramisi. From results of the study, it is evident EC values are such that it is inconceivable that KISCOL would consider utilizing this source barring some expensive and time consuming amelioration interventions. The river salinity profile indicates that EC rise drastically 6-folds over a distance of 3km between the Midstream and downstream sampling points. This drastic rise is indicative of the sea water intrusion that the river suffers from the Indian Ocean, particularly during high tides when the Ocean’s water can visibly be noticed rising up the river.
### Table 3: Analysis of metals ± SE of KISCOL proposed water sources

<table>
<thead>
<tr>
<th>Sampling site</th>
<th>Iron (mg/l)</th>
<th>Manganese (mg/l)</th>
<th>Calcium (mg/l)</th>
<th>Magnesium (mg/l)</th>
<th>Sodium (mg/l)</th>
<th>Potassium (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koromojo dam</td>
<td>4.21±1.096</td>
<td>0.016±0.0143</td>
<td>10.80±0.8957</td>
<td>5.82±0.58</td>
<td>38.70±0.895</td>
<td>1.53±0.7590</td>
</tr>
<tr>
<td>Mkurumudzi river</td>
<td>1.24±0.245</td>
<td>0.200±0.0000</td>
<td>11.20±3.5829</td>
<td>5.78±0.20</td>
<td>34.13±2.2949</td>
<td>1.50±2.2949</td>
</tr>
<tr>
<td>Mkanda stream</td>
<td>1.13±0.352</td>
<td>1.63±0.9406</td>
<td>13.60±5.258</td>
<td>9.84±0.31</td>
<td>56.33±1.1202</td>
<td>2.36±0.5172</td>
</tr>
<tr>
<td>Ramisi river (Upstream)</td>
<td>1.22±0.633</td>
<td>0.000±0.0000</td>
<td>74.60±20.9318</td>
<td>0.03±0.03</td>
<td>1.20±2.5248</td>
<td>17.33±12.2549</td>
</tr>
<tr>
<td>Ramisi River (Midstream)</td>
<td>1.65±0.923</td>
<td>0.000±0.0000</td>
<td>54.93±42.4219</td>
<td>24.39±0.25</td>
<td>1.18±26.711</td>
<td>14.33±6.2521</td>
</tr>
<tr>
<td>Ramisi River (Downstream)</td>
<td>0.53±0.485</td>
<td>0.000±0.0000</td>
<td>263.36±48.8000</td>
<td>1030.8±2249</td>
<td>5.91±71.775</td>
<td>79.66±3.7949</td>
</tr>
<tr>
<td>Ramisi River (Bridge)</td>
<td>0.72±0.728</td>
<td>0.000±0.0000</td>
<td>305.56±27.3636</td>
<td>650.20±6070</td>
<td>5.94±75.558</td>
<td>81.66±7.1716</td>
</tr>
<tr>
<td>Vidugeni Shallow Well</td>
<td>0.30±0.114</td>
<td>0.020±0.0000</td>
<td>3.63±1.8646</td>
<td>1.84±0.23</td>
<td>6.32±0.3569</td>
<td>0.73±0.1434</td>
</tr>
<tr>
<td>Kidzumbani Spring</td>
<td>2.51±0.398</td>
<td>0.05±0.0143</td>
<td>0.00±0.0000</td>
<td>1.64±0.62</td>
<td>5.33±0.4962</td>
<td>0.26±0.2869</td>
</tr>
<tr>
<td>Makambani Borehole</td>
<td>0.00±0.000</td>
<td>0.00±0.0000</td>
<td>53.06±2.8794</td>
<td>73.08±1.74</td>
<td>260.0±17.3903</td>
<td>1.46±0.2869</td>
</tr>
<tr>
<td>Milalani Pry School Borehole</td>
<td>0.00±0.000</td>
<td>0.00±0.0000</td>
<td>30.66±0.6252</td>
<td>14.70±2.84</td>
<td>47.46±2.869</td>
<td>0.96±0.7590</td>
</tr>
<tr>
<td>Kingwede Borehole</td>
<td>0.00±0.000</td>
<td>0.00±0.0000</td>
<td>36.66±2.1419</td>
<td>8.77±0.1045</td>
<td>77.53±2.7365</td>
<td>0.26±0.2869</td>
</tr>
<tr>
<td>Barabarani Shallow Well</td>
<td>1.39±0.972</td>
<td>0.02±0.0000</td>
<td>8.36±0.5737</td>
<td>2.18±0.56</td>
<td>48.53±0.1434</td>
<td>1.40±0.2484</td>
</tr>
<tr>
<td>Gonjora Well</td>
<td>1.86±0.676</td>
<td>0.00±0.0000</td>
<td>1.60±0.2484</td>
<td>0.72±0.49</td>
<td>10.96±1.1928</td>
<td>0.40±0.2484</td>
</tr>
<tr>
<td>Tuliani Borehole</td>
<td>0.36±0.732</td>
<td>0.00±0.0000</td>
<td>5.33±0.8725</td>
<td>6.94±0.28</td>
<td>97.46±4.3905</td>
<td>1.56±0.6252</td>
</tr>
<tr>
<td>KISCOL existing Borehole</td>
<td>0.00±0.000</td>
<td>0.00±0.0000</td>
<td>46.16±2.8794</td>
<td>73.08±1.74</td>
<td>260.0±17.3903</td>
<td>1.46±0.2869</td>
</tr>
<tr>
<td>KISCOL new Borehole</td>
<td>0.18±0.323</td>
<td>0.52±0.5178</td>
<td>13.60±3.3607</td>
<td>0.71±0.52</td>
<td>65.86±3.8833</td>
<td>32.63±26.6754</td>
</tr>
<tr>
<td>Kidzumbani Shallow Well</td>
<td>0.00±0.000</td>
<td>0.00±0.0000</td>
<td>33.10±8.1757</td>
<td>26.39±0.5075</td>
<td>96.56±6.0870</td>
<td>1.83±0.1434</td>
</tr>
</tbody>
</table>

### Table 4: Analysis of Hardness and associated parameters of KISCOL proposed water sources

<table>
<thead>
<tr>
<th>Sampling site</th>
<th>Total hardness (mg CaCO₃)</th>
<th>Total alkalinity (mg CaCO₃)</th>
<th>Free CO₂ (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koromojo dam</td>
<td>63.00±23.6990</td>
<td>72.66±12.5042</td>
<td>10.00±0.0000</td>
</tr>
<tr>
<td>Mkurumudzi river</td>
<td>53.66±6.2521</td>
<td>74.33±5.1715</td>
<td>10.00±0.0000</td>
</tr>
<tr>
<td>Mkanda stream (Mkurumudzi)</td>
<td>68.33±21.4191</td>
<td>71.33±10.3431</td>
<td>10.00±0.0000</td>
</tr>
<tr>
<td>Ramisi river (Upstream)</td>
<td>179.00±64.4490</td>
<td>643.00±118.8588</td>
<td>0.00±0.0000</td>
</tr>
<tr>
<td>Ramisi River (Midstream)</td>
<td>206.33±43.1968</td>
<td>607.66±83.5980</td>
<td>0.00±0.0000</td>
</tr>
<tr>
<td>Ramisi River (Downstream)</td>
<td>4.00±0.0000</td>
<td>3.00±0.0000</td>
<td>8.50±0.0000</td>
</tr>
<tr>
<td>Ramisi River (Bridge)</td>
<td>3.00±0.0000</td>
<td>689.66±141.8533</td>
<td>11.33±2.8687</td>
</tr>
<tr>
<td>Vidugeni Shallow Well</td>
<td>15.66±1.4343</td>
<td>15.66±5.1715</td>
<td>9.33±5.7373</td>
</tr>
<tr>
<td>Kidzumbani Spring</td>
<td>7.33±2.8687</td>
<td>11.00±6.5729</td>
<td>15.33±7.1716</td>
</tr>
<tr>
<td>Makambani Borehole</td>
<td>436.66±75.897</td>
<td>391.33±137.3662</td>
<td>24.00±8.6060</td>
</tr>
<tr>
<td>Milalani Pry School Borehole</td>
<td>140.00±24.8433</td>
<td>199.00±57.8907</td>
<td>25.33±10.3431</td>
</tr>
<tr>
<td>Kingwede Borehole</td>
<td>129.33±2.8687</td>
<td>208.66±98.6666</td>
<td>25.33±10.3432</td>
</tr>
<tr>
<td>Barabarani Shallow Well</td>
<td>30.66±7.5897</td>
<td>26.33±16.5415</td>
<td>8.66±2.8687</td>
</tr>
<tr>
<td>Gonjora Well</td>
<td>6.66±5.1715</td>
<td>21.66±8.7247</td>
<td>7.66±1.4343</td>
</tr>
<tr>
<td>Tuliani Borehole</td>
<td>40.00±17.9147</td>
<td>50.66±22.4049</td>
<td>20.33±8.7247</td>
</tr>
<tr>
<td>KISCOL existing Borehole</td>
<td>242.00±19.7187</td>
<td>239.00±21.2261</td>
<td>1.33±2.8687</td>
</tr>
<tr>
<td>KISCOL new Borehole</td>
<td>19.66±20.2337</td>
<td>16.00±9.9373</td>
<td>2.00±0.0000</td>
</tr>
<tr>
<td>Kibaoni Shallow Well</td>
<td>153.66±72.6993</td>
<td>280.66±97.5658</td>
<td>17.33±5.1715</td>
</tr>
</tbody>
</table>
Table 5: Analysis of nutrients of KISCOL proposed water sources

<table>
<thead>
<tr>
<th>Sampling site</th>
<th>Fluorides (mg/l)</th>
<th>Nitrates (mgN/l)</th>
<th>Nitrites (mgN/l)</th>
<th>Sulphates (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koromojo dam</td>
<td>0.433±0.7986</td>
<td>0.753±0.1004</td>
<td>0.076±0.0379</td>
<td>0.000±0.0000</td>
</tr>
<tr>
<td>Mkurumudzi river</td>
<td>0.633±0.5737</td>
<td>0.703±0.2656</td>
<td>0.000±0.0000</td>
<td>1.466±0.1434</td>
</tr>
<tr>
<td>Mkanda stream (Mkurumudzi)</td>
<td>0.166±0.1434</td>
<td>1.356±0.2879</td>
<td>0.000±0.0000</td>
<td>0.700±0.4969</td>
</tr>
<tr>
<td>Ramisi river (Upstream)</td>
<td>5.400±1.3146</td>
<td>11.933±4.4186</td>
<td>0.000±0.0000</td>
<td>9.800±5.4486</td>
</tr>
<tr>
<td>Ramisi River (Midstream)</td>
<td>5.333±0.7986</td>
<td>13.167±3.4454</td>
<td>0.000±0.0000</td>
<td>8.566±3.4842</td>
</tr>
<tr>
<td>Ramisi River (Downstream)</td>
<td>1.333±0.6252</td>
<td>56.633±12.9812</td>
<td>0.000±0.0000</td>
<td>570.033±7.9511</td>
</tr>
<tr>
<td>Mkurumudzi River</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vidungeni Shallow Well</td>
<td>0.166±0.1225</td>
<td>0.343±0.0379</td>
<td>0.000±0.0000</td>
<td>0.000±0.0000</td>
</tr>
<tr>
<td>Kidzumbani Spring</td>
<td>0.183±0.0941</td>
<td>0.616±0.1225</td>
<td>0.050±0.0430</td>
<td>0.300±0.0000</td>
</tr>
<tr>
<td>Makambani Borehole</td>
<td>0.363±0.5342</td>
<td>5.533±1.0040</td>
<td>0.030±0.0000</td>
<td>34.433±3.5944</td>
</tr>
<tr>
<td>Milalani Pry School Borehole</td>
<td>0.183±0.1004</td>
<td>1.966±1.8312</td>
<td>0.020±0.0000</td>
<td>3.966±1.0343</td>
</tr>
<tr>
<td>Kingwede Borehole</td>
<td>0.143±0.0517</td>
<td>3.066±1.2504</td>
<td>0.020±0.0000</td>
<td>1.866±1.1740</td>
</tr>
<tr>
<td>Barabarani Shallow Well</td>
<td>0.130±0.0896</td>
<td>0.926±0.1881</td>
<td>0.000±0.0000</td>
<td>3.133±0.6252</td>
</tr>
<tr>
<td>Gonjora Well</td>
<td>0.096±0.0517</td>
<td>0.430±0.0430</td>
<td>0.050±0.0248</td>
<td>0.000±0.0000</td>
</tr>
<tr>
<td>Tuliani Borehole</td>
<td>0.170±0.0248</td>
<td>0.490±0.3944</td>
<td>0.000±0.0000</td>
<td>3.600±1.5515</td>
</tr>
<tr>
<td>KISCOL existing Borehole</td>
<td>0.160±0.0861</td>
<td>0.033±0.0799</td>
<td>0.000±0.0000</td>
<td>27.466±4.8066</td>
</tr>
<tr>
<td>KISCOL new Borehole</td>
<td>0.170±0.1291</td>
<td>0.013±0.0143</td>
<td>0.000±0.0000</td>
<td>35.000±5.1695</td>
</tr>
<tr>
<td>Kibaoni Shallow Well</td>
<td>0.133±0.0379</td>
<td>0.900±0.0861</td>
<td>0.000±0.0000</td>
<td>6.400±1.0829</td>
</tr>
</tbody>
</table>

The inferential analysis sought to determine whether there are significant differences at 95% confidence level in EC and therefore salinity between the surface and groundwater sources. If significant, the differences can be interpreted to mean that their continued aggravation by avaricious abstraction by the Ramisi sugar factory could irreversibly affect the quality of the waters around the Ramisi area, and in particular its salinity, which is the prime focus of this study. This would mainly be due to sea water intrusion, and to a lesser extent as a factor of the resultant upsetting of the water balance.

Ramisi River and Mkurumudzi River are the only two surface water sources KISCOL intends to utilize for cane sugar production. Therefore, adopting EC as a yardstick for assessing irrigation water salinity (Ayer, 1985); it is clear that no challenges would emanate from the Mkurumudzi River and its dam, Koromojo. This is because the highest figure returned from the source was 404.6667µs/cm from the Mkanda Stream, with a mean of 315 µs/cm overall. Both these figures are well below the maximum guideline value of 3000 µs/cm.

Table 6: Total and fecal coliform counts in KISCOL proposed surface and ground water sources

<table>
<thead>
<tr>
<th>Sampling site</th>
<th>Mean coliform cont/100ml ± SE</th>
<th>Mean E. coli count/100ml ± SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface water sources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Koromojo Dam</td>
<td>147.666±103.2217</td>
<td>23.000±0.0000</td>
</tr>
<tr>
<td>Mkurumudzi River</td>
<td>221.666±47.2893</td>
<td>22.000±8.6060</td>
</tr>
<tr>
<td>Mkanda Stream (Mkurumudzi)</td>
<td>119.333±40.9976</td>
<td>8.666±7.9860</td>
</tr>
<tr>
<td>River Ramisi Upstream</td>
<td>123.666±56.9953</td>
<td>13.333±12.2549</td>
</tr>
<tr>
<td>River Ramisi Midstream</td>
<td>435.333±53.5908</td>
<td>436.666±51.7154</td>
</tr>
<tr>
<td>River Ramisi Downstream</td>
<td>823.333±37.9487</td>
<td>710.000±49.6865</td>
</tr>
<tr>
<td>River Ramisi Bridge</td>
<td>1150.000±124.2163</td>
<td>816.666±37.9487</td>
</tr>
<tr>
<td>Ground water sources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vidungeni Shallow Well</td>
<td>5.333±10.3431</td>
<td>0.000</td>
</tr>
<tr>
<td>Kidzumbani Spring</td>
<td>5.333±2.8687</td>
<td>0.000</td>
</tr>
<tr>
<td>Makambani Borehole</td>
<td>11.000±4.3030</td>
<td>0.000</td>
</tr>
<tr>
<td>Milalani Pry School Borehole</td>
<td>81.000±2.4843</td>
<td>15.000±11.3846</td>
</tr>
<tr>
<td>Kingwede Borehole</td>
<td>4.333±6.2521</td>
<td>0.000</td>
</tr>
<tr>
<td>Barabarani Shallow Well</td>
<td>7.333±12.2549</td>
<td>0.000</td>
</tr>
<tr>
<td>Gonjora Well</td>
<td>7.333±14.3433</td>
<td>0.000</td>
</tr>
<tr>
<td>Tuliani Borehole</td>
<td>72.000±2.4843</td>
<td>18.000±12.9089</td>
</tr>
<tr>
<td>KISCOL existing Borehole</td>
<td>3.333±2.8687</td>
<td>0.000</td>
</tr>
<tr>
<td>KISCOL new Borehole</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Kibaoni Shallow Well</td>
<td>10.000±7.4530</td>
<td>0.000</td>
</tr>
</tbody>
</table>
Ground water characteristics of the area, salinity in particular, exhibit surprising traits indicative of what can be described as a desirable data set insofar as irrigation water is concerned. Not only are the indicators for salinity (EC and TDS) both depressed, they are less than figures for salinity of River Ramisi in the same locality. In fact, other than the Makambani Borehole the rest of the sources average 341µs/cm. It can therefore be said with authority, that the risk of sea water intrusion as a direct result of over abstraction of ground water is remote.

The salinity levels exhibited are so high that major and expensive interventions would be required to render the water available for the intended uses. This finding deals a major blow to plans by KISCOL to revive the cane plant. This is because the major reliance for water supply for domestic and irrigation uses was first surface sources, represented by Rivers Ramisi and Mkurumudzi, and groundwater as a supplementary source. Sea water intrusion was a concept studied in the project with regard to the potential for fouling up the Msambweni groundwater aquifer as a consequence of over abstraction of groundwater. The threat of sea water intrusion can thus be eliminated in the foreseeable future, even with the drilling of the 37 boreholes contemplated by KISCOL. This is good news for the proponent, considering the apparent low utility value of the Ramisi River as shown by analysis results.

From the observed levels of microbiological organisms, it can be safely concluded that the microbiological quality of the water does not present any challenge to the utilization of the various water sources for irrigation purposes. However, the water sources shall have to be treated before consumption for domestic purposes.

The source of water KISCOL intends to use is good in terms of microbiological contents (Table 6). The worst condition in this respect is again in midstream and downstream Ramisi River. This can be attributed to the socio-economic activities of populations straddling the River at this point in its migration to the sea. There is much more farming and settlement towards the Ocean than there is upstream, accounting for more river pollution.

**CONCLUSION**

The study disabuses some of the notions that were held at the outset, and also confirm some notions similarly held. The study results indicate that River Mkurumudzi does not suffer the adverse effects of overly saline waters, while River Ramisi is so saline as to render the waters unavailable for use in cane irrigation and other domestic utility. The study indicates that the prevailing EC numbers are so low as to lay to rest the fears of sea water intrusion on the Msambweni groundwater aquifer. The upshot of the study results suggests that KISCOL should concentrate on developing River Mkurumudzi, and its Koromojo Dam, and the groundwater sources for maximum utility in coming up with the huge volumes of water it requires. River Ramisi can only be utilized after certain interventions as recommended in the following discussion.

**RECOMMENDATION**

Salinity control through leaching to reduce the accumulated salts and adequate drainage to control and stabilize the water table is recommended which will help to maintain an acceptable crop yield. Consideration should be given to blending the poorer Ramisi River with the better quality Mkurumudzi River, groundwater supplies, thus increasing the total quantity of usable water available. Future research on the effects of groundwater abstraction from the 37 boreholes after KISCOL has started operating the sugar factory to shed light on the actual effects and not the interpolated effects is paramount. Determination of the interplay of the salinity dynamics between ground and surface waters, their effects on irrigation water quality, and how the two sources can then be utilized in different combinations/ratios to achieve optimal salinity levels for sugarcane irrigation may be a valuable area of research into this industry.

**REFERENCES**


FARMER GROUPS’ CHARACTERISTICS INFLUENCING APPLICATION OF SOIL FERTILITY TECHNOLOGIES IN THE CENTRAL HIGHLANDS OF KENYA

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ABSTRACT
Declining soil fertility is a major problem in East and Central Africa. Soil fertility enhancement (SFE) technologies have been developed, but their uptake has remained low. This first study assessed the influence of farmer groups’ characteristics on the technology application. The study was carried out in Mbeere South and Maara sub-counties in Kenya. Interview schedules were administered to a total sample of 60 farmer groups. Data were analysed using SPSS software. Variables that influenced groups’ application of animal manure were: group size ($p=0.019$), frequency of group meetings ($p=0.050$) and the number of females in the group ($p=0.027$). Variables that influenced application of fertilizer included: Tropical livestock unit ($p=0.045$), group formation prompt ($p=0.098$) and qualification into group membership ($p=0.028$). Variables that influenced application of a combination included: reason for applying a combination ($p=0.003$), number of females in the group ($p=0.067$) and group gender ($p=0.056$). This information will be helpful to the groups, researchers, policy makers, farmers’ training designers and other stakeholders wishing to disseminate technologies in natural resource management programmes.

Key words: Farmers group, Group characteristics, SFE technologies, Animal manure, Inorganic fertilizers, Application

1. INTRODUCTION
Smallholder farmers in Sub-Saharan Africa (SSA) face severe soil fertility crisis (Gonsalves et al., 2005). A survey in Kenya showed high amount of soil nutrient deficiencies caused by continuous cereal cultivation with limited use of fertility inputs (Gonsalves et al., 2005). Research on soil fertility improvement in Central Kenya highlands has generated recommendations for improving soil fertility on smallholder farms (Mugendi et al., 2006). For instance, some herbaceous legumes, leguminous shrubs, cover crops, biomass transfer, and cattle manure technologies applied alone or combined with inorganic fertilizers have been identified as potential soil nutrient replenishment technologies due to their costs, effectiveness, appropriateness, simplicity, and multipurpose nature in meeting the needs of the resource poor farmers (Franzel et al., 2002; Mucheru, 2003).

Despite the obvious benefits of these soil fertility enhancement (SFE) technologies, the adoption rate has been slower than anticipated by the researchers as observed by Adiel (2004). On the other hand, if farmers can adopt these technologies, they can increase their farm productivity up to five-fold (Mugwe et al., 2009). Causes of low adoption may be attributed to the extension methods/approaches used in the dissemination of the soil fertility enhancement innovations among other reasons.
Farmers’ groups is one of the approaches that have been used successfully to catalyze the participation of farmers as partners in research and development activities (CIAT, 2003; Sanginga et al., 2005), and target technology to specific groups (Reddy et al., 2010). Farmers’ groups are community-based and their joint activities therefore have an out-scaling effect on the community (Wennink and Heemskerk, 2006). The smallscale farmers form these farmers’ groups, which are key to up-scaling of technologies and they have self monitoring mechanisms to enforce collective actions through collective activities of the group (Bingen et al., 2003). For example, Peterson et al. (2004) found out that, group members who were not successful with their first attempt to test soil nutrient replenishment technologies (SNRT) continued to use the technologies after visiting other farmers and getting convinced. Kiptot (2007) however showed that the use of the village committee approach was misapplied as the approach assumed that groups are fully appropriate vehicles for technology development and dissemination.

The success of farmer groups depends on various factors which include small group sizes, group maturity and internal factors (common interests, group commitment and trustworthy leadership). Others are external factors (extension agents, researchers) , structural social factors (roles, rules, procedures, social networks) and cognitive (norms, values, attitude and trust) social factors (Ostrom, 1992; Baland and Platteau, 1996; Uphoff and Wijayaratna, 2000; Agrawal, 2001; Haan, 2001; Johnson et al., 2002; Place et al., 2002; Jones, 2004). However, the cumulative effects of these factors and their direct influence on the application of technologies have not been well understood. For instance, Agrawal, (2001) found out that, like group size alone gave different results on group’s success. Therefore, there is a need for more social-economic research to understand how farmer groups view and understand the technologies (Misiko, 2007; Kiptot et al., 2007). This calls for a study that focuses on factors that influence the application of the technologies by the groups.

2. MATERIALS AND METHODS
2.1 Study Area
The study was carried out in Mbeere South and Maara sub-counties in the Central highlands of Kenya. Mbeere South sub-county lies in the Agro-ecological Zone (AEZ) Lower midland 4 and 5 (LM 4 and LM 5), with an altitude of about 800m above sea level (Jaetzold et al., 2007). The average rainfall is between 600-800 mm per year, in a bimodal regime, where long rains come from mid March to June and the short rains from late October to December. The annual mean temperature is between 21.7 to 22.5°C. The sub-county experiences two cropping seasons per year, with the long rains season and the short rains season. The soils are predominantly Ferralsols and Acrisols (Jaetzold et al., 2007), and the predominant land uses are dry land farming and livestock production.

Maara sub-county on the other hand lies in the Agro-ecological Zone (AEZ) Upper Midland (UM2-UM3) (Jaetzold et al., 2007) on the eastern slopes of Mount Kenya, with an altitude of 1500 m above sea level. It receives an average rainfall of 1200-1400mm per annum with a bimodal regime where long rains come from March to June and short rains from October to December. The mean temperature is 20°C. Two cropping seasons are experienced in a year. The sub-county is predominantly maize/coffee growing zone with some dairy enterprises, ranging from 0.1 to 2 ha and an average of 1.2 ha per household. The soils are mainly humic Nitisols (Jaetzold et al., 2007).

2.2. Data collection
A survey was conducted in Mbeere South and Maara sub-counties. Before the survey, enumerators were trained on how to go about data collection. Pre-testing of the survey tools was done on two groups per sub-county and field and direct observations were also used to collect the data.

2.3. Data Analysis
Data cleaning and close examination was done to ensure completeness and consistency in the survey tool. The questions were coded, managed and the responses stored in MS Excel, and later transferred to SPSS software. SPSS, version 12 software, was used for data analysis. Descriptive statistical analysis was applied, involving the use of means, frequencies, percentages, standard deviation. For categorical variables, cross tabulation was carried out by testing for association using Pearson chi-square statistics. In the regression analysis, the group characteristics independent (explanatory) variables while the dependent variables were the farmers’ groups’ technology application. Results were presented in form of tables.

For logistic analysis, various factors were regressed upon the dependent variable “SFE technology application” in a binary logistic model. Such models are used when response variables are binary; that is, they have only two possible outcomes (Agresti & Finlay, 1997). The generic terms for the two possible outcomes are success and failure, and the
“odds” equal the probability of success divided by the probability of failure. A value of 0 was assigned if the farmer group did not apply and 1 if the farmer group applied, giving the regression of non-linear form. In this case a group was considered to have applied if over 80 % of its members had applied the technology and vice versa when 20 % and below of its members had applied the technology. All variables were transformed, coded and included into the Logit regression model to determine which factors/variables significantly influenced the application of animal manure, inorganic fertilizers and a combination of animal manure plus inorganic fertilizers (the soil fertility enhancement technologies) (Table 1).

3. RESULTS AND DISCUSSION
3.1 The effect of farmer groups’ characteristics on the application of SFE technologies
3.1.1 Group characteristics influencing the use of animal manure in Embu and Tharaka-Nithi Counties
The results of the Logit model are presented in (Table 2). The model was significant at p<0.01 and correctly predicted 78.3% of both that applied and those that did not apply animal manure. Group size (p=0.019), frequency of group meetings (p=0.050) and the number of females in the group (p=0.008) were significant in explaining the application of animal manure in Embu and Tharaka-Nithi counties (Table 2).

Number of Females in the Group
The number of females in the groups significantly (β= 0.197, p=0.008) influenced application of animal manure (Table 2). This implies that an increase in the number of women in the groups increased the likelihood of application of animal manure. Explanation for this could be because manure is a resource that is easily available at the household level and hence does not require cash. Another is that manure application happens to be a labour-intensive exercise (Place et al., 2005). Palm et al. (1997) also noted that processing and application of traditional organic materials such as crop residues and organic manure are labour intensive. Women are the main labour providers on the farms (Quisunbing and Pandolfelli, 2008). At the same time, women are known to talk a lot, share a lot and also influence each other easily. Manure application is not a knowledge-intensive exercise and therefore women could apply it with no problem as long as a demonstration on application is done. This agrees with Place et al. (2005) who reported that in Kenya, women who had less education than men excelled in the uptake of soil fertility replenishment technologies as long as explanations were given in the simplest terms possible.

Table7: Definition of study variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent variables</strong></td>
<td></td>
</tr>
<tr>
<td>Application (Manure, inorganic fertilizer, manure + fertilizer)</td>
<td>0 Not applied, 1 Applied</td>
</tr>
<tr>
<td><strong>Independent variables</strong></td>
<td></td>
</tr>
<tr>
<td>Group age</td>
<td>Continuous variable</td>
</tr>
<tr>
<td>Group size</td>
<td>0 Small, 1 Large</td>
</tr>
<tr>
<td>Group gender</td>
<td>1 Male, 2 Female</td>
</tr>
<tr>
<td></td>
<td>3 Mixed</td>
</tr>
<tr>
<td>Educated group</td>
<td>0 Not educate, 1 Educated</td>
</tr>
<tr>
<td>Ages of group members</td>
<td>0 Young</td>
</tr>
<tr>
<td></td>
<td>1 Old</td>
</tr>
<tr>
<td></td>
<td>1 Weekly</td>
</tr>
<tr>
<td>Frequency of group meetings</td>
<td>2 Fortnightly</td>
</tr>
<tr>
<td></td>
<td>3 Monthly</td>
</tr>
<tr>
<td>Meeting venues</td>
<td>0 Members’ homes/farms</td>
</tr>
<tr>
<td></td>
<td>1 Public places</td>
</tr>
<tr>
<td>Tropical Livestock Unit (TLU)</td>
<td>Continuous variable</td>
</tr>
<tr>
<td>Common agenda during group meetings</td>
<td>1 Planning for trainings</td>
</tr>
<tr>
<td></td>
<td>2 Contributions / Benefits</td>
</tr>
<tr>
<td></td>
<td>3 Group investments</td>
</tr>
<tr>
<td>Number of males/females in the group</td>
<td>Continuous variable</td>
</tr>
</tbody>
</table>
Prompt for group formation
0 External influence
1 Internal influence

Qualification of group membership
1 Character / behaviour
2 Family relations
3 Ability to contribute financially

Reason for applying animal manure
1 Soil fertility & structure
2 High cost of fertilizers
3 Availability

Reason for applying inorganic fertilizer
1 Ease of application
2 Fast growth & maturity
3 High yields

Reason for applying a combination
1 High yields
2 Soil fertility & structure
3 Fast growth & maturity

Number of beneficiaries from agricultural activities
Continuous variable

Rating of participation in group activities
1 Fair, 2 Good, 3 V. good

Table 2: Group characteristics influencing application of animal manure technology by groups in the Embu and Tharaka-Nithi Counties

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group age</td>
<td>0.131</td>
<td>0.083</td>
<td>2.497</td>
<td>0.114</td>
<td>1.140</td>
</tr>
<tr>
<td>No of females in the group</td>
<td>0.197**</td>
<td>0.074</td>
<td>7.045</td>
<td>0.008</td>
<td>1.218</td>
</tr>
<tr>
<td>Frequency of group meetings</td>
<td>-0.920*</td>
<td>0.470</td>
<td>3.834</td>
<td>0.050</td>
<td>0.399</td>
</tr>
<tr>
<td>Participation rate</td>
<td>1.068</td>
<td>0.665</td>
<td>2.575</td>
<td>0.109</td>
<td>2.908</td>
</tr>
<tr>
<td>Tropical Livestock Unit</td>
<td>0.120</td>
<td>0.511</td>
<td>0.056</td>
<td>0.814</td>
<td>1.128</td>
</tr>
<tr>
<td>No of males in the group</td>
<td>0.076</td>
<td>0.061</td>
<td>1.583</td>
<td>0.208</td>
<td>1.079</td>
</tr>
<tr>
<td>Group size</td>
<td>-3.898**</td>
<td>1.657</td>
<td>5.535</td>
<td>0.019</td>
<td>0.020</td>
</tr>
</tbody>
</table>

N=60, **Significant at 5% probability level, *Significant at 10% probability level

Less educated women were found to excel in adopting new technologies as long as explanations were provided in simple language and that this could explain why women were enthusiastic of soil fertility replenishment technologies and decided to adopt such techniques (Place et al., 2005). That means that once they understand and have the numbers, they can influence each other in to adoption.

A study carried out in Ghana by Quisumbing and Pandolfell (2008) showed that the adoption of cocoa farming increased women’s labour burdens, but also increased their control over land as husbands transferred land to their wives in exchange for their wives’ labour in their fields. This is however contrary to the findings of Mwangi et al (2011) who found that higher proportions of females in user groups, and especially user groups dominated by females perform less well than mixed groups or male dominated ones. Simply adding women to groups does not lead to greater effectiveness. Women’s inclusion in collective action needs to be accompanied by measures to strengthen their capacities for assuming active roles in leadership positions (Quisumbing and Pandolfell, 2008).

Frequency of group meetings
The frequency of group meetings negatively (β=-0.920, p=0.050) influenced application of animal manure (Table 2). This implies that the less the frequency of the group meetings, the more the likelihood of groups applying animal manure. That means that groups that meet monthly are more likely to adopt soil fertility technologies more than those that meet weekly. The reason for this could be that agricultural activities that involve soil inputs application are normally seasonal, and monthly meeting can address agricultural issues such as soil fertility replenishment which is once a season activity. On the other hand, most groups that meet weekly address resource issues such as merry-go-round, household items and credit issues. Where groups have accessed loans from their revolving fund or from outside, and repayments are mostly weekly or fortnightly, forcing the group to meet for loan repayment. Davis and Negash (2007) reported that the “poor” are the ones participating in many of the groups, and that they naturally come together because they have needs and togetherness may marginally reduce the resource poverty they experience.
Less frequent meetings allow group members to assist on each other’s farms and this provides a learning experience forum for each one of them. These visits in each others’ farms provide opportunities for them to have an experience with soil fertility technologies, especially if they had not succeeded on their farms during their first attempt (Peterson et al., 2004). This agrees with Cramb (1999) who reported that farmers group themselves work on each others’ farms on a rotation basis. This not only assists in labour sharing but also hastens adoption of SFE technologies. In the study, Meinzen-Dick and Di-Gregorio (2004) noted that the number of meetings may be a convenient indicator because it is relatively easy to measure, but it is not clear whether meetings are a transaction cost of collective action or an indication of effectiveness.

**Group size**

Group size negatively ($\beta = -3.898$, $p=0.019$) influenced application of animal manure (Table 2). This implies that the smaller the group sizes the higher the likelihood of using animal manure. This is probably because members of smaller groups are able to interact and share closely as opposed to members of large groups. According to Howard (2002), larger groups are less likely to achieve their goals than smaller groups because smaller groups are more viable since the costs of organization are less, and each member receives a more substantial portion of the collective good. Davis (2004) noted that cohesion was assisted by small group size, homogeneity of members and member accountability. Pretty (2003) and Sanginga et al. (2001) also noted that groups of less than 20 farmers can also function well. Small groups maintain a greater sense of solidarity and mutual responsibility (Uphoff and Wijayaratna, 2000). Large groups on one hand gain a wide range of experiences due to numbers and are likely to include persons from various farmer categories. On the other hand, such large groups are sometimes characterized by a less intensive exchange of experiences among themselves; they tend to be more subject to social problems and are often difficult to manage, therefore requiring strong leadership (Kampen and Shapland, 2004). Group sizes are determined by the members themselves (Heemskerk et al., 2003). Mavedzenge Blasio et al. (1999) also reported that for adaptability analysis, an optimal common interest group size for development of flexible recommendations is a minimum of 15 members.

### 3.1.2 Characteristics influencing application of inorganic fertilizers in Embu & Tharaka-Nithi Counties

The results of the Logit model are presented in (Table 3). The model was significant at $p<0.01$ and correctly predicted 86.8% of both that applied and those that did not apply inorganic fertilizer. Qualification of group membership ($p=0.028$), prompt of group formation ($p=0.098$) and the Tropical Livestock Unit (TLU) ($p=0.045$) were significant in explaining the application of inorganic fertilizer in Embu and Tharaka-Nithi counties (Table 3).

#### Table 3: Group characteristics influencing application of inorganic fertilizer technology by groups in the Embu and Tharaka-Nithi Counties

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of beneficiaries of agric activities in the group</td>
<td>0.134</td>
<td>0.109</td>
<td>1.507</td>
<td>0.220</td>
<td>1.144</td>
</tr>
<tr>
<td>Tropical Livestock Unit</td>
<td>1.926**</td>
<td>0.963</td>
<td>4.000</td>
<td>0.045</td>
<td>6.859</td>
</tr>
<tr>
<td>Group formation prompt</td>
<td>1.891*</td>
<td>1.143</td>
<td>2.736</td>
<td>0.098</td>
<td>6.624</td>
</tr>
<tr>
<td>Membership qualification</td>
<td>1.624**</td>
<td>0.741</td>
<td>4.802</td>
<td>0.028</td>
<td>5.073</td>
</tr>
<tr>
<td>Ages of group members</td>
<td>0.686</td>
<td>1.202</td>
<td>0.326</td>
<td>0.568</td>
<td>1.986</td>
</tr>
<tr>
<td>Educated group</td>
<td>0.222</td>
<td>0.231</td>
<td>0.925</td>
<td>0.336</td>
<td>1.248</td>
</tr>
<tr>
<td>No of females in the group</td>
<td>-0.336</td>
<td>0.275</td>
<td>1.499</td>
<td>0.221</td>
<td>0.714</td>
</tr>
<tr>
<td>No of males in the group</td>
<td>-0.395</td>
<td>0.281</td>
<td>1.979</td>
<td>0.160</td>
<td>0.674</td>
</tr>
<tr>
<td>Frequency of group meetings</td>
<td>0.250</td>
<td>0.658</td>
<td>0.144</td>
<td>0.704</td>
<td>1.284</td>
</tr>
</tbody>
</table>

N=60, **Significant at 5% probability level, *Significant at 10% probability level

#### Tropical Livestock Unit (TLU)

The Tropical Livestock Unit (TLU) significantly ($\beta = 1.926$, $p=0.045$) influenced the application of inorganic fertilizer (Table 3) which implies that an increase in the TLU increases the likelihood of farmers to make decision to apply inorganic fertilizer. Ownership of domestic animals is assumed to generate increased income through sales of the animals or their products and is thus hypothesized to accelerate adoption of inorganic fertilizers (Odendo et al., 2010). This agrees with Davis (2004) who found out that there was a positive correlation between wealth level and the number of animals. These animals could either be a source of wealth or capital through their sales or manure sales. Ajayi et al., (2007) noted that animal manure was becoming scarcer because most farmers had too few animals to produce adequate quantities of manure.
Sanginga and Woolmer (2009) also found that livestock rearing is a near-universal smallholder enterprise that serves to accumulate wealth, generate income, improve household nutrition and provide sources of soil organic inputs as waste products. In addition, households that were not selling produce or animal products found it difficult to afford mineral fertilizers, even at rates well below recommended levels (Hartemink, 2003). Mugwe et al. (2009) also reported that birds (poultry) are not only seen as a source of wealth but also manure providers. Birds or manure sales could provide capital to invest in inorganic fertilizers. Resource poor households were also found to occupy smaller farms, practice fewer farm enterprises, own fewer domestic animals and use less mineral fertilizers according to Sanginga and Woolmer (2009).

**Reason for Group Formation**

The reason that prompted the group to start significantly (β= 1.891, \(p=0.098\)) influenced the application of inorganic fertilizer (Table 3). Results show that a majority (84.4%) of the groups that applied inorganic fertilizer were prompted to start by internal issues. These issues include inadequate financial resources, social support, agricultural marketing and risk coping strategies. Davis and Negash (2007) also reported that the “poor” will naturally come together because they have needs and togetherness may marginally reduce the resource poverty they experience. This means that if ‘poor’ farmers realized that they had soil fertility need, they would come together on top of joining many groups. This is in line with Stringfellow et al. (1997) who noted that donors and NGOs wanting to promote farmer cooperation need to refrain from pushing the process of group formation. This deprives the group members of their responsibility of taking charge of their situations. Farmers should instead be encouraged to develop their own forms of group organizations after analyzing their circumstances and the resources at their disposal.

### 3.1.3 Group characteristics influencing application of animal manure + fertilizers in the two Counties

The results of the Logit model are presented in (Table 4). The model was significant at \(p<0.01\) and correctly predicted 80.7% of both that applied and those that did not apply manure plus fertilizer. Number of females in the group (\(p=0.067\)), reason for applying combination (\(p=0.003\)) and group gender (\(p=0.056\)) were significant in explaining the application of inorganic fertilizer in Embu and Tharaka-Nithi counties (Table 4).

#### Table 4: Group characteristics influencing application of a combination of manure + fertilizer technology by groups in the Embu and Tharaka-Nithi Counties

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group age</td>
<td>-0.090</td>
<td>0.091</td>
<td>0.973</td>
<td>0.324</td>
<td>0.914</td>
</tr>
<tr>
<td>No of females in the group</td>
<td>-0.142**</td>
<td>0.078</td>
<td>3.349</td>
<td>0.067</td>
<td>0.867</td>
</tr>
<tr>
<td>Educated group</td>
<td>0.128</td>
<td>0.098</td>
<td>1.726</td>
<td>0.189</td>
<td>1.137</td>
</tr>
<tr>
<td>Age of group members</td>
<td>0.683</td>
<td>0.949</td>
<td>0.517</td>
<td>0.472</td>
<td>1.980</td>
</tr>
<tr>
<td>Venue of group meeting</td>
<td>0.977</td>
<td>0.879</td>
<td>1.236</td>
<td>0.266</td>
<td>2.657</td>
</tr>
<tr>
<td>Tropical Livestock Unit</td>
<td>0.294</td>
<td>0.487</td>
<td>0.364</td>
<td>0.546</td>
<td>1.342</td>
</tr>
<tr>
<td>Reason for combination</td>
<td>-1.848*</td>
<td>0.623</td>
<td>8.793</td>
<td>0.003</td>
<td>0.158</td>
</tr>
<tr>
<td>Group gender</td>
<td>1.577**</td>
<td>0.825</td>
<td>3.655</td>
<td>0.056</td>
<td>4.839</td>
</tr>
</tbody>
</table>

\(N=60\), **Significant at 5% probability level, *Significant at 10% probability level

### Number of Females in the Group

The number of females in the groups negatively (\(\beta=-0.142, p=0.067\)) influenced the application of combination of manure plus fertilizer (Table 4). That means that an increase in the number of females in a group decreases the group’s application of the combination of manure plus fertilizer. This is especially in mixed gendered groups. Normally, women have been treated as physically weaker sex and when they are in mixed groups, they could take advantage of that and leave most of the application work to the men in the group. This agrees with Mwangi et al. (2011) who found that higher proportions of females, and especially user groups dominated by females perform less well than mixed groups or male dominated ones. Simply adding women to groups does not lead to greater effectiveness. Women’s inclusion in collective action needs to be accompanied by measures to strengthen their capacities for assuming active roles, including leadership positions (Quisumbing and Pandolfell, 2008).

### Reason for Using Combination

The reason for using a combination of manure plus fertilizer significantly influenced the application of combination of manure plus fertilizer (Table 4). Cross tabulation results showed that the reason for applying a combination of manure
fertilizer by the group significantly ($p=0.022$, $\chi^2 = 7.673$) influenced application of manure + fertilizer. A majority (85.7 %) of the groups that applied a combination did so because of its association with high yields while 44.4% of groups that applied the combination did so because of its association with fast crop growth and maturity. This implies that an increase in the application of the combination is influenced by its association with high yields. This could be because most groups never felt that manure was unavailable, now that they just collect it from their cattle sheds, and combining it with fertilizer gave high yields. Combination of manure plus fertilizer has also been reported to give the highest yields. This agrees with Makinde et al (2001) and Bayu et al (2006) who reported that high and sustained crop yield could be obtained with judicious and balanced NPK fertilization combined with organic matter amendments. Place et al (2005) also noted that the use of manure and fertilizer has increased steadily over the last few years, partly due to some users’ strong belief in fertilizers. Combining organic amendments and mineral fertilizers is often the best strategy for maintaining or even increasing soil fertility (Wopereis et al., 2009).

**Group Gender**

Group gender influenced ($\beta = 1.577$, $p=0.056$) the application of a combination of manure plus fertilizer (Table 4). Results showed that 82.5% of the groups that applied a combination were mixed gendered (N=40), while 66.0% of the groups that applied a combination were male gendered (N=3). This implies that when men and women are mixed, there is synergy from both gender and the results are better. When the two genders are in the same group, it shows that they have accepted each other with their different contributions. A study carried out in Zimbabwe reported that women indicated that it was not necessary to have separate women’s groups since their needs were the same as the men’s (Jiggins et al., 1992). According to Sanginga et al. (2005) men make decisions, organize group activities and maintain discipline in groups. They are also better placed to establish contacts with external institutions and to voice their needs and demands, while Kaaria and Ashby (2000) reported that the higher participation of women can be explained by their dormant roles and responsibilities in crop production.

While investigating the gender variable, Mwangi et al. (2011) found out that user groups dominated by females, perform less well than mixed groups or male dominated ones as far as technology access and dissemination was concerned. Mixed-sex groups were also found to be more effective at meeting project objectives, especially when women and men are both key users of a resource (Quisumbing, 2009). Kariuki and Place (2005) during their study in the central highlands of Kenya also reported that men express more satisfaction with how group finances are managed in mixed-sex groups than they do in all-male groups, because men are perceived as being more vulnerable to corruption. On the other hand however, Varughese and Ostrom (2001) found that heterogeneity in groups was not an important predictor of outcomes in collective action such as farmers’ groups.

**4. CONCLUSION**

The objective was to assess the effect of farmer groups’ characteristics on the choice of soil fertility enhancement technologies by individual members. Results showed that group characteristics that significantly influenced application of manure were: group size, frequency of group meetings and the number of women in the group while, Tropical Livestock Units (TLU) and group formation prompt were the likely factors that influenced the application of fertilizer. On the other hand, the number of females in the group, reason for applying the combination and gender of the groups influenced the application of combination. This implies that groups should be of manageable sizes, hold timely and regular meetings, have some livestock, be self motivated by their objectives, have some knowledge on the effects of the technology application and if possible have mixed gender in order to benefit from their interactions and synergies.

**ACKNOWLEDGEMENTS**

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Stringfellow, R., Coulter, J., Lucey, T., Mc Kone C. and Hussain, A. 1997. Improving the access of smallholders to agricultural services in Sub-Saharan Africa: Farmer cooperation and the role of the donor community,
FARMER GROUPS’ MEMBERS’ HOUSEHOLD FACTORS INFLUENCING SELECTION OF SOIL FERTILITY TECHNOLOGIES IN THE CENTRAL HIGHLANDS OF KENYA

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ABSTRACT
This second study assessed the influence of farmer groups’ socio-economic factors on the selection of the technologies. Household variables that influenced selection of manure include: HH size (p=0.001), benefits of manure (p=0.011), land tenure (p=0.056), HHH education (p=0.075), TLU (p=0.036), and land under food crops (p=0.014). Variables that influenced selection of fertilizer included: HHH education (p=0.033), land under food crops (p=0.012), HHH occupation (p=0.041) and availability of on-farm income (p=0.012). Variables that influenced selection of a combination included: HHH education (p=0.001), land under food crops (p=0.041), TLU (p=0.011) and the most effective method to teach combination (p=0.001). This results could be helpful to the groups, researchers, policy makers, farmers’ training designers and other stakeholders in natural resource management programmes.

Key words: Farmers group members, Household characteristics, Animal manure, Inorganic fertilizers, Selection

INTRODUCTION
Smallholder farmers in Sub-Saharan Africa (SSA) face severe soil fertility crisis (Gonsalves et al., 2005). A survey in Kenya showed high amount of soil nutrient deficiencies caused by continuous cereal cultivation with limited use of fertility inputs (Gonsalves et al., 2005). Research on soil fertility improvement in Central Kenya highlands has generated recommendations for improving soil fertility on smallholder farms (Mugendi et al., 2006). For instance, some herbaceous legumes, leguminous shrubs, cover crops, biomass transfer, and cattle manure technologies applied alone or combined with inorganic fertilizers have been identified as potential soil nutrient replenishment technologies due to their costs, effectiveness, appropriateness, simplicity, and multipurpose nature in meeting the needs of the resource poor farmers (Franzel et al., 2002; Mucheru, 2003). Despite the obvious benefits of these soil fertility enhancement (SFE) technologies, the adoption rate has been slower than anticipated by the researchers as observed by Adiel (2004). Causes of low adoption may be attributed to the extension methods/approaches used in the dissemination of the soil fertility enhancement innovations among other reasons.

Farmers’ groups is one of the approaches that has been used successfully to catalyze the participation of farmers as partners in research and development activities (CIAT, 2003; Sanginga et al., 2005), and target technology to specific groups (Reddy et al., 2010). Farmers’ groups are community-based and their joint activities therefore have an out-scaling effect on the community (Wennink and Heemskerk, 2006). The small-scale farmers form these farmers’ groups, which are key to up scaling of technologies and they have self monitoring mechanisms to enforce collective actions through collective activities of the group (Bingen et al., 2003). For example, Peterson et al. (2004) found out those group members who were not successful with their first attempt to test soil nutrient replenishment technologies (SNRT) continued to use the technologies after visiting other farmers and getting convinced. Kiptot (2007) however showed that the use of the village committee approach was misapplied as the approach assumed that groups are fully appropriate vehicles for technology development and dissemination.
The success of farmer groups depends on various factors which include small group sizes, group maturity and internal factors (common interests, group commitment and trustworthy leadership). Others are external factors (extension agents, researchers), structural social factors (roles, rules, procedures, social networks) and cognitive (norms, values, attitude and trust) social factors (Ostrom, 1992; Baland and Platteau, 1996; Uphoff and Wijayaratna, 2000; Agrawal, 2001; Haan, 2001; Johnson et al., 2002; Place et al., 2002; Jones, 2004). However, the cumulative effects of these factors and their direct influence on selection of SFE technologies have not been well understood. For instance, Agrawal (2001) found that, group size alone gave different results on group’s success. Therefore, there is a need for more social-economic research to understand how farm households view and understand the technologies (Misiko, 2007; Kiptot et al., 2007). This calls for a study that focuses on factors that influence selection of SFE technologies at household and group levels.

MATERIALS AND METHODS

Research Site

The study was carried out in Mbeere South and Maara sub counties. These sub counties were selected because research and dissemination on soil fertility had been done in the area. Mbeere South lies in the Agro-ecological Zone (AEZ) Lower midland 4 and 5 (LM 4 and LM 5), with an altitude of about 800m above sea level (Jaetzold et al., 2006). The average rainfall is between 600-800 mm per year, in a bimodal regime, where long rains come from mid March to June and the short rains from late October to December. The annual mean temperature is between 21.7 to 22.5°C. The soils are predominantly Ferralsols and Acrisols (Jaetzold et al., 2006), and the predominant land uses are dry land farming and livestock production.

Maara sub-county lies in the Agro-ecological Zone (AEZ) Upper Midland (UM2-UM3) (Jaetzold et al., 2006) on the eastern slopes of Mount Kenya, with an altitude of 1500 m above sea level. It receives an average rainfall of 1200-1400 mm per annum with a bimodal regime where long rains come from March to June and short rains from October to December. The mean temperature is 20°C. Two cropping seasons are experienced in a year. The district is predominantly maize/coffee growing zone with some dairy enterprises, with smallholdings ranging from 0.1 to 2 ha and an average of 1.2 ha per household (Jaetzold et al., 2006). The soils are mainly humic Nitisols.

Research design

Primary data was collected through face to face interviews with individual farmers. The study aimed at collecting information from the individual farmers who were members of farmer groups on the household factors that enhanced uptake of various soil fertility management technologies. Both primary and secondary sources of data were used. Primary sources of data were questionnaires and interview schedules while secondary sources included journal articles, Government reports, theses and dissertations.

Sampling strategy

The category of interviewee that was targeted for data collection through questionnaires was individual farmers who were members of farmer groups. A total of 218 farmers were sampled. The sample size calculated was based on the groups’ household population of 1200 by applying 95% confidence level and 6% confidence interval. The population was derived from the total number of farmers who had participated in the previous soil fertility activities. Individual farmers were randomly selected from the single gendered groups, but purposively selected from mixed gendered groups in order to capture gender in the mixed groups.

Data collected

A pre-test was done before the main survey. This was conducted in order to check for face, content and criterion validity of the farmers’ interview schedules. It also helped to ascertain the amount of time needed to administer the tools. A sample of 7 farmers from each site were randomly selected and interviewed. The data collected included: (i) Household characteristics, (ii) group activities, (iii) group trainings, (iv) soil fertility and technologies’ use.

Data Analysis

Data cleaning and close examination was done to ensure completeness and consistency in the questionnaires. The questions were coded, managed and stored in MS Excel. SPSS, version 12 software, was used for data analysis. Descriptive statistical analysis was applied, involving the use of means, frequencies, percentages, standard deviation. For categorical variables, cross tabulation was carried out while for quantitative variables, Pearson correlation was done. In the regression analysis, the household and socio-economic variables were independent (explanatory) variables
while the dependent variables were the individual farmers SFE technology selection (Table 1). Results were presented in form of tables.

For logistic analysis, various factors were regressed upon the dependent variable “group membership” in a binary logistic model. Such models are used when response variables are binary; that is, they have only two possible outcomes (Agresti & Finlay, 1997). The generic terms for the two possible outcomes are success and failure, and the “odds” equal the probability of success divided by the probability of failure (Table 1). As the outcome (in this case, participation in a group) increases from 0 to 1, the odds increase from 0 to infinity. This model tests the probability that the independent variable X has no effect on the dependent variable Y (Agresti & Finlay, 1997). The independent variables consisted of both categorical and continuous variables and were coded accordingly (Table 1). In the logistic regression model, B is the estimated coefficient with standard error S.E. The ratio of B to S.E., squared, equals the Wald statistic. If the Wald statistic is significant (i.e less than 0.05) then the parameter is useful to the model. Exp(B) is the predicted change in the odds for a unit increase in the predictor. When Exp(B) is less than 1, increasing values of the variable corresponds to decreasing odds of the event’s occurrence and when Exp(B) is greater than 1, increasing values of the variable correspond to increasing odds of the event’s occurrence.

RESULTS AND DISCUSSION

Socio-economic characteristics of the households influencing decision to select soil fertility technologies

Socio-economic factors influencing the farmers’ selection of animal manure

The results of the Logit model developed to determine factors influencing use of animal manure was significant at $p<0.01$ and correctly predicted 67.4% of both users and non users of animal manure with the selection and non selection of animal manure (Table 2). Size of the household ($p=0.096$), farmer’s education ($p=0.075$), land with or without title deed ($p=0.056$), land under food crops ($p=0.014$), Tropical Livestock Units on the farm ($p=0.036$) and benefits of animal manures ($p=0.062$) were significant in explaining the selection of animal manure in Embu and Tharaka-Nithi counties (Table 2).

Table 8: Definition of study variables influencing the farmers’ selection of animal manure, inorganic fertilizers and manure + fertilizers technologies in Embu and Tharaka-Nithi counties

<table>
<thead>
<tr>
<th>Dependent variables</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection of animal manure, inorganic fertilizer and manure + fertilizer</td>
<td>0 No</td>
</tr>
<tr>
<td></td>
<td>1 Yes</td>
</tr>
<tr>
<td>Independent variables</td>
<td></td>
</tr>
<tr>
<td>HH head gender</td>
<td>1 Male</td>
</tr>
<tr>
<td></td>
<td>2 Female</td>
</tr>
<tr>
<td>HH head age</td>
<td>Continuous variable</td>
</tr>
<tr>
<td>Education</td>
<td>0 Not educated</td>
</tr>
<tr>
<td></td>
<td>1 Educated</td>
</tr>
<tr>
<td>Number of months spent on the farm</td>
<td>Continuous variable</td>
</tr>
<tr>
<td>Benefits of animal manure</td>
<td>1 Fertile soil</td>
</tr>
<tr>
<td></td>
<td>2 High yields</td>
</tr>
<tr>
<td></td>
<td>3 Water retention</td>
</tr>
<tr>
<td>Participation in group activities</td>
<td>0 No</td>
</tr>
<tr>
<td></td>
<td>1 Yes</td>
</tr>
<tr>
<td>House hold size</td>
<td>Continuous variable</td>
</tr>
<tr>
<td>Total land for the HH</td>
<td>Continuous variable</td>
</tr>
<tr>
<td>Total HH land with food crops</td>
<td>Continuous variable</td>
</tr>
<tr>
<td>Tropical Livestock Units (TLU)</td>
<td>Continuous variable</td>
</tr>
<tr>
<td>Number of donkeys</td>
<td>Continuous variable</td>
</tr>
<tr>
<td>Number of groups farmer belongs to</td>
<td>0 Without title</td>
</tr>
<tr>
<td>Land with/without title deed</td>
<td>1 With title</td>
</tr>
<tr>
<td>Full / part-time farmer</td>
<td>0 Part-time</td>
</tr>
<tr>
<td></td>
<td>1 Full-time</td>
</tr>
<tr>
<td>Any on-farm income</td>
<td>0 No</td>
</tr>
<tr>
<td></td>
<td>1 Yes</td>
</tr>
<tr>
<td>Benefits of fertilizer / combination</td>
<td>1 Fertile soil</td>
</tr>
<tr>
<td></td>
<td>2 High yields</td>
</tr>
<tr>
<td></td>
<td>3 Early maturity</td>
</tr>
<tr>
<td>Source of knowledge of manure, fertilizer and manure + fertilizer</td>
<td>1 Extension</td>
</tr>
<tr>
<td></td>
<td>2 Researchers</td>
</tr>
<tr>
<td></td>
<td>3 Other farmers</td>
</tr>
</tbody>
</table>
Most effective method to teach manure, fertilizer and manure +

1 Demonstrations
2 Meetings
3 Media

Table 2: Logistic regression estimates of factors influencing selection of animal manure technology in the Embu and Tharaka-Nithi Counties

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HH marital status</td>
<td>0.829</td>
<td>0.845</td>
<td>0.964</td>
<td>0.326</td>
<td>2.291</td>
</tr>
<tr>
<td>Education</td>
<td>-0.564*</td>
<td>0.316</td>
<td>3.179</td>
<td>0.075</td>
<td>0.569</td>
</tr>
<tr>
<td>HH size</td>
<td>0.147*</td>
<td>0.088</td>
<td>2.779</td>
<td>0.096</td>
<td>1.158</td>
</tr>
<tr>
<td>Land under food crops</td>
<td>0.397**</td>
<td>0.161</td>
<td>6.081</td>
<td>0.014</td>
<td>1.487</td>
</tr>
<tr>
<td>Land with/without title</td>
<td>-0.655*</td>
<td>0.342</td>
<td>3.659</td>
<td>0.056</td>
<td>0.520</td>
</tr>
<tr>
<td>Tropical Livestock Units</td>
<td>0.206**</td>
<td>0.099</td>
<td>4.376</td>
<td>0.036</td>
<td>1.229</td>
</tr>
<tr>
<td>Animal manure benefits</td>
<td>0.163*</td>
<td>0.087</td>
<td>3.482</td>
<td>0.062</td>
<td>1.177</td>
</tr>
</tbody>
</table>

N=218, **Significant at 5% probability level, *Significant at 10% probability level

HH Head Education

Household head education negatively influenced ($\beta = -0.564, p=0.075$) the selection of animal manure (Table 2). This implies that an increase in the household head education did not necessarily increase the chances of selection of animal manure. That means that lack of formal education did not hinder the households from selection of manure. This could be because manual application of manure may just require observation as a demonstrator illustrates the amount to apply, how to apply and the equipment to use. This also means that an increase in education could mean more opportunities to earn off-farm income which could be a dis-incentive in investing in manure. Off-farm income negatively influenced farmer uptake of ISFM as sometimes individuals with higher incomes tend to invest their time, energies and money in non-farm activities at the expense of on-farm activities (Adolwa et al., 2010). These results agree with those of Place et al. (2005) that education was not found to play a major role in the decision to take up technologies. Preparation and application of manure may require practical hands-on management, skills and conceptual understanding (Okoth et al., 2006) based on non-formal adult education principles. The study by Kiptot (2006) on sharing seed and knowledge agreed with the results that education has a negative influence by indicating that an increase in the number of years of schooling reduced the probability of giving out seed by 0.16. Muge et al (2003) also reported that those farmers who had attained their formal education up to secondary level had about 63% higher chances of adopting SRFT than those with tertiary education. This is contrary to what Kariuki and Place (2005) found, that more educated household heads are more likely to have adopted bio-mass transfer than non-educated household heads.

Household Size

Household size positively influenced ($\beta = 0.147, p=0.096$) the selection of manure (Table 2). This implies that an increase in the household size increases the selection of manure. This could be because a higher number of household members can provide timely labour that is required to apply manure since manure application is a labour intensive activity. Household labour provision is very important for speeding up implementation of labour intensive technologies such as manure application. This is consistent with Odendo et al. (2010) who found out that due to high labour demands for preparation and application of manure, compost and mineral nutrient sources, higher ratio of household members who contribute to farm work is hypothesized to increase the speed of the adoption of all the studied practices because of the low opportunity cost of labour in Western Kenya. Franzel (1999) also reported that labour constraints had a significant impact on the adoption decision, as tree fallows are a relatively labour-intensive activity, and that the ratio of household members who provide farm labour to total household size accelerated the adoption of manure as expected (Odendo et al., 2010). At the same time, the household size also can address issues of synergy in SFE technology adoption. This agrees with Kacharo (2007) who found out that the higher number of family members leads to higher decision to take risks for participation in technology packages and this leads to increased chances of getting agricultural information and consequently ISFM knowledge. Mapiye et al. (2006) in a study in Chikomba district, Zimbabwe noted that household size influences adoption of soil fertility technologies through increase in knowledge base. Similarly, households with large numbers have more labour and needed more food, both of which increased the tendency to learn more on how to conserve the soil in order to feed themselves (Odendo et al., 2010).

HH Total Land Under Food Crops

Total land under food crops significantly ($\beta = 0.397, p=0.014$) influenced the selection of manure (Table 2). This implies that an increase in the land under food crops increases the selection of manure. These findings also agree with...
those of Kebede et al. (1990) who in a study carried out in Tegulet-Bulga district, Ethiopia found out that farm size have a significant effect in increasing information and adoption of soil fertility technologies. In addition to providing food security, food crops can also be sources of farm income. Barhama and Chitemi (2008) reported that cereals and legumes are the traditional staple food crops for many smallholders, and that when these staple food crops are grown on a large scale, they offer substantial regional and international market potential. Such food crops can therefore attract attention and enhance the likelihood of selection of inorganic fertilizer and other soil fertility enhancing technologies.

**Land With / Without Title Deed**

Owning land with title deed negatively influenced ($\beta=-0.655, p=0.056$) the selection of manure (Table 2). This implied that owning land with title did not necessarily increase the likelihood of selecting manure. This could be because the land with title could be far and with poor communication, or that the crop grown did not attract good market, and therefore not profitable enough to warrant investing in manure. Cramb (1999) in his study found out that success of adoption of conservation technologies was also due to a number of site-specific factors, which included good communications, close community interaction, stable land tenure, increasing accessibility and market link-ages, and the evolution of the farming systems towards new enterprises. Contrary to the results, Lastarria-Cornhiel (1997) reported that individual and private ownership of holdings tends to provide greater security of access and control over land, and without this security farmers may lack incentives to invest. This also contradicts Onduru et al. (2001) who reported that facilitation of the acquisition of title deeds encourages investment in short- and long-term soil fertility management strategies.

**Tropical Livestock Units (TLU)**

Tropical Livestock Units (TLU) a farmer owns significantly ($\beta=0.206, p=0.036$) influenced the selection of manure (Table 2) which implies that an increase in the number of domestic animals increases the likelihood of farmers to make decision to select manure. Ownership of domestic animals is assumed to increase availability of manure and to generate income through sales of the animals or their products and is thus hypothesized to accelerate adoption of manure and mineral fertilizers (Odendo et al., 2010). Green (2003) found out that livestock, a proxy for the wealth position of households, positively and significantly related with the likelihood of using inorganic fertilizers and ISFM practices. He added that livestock also has a positive and significant effect on the intensity of use of inorganic fertilizers and stone/soil bunds. Pezo et al. (1999) also reported that buffalo numbers remained larger than expected probably due to their ability to utilize crop residues and forage in waste areas and thus continued to have a role as an asset and contributing manure for rice-based systems in the Phillipines.

**Manure Benefits**

The benefits derived from manure significantly ($P=0.011, \chi^2=9.008$) influenced the selection of manure (Table 2). The results showed that a majority (71.0%) of the farmers that selected manure did so because of its benefit of high yields, while 48.8% selected it because of its benefit of fertile soil. This implies that an increase in the yields as a benefit increases the probability of the farmers’ selection of manure. This agrees with Harris et al.’s (1997) survey that gained the impression from farmers that inorganic fertilizer is for feeding plants (short term response) but manure is required to feed the soil (long term sustainability) (Lekasi et al., 2001). Research also has shown that a combination of run off-harvesting and farmyard manure significantly increases grain yields in these semi-arid areas (Jaetzold et al., 2007).

**Socio-economic factors influencing the farmers’ selection of inorganic fertilizer**

The results of the Logit model developed to determine factors influencing use of inorganic fertilizer was significant at $p<0.01$ and correctly predicted 70.2% of both users and non users of inorganic fertilizers with the selection and non selection of inorganic fertilizer (Table 3). Four variables: household head education ($p=0.014$), total land under food crops ($p=0.031$), availability of on-farm income ($p=0.055$) and whether the household head is a full-time or part-time farmer ($p=0.019$) were significant in explaining the selection of inorganic fertilizers in the central highlands of Kenya (Table 3).

Table 3: Factors influencing selection of inorganic fertilizer technology in the two Counties

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HHHH gender</td>
<td>-0.105</td>
<td>0.353</td>
<td>0.088</td>
<td>0.766</td>
<td>0.900</td>
</tr>
<tr>
<td>Education</td>
<td>-1.070**</td>
<td>0.369</td>
<td>8.382</td>
<td>0.004</td>
<td>0.343</td>
</tr>
<tr>
<td>Number of groups one belongs to</td>
<td>0.094</td>
<td>0.220</td>
<td>0.183</td>
<td>0.669</td>
<td>1.099</td>
</tr>
<tr>
<td>Land under food crops</td>
<td>0.353**</td>
<td>0.164</td>
<td>4.661</td>
<td>0.031</td>
<td>1.424</td>
</tr>
<tr>
<td>With / without title deed</td>
<td>0.126</td>
<td>0.366</td>
<td>0.119</td>
<td>0.730</td>
<td>1.134</td>
</tr>
</tbody>
</table>
Full/Part-time Farming

Being a fulltime farmer negatively influenced ($\beta=-1.194$, $p=0.019$) the selection of inorganic fertilizer (Table 3). This implies that farmers who spent more time on the farm selected less of inorganic fertilizer. Lack of cash to buy fertilizer could have been the reason of non selection of fertilizer. Ajayi et al. (2007) noted that lack of cash to buy mineral fertilizers or non-availability of fertilizer in rural areas at the right time was a constraint in fertilizer adoption. This could also be because they had an opportunity to use other SFE technologies like manure which on the other hand required more time to prepare and apply and at the same time was cheaper than inorganic fertilizer. A fulltime farmer spends more time on the farm and therefore gets more experience on farm activities, including use of new technologies. A greater number of hours worked by the farmer lower the probability of adoption of new technologies (Dorfman, 1996). Odendo et al. (2010) found out that relative farming experience retards the adoption new technologies. Edemeades et al. (2008) however reported that relative farming experience increased the likelihood of the adoption of different banana varieties in Uganda.

Farm Income Availability

 Availability of farm income negatively ($P=0.012$, $\chi^2=6.266$) influenced the selection of fertilizer (Table 3). Results showed that a majority (68.4%) of the farmers that had on-farm income did not select fertilizer, while 31.6% of the farmers that had off-farm income selected fertilizer. This implies that an increase in the availability of on-farm income does not necessarily increase the probability of fertilizer selection. This could be because the farmers might have preferred to invest in other technology options but not fertilizer. Other times, farmers do not adopt because the technology does not fit with their existing options. Giller et al. (2009) in his study reported that farmers’ involvement in new technologies requires trade offs with other activities from which they currently generate their livelihood and if the new technology does not fit with them, they will hesitate to take it up. This could also be that possibly the complexities

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropical Livestock Unit (TLU)</td>
<td>-0.060</td>
<td>0.105</td>
<td>0.332</td>
<td>0.564</td>
<td>0.941</td>
</tr>
<tr>
<td>Any on-farm income</td>
<td>-1.342*</td>
<td>0.701</td>
<td>3.668</td>
<td>0.055</td>
<td>0.261</td>
</tr>
<tr>
<td>Benefits of fertilizer</td>
<td>0.399</td>
<td>0.310</td>
<td>1.661</td>
<td>0.197</td>
<td>1.490</td>
</tr>
<tr>
<td>Full / part-time farmer</td>
<td>-1.194**</td>
<td>0.510</td>
<td>5.487</td>
<td>0.019</td>
<td>0.303</td>
</tr>
</tbody>
</table>

N=218, **Significant at 5% probability level, *Significant at 10% probability level

HH Head Education

Household head education negatively ($\beta=-1.070$, $p=0.004$) influenced selection of inorganic fertilizer respectively (Table 3) which implies that inorganic fertilizer selection decreases with increase in education. These results agree with Place et al. (2005) who reported that education was not found to play a major role in the decision to take up improved fallows and biomass transfer technologies. Preparation and application of fertilizer may require practical hands-on management, skills and conceptual understanding (Okoth et al., 2006) based on non-formal adult education principles. These results disagree with the normal expectation that the education level of the household head to be positively related to productivity per acre since better educated farmers may have improved access to knowledge and tools that enhance productivity (Fatma Gül Ünal, 2008). Kariuki and Place et al. (2005) had also found out that more educated household heads are more likely to have adopted biomass transfer than non-educated household heads. These results could therefore be because as long as fertilizer is available, application of it just needs to be demonstrated by an expert and this physical activity can be done even without formal education. Its rates of application can be determined by physical objects such as soda bottle tops. This calls for simplification of technical information by development professionals in order to help support farmers’ understanding and communication of complex principles (Kiptot et al., 2006). This also agrees with the Place et al. (2005) who noted that education was not found to play a major role in the decision of farmers to take up technologies.

HH Land under Food Crops

Land under food crops positively influenced ($\beta=0.353$, $p=0.031$) the selection of inorganic fertilizer (Table 3). This implies that an increase in the size of the land under food crops increases the selection of inorganic fertilizer. In addition to providing food security, food crops can also be sources of farm income. Barhama and Chitemi (2008) reported that cereals and legumes are the traditional staple food crops for many smallholders, and that when these staple food crops are grown on a large scale, they offer substantial regional and international market potential. Such food crops can therefore attract attention and enhance the likelihood of selection of inorganic fertilizer and other soil fertility enhancing technologies. Arifalo and Mafimisebi (2011) also found out that the respondents who applied inorganic fertilizers only, had the greatest yield of maize and yam crops.

Full/Part-time Farming

Being a fulltime farmer negatively influenced ($\beta=-1.194$, $p=0.019$) the selection of inorganic fertilizer (Table 3). This implies that farmers who spent more time on the farm selected less of inorganic fertilizer. Lack of cash to buy fertilizer could have been the reason of non selection of fertilizer. Ajayi et al. (2007) noted that lack of cash to buy mineral fertilizers or non-availability of fertilizer in rural areas at the right time was a constraint in fertilizer adoption. This could also be because they had an opportunity to use other SFE technologies like manure which on the other hand required more time to prepare and apply and at the same time was cheaper than inorganic fertilizer. A fulltime farmer spends more time on the farm and therefore gets more experience on farm activities, including use of new technologies. A greater number of hours worked by the farmer lower the probability of adoption of new technologies (Dorfman, 1996). Odendo et al. (2010) found out that relative farming experience retards the adoption new technologies. Edemeades et al. (2008) however reported that relative farming experience increased the likelihood of the adoption of different banana varieties in Uganda.

Farm Income Availability

 Availability of farm income negatively ($P=0.012$, $\chi^2=6.266$) influenced the selection of fertilizer (Table 3). Results showed that a majority (68.4%) of the farmers that had on-farm income did not select fertilizer, while 31.6% of the farmers that had off-farm income selected fertilizer. This implies that an increase in the availability of on-farm income does not necessarily increase the probability of fertilizer selection. This could be because the farmers might have preferred to invest in other technology options but not fertilizer. Other times, farmers do not adopt because the technology does not fit with their existing options. Giller et al. (2009) in his study reported that farmers’ involvement in new technologies requires trade offs with other activities from which they currently generate their livelihood and if the new technology does not fit with them, they will hesitate to take it up. This could also be that possibly the complexities
of using fertilizer in terms of types, time of application and rates of application could have discouraged the farmers from selecting it. This agrees with Doss and Morris (2001) who indicated that there are certain technology specific factors that influence the decision to adopt.

3.1.3: Socio-economic factors influencing the farmers’ selection of a combination of animal manure and fertilizer

The results of the Logit model developed to determine factors influencing use of a combination of animal manure + inorganic fertilizer was significant at $p<0.01$ and correctly predicted 75.3% of both users and non users of the combination of animal manure + inorganic fertilizers with the selection and non selection of the combination (Table 4). Household head education ($p=0.021$), total land under food crops ($p=0.058$), Tropical Livestock Units (TLU) ($p=0.011$) and the most effective method to teach combination ($p=0.001$) were significant in explaining the selection of a combination of animal manure + inorganic fertilizers in the central highlands of Kenya (Table 4).

Table 4: Factors influencing selection of a combination of animal manure + inorganic fertilizers technology in the Embu and Tharaka-Nithi Counties

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>1.004**</td>
<td>0.436</td>
<td>5.301</td>
<td>0.021</td>
<td>2.730</td>
</tr>
<tr>
<td>Land under food crops</td>
<td>-0.604*</td>
<td>0.318</td>
<td>3.601</td>
<td>0.058</td>
<td>0.546</td>
</tr>
<tr>
<td>Land with title deed</td>
<td>0.608</td>
<td>0.454</td>
<td>1.796</td>
<td>0.180</td>
<td>1.836</td>
</tr>
<tr>
<td>Tropical Livestock Units</td>
<td>0.441**</td>
<td>0.173</td>
<td>6.538</td>
<td>0.011</td>
<td>1.555</td>
</tr>
<tr>
<td>Participate in group activities</td>
<td>1.230</td>
<td>0.830</td>
<td>2.195</td>
<td>0.138</td>
<td>3.422</td>
</tr>
<tr>
<td>HH total land</td>
<td>0.258</td>
<td>0.157</td>
<td>2.694</td>
<td>0.101</td>
<td>1.295</td>
</tr>
<tr>
<td>Benefits of combination</td>
<td>0.138</td>
<td>0.399</td>
<td>0.120</td>
<td>0.729</td>
<td>1.148</td>
</tr>
<tr>
<td>Source of knowledge-combination</td>
<td>0.510</td>
<td>0.463</td>
<td>1.214</td>
<td>0.271</td>
<td>1.665</td>
</tr>
<tr>
<td>Effective method teach combination</td>
<td>-0.957**</td>
<td>0.265</td>
<td>13.021</td>
<td>0.001</td>
<td>0.384</td>
</tr>
</tbody>
</table>

N=218, **Significant at 5% probability level, *Significant at 10% probability level

HH Head Education

Household head education significantly ($\beta= 1.004, p=0.021$) influenced the selection of manure plus fertilizer (Table 4). This implies that the more educated the farmers, the more likely they are to select manure + fertilizer technology. This is because education exposes the farmers to details of the manure + fertilizer use such as types, application rates, methods and timings, which are critical in productivity. A well-founded knowledge supports well-informed decision-making with respect to resource use and management (Jansen et al., 2006). This is as expected that education of the head of the household positively and significantly influenced both the likelihood of adoption and intensity of inorganic fertilizer use (Green, 2003). Conventional methods are complex and difficult to use, particularly for non or semi-literate farmers with little or no formal education (Galpin et al., 2000). Higher education also broadens the opportunities of the farmers to engage in off-farms income generating activities which in turn can support investment in on-farm activities including SFE technologies for higher incomes. This agrees with Odendo et al. (2010) who found out that higher education level are most likely to obtain off-farm income through employment, hence hasten the adoption. Higher education also provides a well founded knowledge base which may help to distinguish myths from facts, and beliefs from realities as noted by Francisco (2008), and this also helps to support well informed decision making with respect to resource use and management (Jansen et al., 2006).

HH Land under Food Crops

Land under food crops negatively influenced ($\beta=-0.604, p=0.058$) the selection of a combination of manure plus fertilizer (Table 4). This implies that an increase in the size of the land under food crops decreases the selection of a combination of manure plus fertilizer. This could be because of the labour involved since the use of combination requires a lot of labour for both preparation and application. Women provide a significant share of labour for farm activities (Dixon, 1982) and are important as primary producers of food crops (FAO, 1985; Weekes-Vagliani, 1985). A NALEP-SIDA evaluation report (Cuellar et al., 2006) showed that women comprise of 70% of the members of CIGs that are food crops and small livestock production based. In most cases, high costs prohibit farmers from applying both manure plus fertilizer although they know that the resulting yields are high.

Tropical Livestock Units

Total livestock unit (TLU) owned by the household significantly ($\beta= 0.441, p=0.011$) influenced the selection of the combination (Table 4). Results showed that the households that selected the combination had a TLU mean of 2.5 while those that did not select it had a mean of 2.4. This implies that an increase in the TLU in the household increases the
probability of selection the combination. This could be because owning domestic livestock is considered as a source of wealth through the sales of the animals and their products like milk which can facilitate buying of fertilizers, while the animals themselves produce manure to be used in the combination. The findings agree with Odendo et al. (2010) who found that ownership of cattle is assumed to increase availability of manure and to generate income through sales of the cattle or its products and is thus hypothesized to accelerate adoption of manure and mineral fertilizers. Pezo et al., 1999) reported that buffalo numbers remained larger than expected probably due to their ability to utilize crop residues and forage in waste areas and thus continued to have a role as an asset and contributing manure for rice-based systems in the Phillipines. Birds (poultry) are also not only seen as a source of wealth but also manure providers. Mugwe et al. (2006), in Mugendi et al. (2006) reported that poultry manures contain sufficient nutrients in 1 to 2 tonne per hectare, compared to at least 10 tonnes per hectare from crop residues for a 2 tonnes per hectare maize crop.

Teaching Method Used for Combination

The most effective method of teaching combination significantly ($\chi^2=47.532, P=0.001$) influenced the selection of a combination (Table 4). Results showed that a majority (78.4%) of the farmers that selected combination were taught through demonstrations, while 27.5% of them that selected combination were taught through meetings. This implies that use of demonstrations as a teaching method increases the probability of farmers to select combination. Demonstration methods are participatory, involving logical description and explanation through experiments and at the same time, the farmers’ involvement is high. According to Knowler and Bradshaw (2007), the use of group approach in technology uptake and transfer has emerged as an important strategy of extending or introducing new technologies in developing countries. Odendo et al. (2000) attested to this by reporting that a larger number of farmers should be involved in technology testing and field days should be held to disseminate the technology. Mburu et al. (2008) during his study in Eastern Kenya Highlands agreed with the use of group approaches, but cautioned that they are costly, although the costs are mainly borne by the members of the groups. Pretty (1995) reiterates that farmers do learn from what they see than just what they are told. Makaya (1999) also noted that accelerated impact can only be achieved by selecting the most effective means of dissemination of the technology.

CONCLUSIONS

The third objective was to determine the influence of household characteristics of the farmers who are members of the groups, on selection of SFE technologies. The characteristics that were found to positively influence the use of manure include; household size, Tropical Livestock Units, total land under food crops, and benefits of manure. On the other hand, household head education and land ownership with title negatively influenced the use of manure. On the likelihood of households’ socioeconomic factors influencing the use of fertilizer, total land under food crops, household head education, availability of farm income and the time spent on the farm were identified as possible predictor factors likely to influence the use of manure. On the likelihood of households’ socioeconomic factors influencing the use of manure plus fertilizer, total land under food crops, household head education, and Tropical Livestock Units were identified as possible predictor factors likely to influence the use of manure plus fertilizer. These results imply that in order to enhance the uptake of the soil fertility enhancement technologies in the Central Highlands of Kenya, the identified factors should be put into consideration.

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ADAPTING TO CLIMATE CHANGE: EVALUATING THE IMPLEMENTATION OF WATER RESOURCE MANAGEMENT STRATEGIES IN HOTELS WITHIN LAKE NAIVASHA ENVIRONS

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ABSTRACT
Sustainability is complicated by the threat of climate change which presents tourism industry with considerable negative effects, creating an urgent need to manage and use such resources responsibly. Water Resource Management (WRM) has become critical in the tourism industry. Consequently, hotels have a unique responsibility in lessening the real and potential negative impacts on the water and promote sustainable water management and use. This study evaluated adoption of WRM strategies in hotels to attain water sustainability, the current structural and non-structural WRM strategies adopted by selected hotels in the environs of Lake Naivasha, perceived effectiveness of both the structural and non-structural WRM strategies adopted to enhance water sustainability, and structural and non-structural water management strategies in terms of sustainability in hotels within environs of Lake Naivasha. A census of 30 Class (A) registered hotels was conducted, and purposive sampling was used to select respondents. Convenience sampling was used to select managers for interviews. Primary data collection used questionnaires and interviews, while secondary data was synthesized from journals, text books, theses and other works and analysed using the SPSS program. Hotels had embraced WRM strategies through development of alternative water resources, water saving technologies, manuals and treatment of recycled water. Structural WRM strategies were perceived to be more effective.
as they impacted more on reducing operating costs, promoted environmental conservation and were more preferred than the non-structural strategies despite being more expensive to implement. Water sustainability is achievable through a combination of WRM strategies. Better water management policies should be formulated and complemented with technological utilization, stiffer penalties on pollution, community involvement, inclusion of donor funding and provision of incentives.

**Key words:** Water sustainability, structural and non-structural water management strategies

**INTRODUCTION**

The United Nations Environment Programme (UNEP) confirms that severe water shortage affects 400 million people today and is predicted to affect 4 billion people by 2050 (Thomas and Durham, 2003). Researchers assert the tourism sector which is one of the major users of fresh water in the world. Indeed, statistics by The International Business Leaders Forum’s Tourism Partnership and World Water Foundation-UK (IBLF, WWF-UK, 2005) and the Environmental Benchmarking guide reveal that water accounts for up to 15% of utility bills and that up to 95% of fresh water leave hotels as waste.

A welfare monitoring survey by Republic of Kenya (1996) indicates that Kenya is mainly an agricultural country with an expanding economy whose basic element for development is water. The annual quantity of renewable fresh water resources is estimated at 20.2 billion m³ comprising 19.59 m³ of surface water and 0.62 billion m³ of ground water. The amount of water actually available for utilization in any one year (among other factors) depends on the rate of run-off, the aridity of the catchment area and the methods of interception at various points in the hydrological cycle. Precipitation across parts of Kenya is exceptionally variable and unpredictable, and runoff is exceptionally low (varying from near zero in the north-eastern part of the country to over 1600 mm/yr in the western part of the country). The consequence of these two features is endemic drought in large parts of the country. Throughout Kenya, even within the same districts, there is an enormous variance in water amounts. Because of pronounced differences in average annual rainfall, evapo-transpiration, and hydrogeology, there is high variability within the same season, between different seasons i.e. twelve-month period, and over several years.

Like many other highly visited areas worldwide, Lake Naivasha is a tourism destination of international importance and biodiversity value and as such in 1995 it became Kenya’s second Ramsar wetland site. This shallow freshwater lake supports a high but uneven biodiversity which includes rich in birds and plants (Harper et al., 1990). Like many of the great East African lakes, Lake Naivasha is an area of interest as it has a high economic value for Kenya since it provides a wide range of opportunities for various economic activities in the area. Today, the fertile soil around the lake is used for agriculture, particularly for the production of fruits, flowers, vegetables and vineyards.

Besides, Lake Naivasha is renowned for its cool climate, peaceful surrounds and tranquil waters thus an excellent holidaying spot for both international and local tourists. However, over the years, the water levels in the lake have significantly declined which is attributed to rapid increase in the demand for lake and river water and clearance of catchment area for human settlement. Similarly, area covered by the papyrus, which has been an important part of the lake’s ecosystem, has declined in acreage from 1200 ha to 200 ha over the last four decades (Lake Naivasha Water Resource Users Association, 2008).

Within sustainable tourism debate, the hotel sector has come under close scrutiny, not only as pivotal to tourism growth but also as a sector with significant implications for both development and environmental conservation. In fact, there is increasing acceptance that hotels, large or small, must adopt an environmental management or “Greening” approach to their operations so that they positively contribute to the sustainability of tourism (Holden, 2000). In spite a wide range of literature on environmental issues in the hospitality industry as well as the factors affecting the hotels’ responses to environmental issues; little research has been done to establish the effectiveness of water resource management strategies on water sustainability in the hospitality industry. It is in this connection that the current study endeavored to assess the effectiveness of water management strategies on water sustainability in the selected hotels around Lake Naivasha.

**Statement of the Problem**

Water exploitation for tourism growth and leisure activities has been playing an increasingly important role in the water budget where it accounts for 15 per cent of the total utility bill of many hotels. Luxury hotels and resorts with their extensive laundry, swimming pools and irrigated gardens and golf courses are obvious examples. In many countries
tourism represents an important income source but at the same time the exploitation of water for such purposes, under conditions of water scarcity, poses priority questions and contributes to the competition over scarce water resources.

Despite the presence of Lake Naivasha and other water resources that are available in the study area, the water status in the region has been dwindling as a result of climate change. According to the Naivasha Management Plan (2004) the water budget of the Naivasha watershed is water surplus and deficit of 415.8m³ and 117.2m³ million during wet and dry season respectively. Future increase in water demand will heighten water deficit with serious ramification on the sustainability of the lake and thus calls for urgent measures to manage the existing water resources.

This study thus evaluated the implementation of water resource management strategies in response to the consequences of climate change in hotels within Lake Naivasha environs. The research primarily examined the water resource management strategies the hotels have implemented, determined and compared the perceived effectiveness of the water resource management practices in the hotel operations, established the existing constraints and suggested solutions.

METHODOLOGY

Research design
A case study research design was used in this study since it is suitable for gathering and analysis of both qualitative and quantitative data, and involves a careful and complete observation of a social unit be it a person, a family, an institution, a cultural group or even an entire community (Yin, 1989). The case study as a research strategy and an empirical inquiry that enabled the researcher to investigate the water resource management strategies within the real-life context.

Target Population
Hotels in Lake Naivasha region represents tourism stakeholders operating under situations of water scarcity hence provides a focal point for assessing the effectiveness of water resource management strategies on water sustainability in hotels. In this study, the target population comprised of the 98 registered hotels as documented by Naivasha Municipal Council (2009), whereby 30 hotels are categorized as class A, 40 hotels in class B and 28 hotels under class C, and water management bodies such as the Lake Naivasha WRMA regional office, World Water Foundation (WWF), National Water Conservation and Pipeline Corporation, Catchment Area Advisory Committee (CAAC), Lake Naivasha Water Users Association (LANA WRUA) and Naivasha Water and Sanitation Services Company (NAWASSCO). The target respondents during the study were in two categories:

a) The hotel management staff in the 30 class A hotel establishments located in the environs of Lake Naivasha which comprised of 120 persons in charge of the general and departmental managers.
b) Managers of the water management bodies within Lake Naivasha and its environs, e.g. regional managers.

Sampling techniques and ample size
In this research, as shown in Table 1 the following sampling techniques were used:

<table>
<thead>
<tr>
<th>Target population</th>
<th>Sampling technique</th>
<th>Target pop.</th>
<th>Sample size</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hotels</td>
<td>Census</td>
<td>98</td>
<td>30</td>
<td>30.6%</td>
</tr>
<tr>
<td>Hotel management staff</td>
<td>Purposive sampling</td>
<td>360</td>
<td>120</td>
<td>33.3%</td>
</tr>
<tr>
<td>Managers of water management bodies</td>
<td>Convenience sampling</td>
<td>24</td>
<td>8</td>
<td>30%</td>
</tr>
</tbody>
</table>

Source: Author (Pilot survey, 2009)

The researcher used both primary and secondary data sources to generate primary and secondary data respectively. In this study, primary data was obtained through the use of questionnaires and scheduled interviews which constituted of open ended questions and close ended questions, that solicited for respondents’ views on use of water by hotels, water resource management strategies put in place in the sampled hotels, the perceived effectiveness of these strategies, the constraints faced and other issues. With the use of observation sheets the researcher recorded data on the various structural measures put in place for water conservation.

Secondary data was obtained from Lake Naivasha Water and Sanitation Services Company (NAWASSCO) records and reports on the hotels’ water consumption records and expenditure. Additional information was obtained from WRMA sub-regional office in Naivasha, World Water Foundation (WWF), National Water Conservation and Pipeline Corporation.
Corporation, Catchment Area Advisory Committee (CAAC), Lake Naivasha Water Users Association (LANA WRUA). These sources provided information on the role and level of participation of the hotel sector in the stakeholders’ meetings and initiatives for water resource management.

Document analysis provided information on documented water consumption, expenditure and the subsequent implementation of structural and non-structural water resource management strategies as a tool towards sustainable use of water resources in the selected hotels in the environs of Lake Naivasha.

Reliability and validity tests
Before embarking on data collection, the questionnaires and the interview schedules were first piloted by using a sample of 4 hotels in Lake Naivasha region. After piloting, the questionnaire was restructured and refined to suit the study. The Coefficient of Stability was used to determine reliability of the questionnaires through test and retest method where two administrations of the same questionnaire were done, separated by a one week delay and the scores between the two tests were then correlated. Methodological triangulation was adopted to verify the validity of the data given in the questionnaires on water resource management strategies in the selected hotels, by cross checking the information through direct observation and from analysis of secondary sources such as hotel bookings, receipts, water bills and others.

Data analysis and interpretation
Data analysis was done using both descriptive and inferential statistics facilitated by the use of SPSS (Statistical Package for Social Science) Computer package. Descriptive analysis involved computing frequencies and percentages (proportions) based on respondents’ responses to diverse questions on the use of structural and non-structural water resource management strategies.

RESULTS AND DISCUSSION
Background information of hotels
The purpose of this study was to evaluate the implementation of structural and non-structural water resource management strategies in hotels within the environs of Lake Naivasha, establish the perceived effectiveness of the structural and non-structural strategies and compare the two options in terms of their effectiveness on water sustainability in the hospitality industry. Hotels constitute one of the main pillars in the tourism sector which is highly unique on issues related to use of water resources and water resource management. However the water use intensity and management practices are dependent on the hotel characteristics. In this study, the 3 star hotels constituted the highest percentage of the respondent hotels (37.0%). At this level, hotels provide a significantly greater quality and range of facilities than at the lower star classifications. All bedrooms will have fully en suite bath and shower rooms and offer a high standard of comfort and equipment. Further, 18.5% constituted both 1 star and 2 star hotels. In the 1 star classification hotels, there may be a limited range of facilities and meals may be fairly simple and some bedrooms may not have en-suite bath/shower rooms. In the two star hotels are typically small to medium sized and offer more extensive facilities than at the one star level. Some business hotels come into the two star classification and guests can expect comfortable, well equipped, overnight accommodation, usually with an en-suite bath/shower room. Reception and other staff will aim for a more professional presentation than at the one star level, and offer a wider range of straightforward services, including food and drink.

Structural and non-structural Water Resource Management strategies adopted
Water resource management requires adoption of a variety of strategies both structural and non-structural so as to maximize the benefits. Singh and Cloude (1999) reported that by adopting such modern water resource management methods, hotels in Barbados and St. Lucia could reduce water consumption by an amount sufficient to accommodate anticipated rates of growth in the industry over the next 20 years, without a net increase in water consumption. From the interview sessions with the staff of water management bodies revealed that hotels within the environs of Lake Naivasha complied in the effort to sustainably manage water. Key informant 3 indicated that practicing rainwater harvesting is a widely recommended structural WRM strategy to hotels to promote water sustainability. From the study results, it was evident that the main structural water resource management strategies adopted by the hotels within the study area was the development of alternative water resources like harvesting of rainwater and drilling of boreholes (66.7%) and installation water saving gadgets (59.9%).

According to Rainwater Connection (2006) rainwater harvesting is an effective method of building freshwater. This involves collecting rainwater from roof and gutter system, transporting it via downspouts and piping to cistern tanks,
filtering and then storage. Rainwater tanks collect rain water directly or surface run off so that no water is lost. A report for International Centre for Responsible Tourism ICRT by Goodwin (2007) indicates that Hilton hotel, Madagascar and Marriott Hotel, India have rain water storage tanks for monsoon rainwater collection which has been successfully used directly for irrigation, flushing toilets, within air con systems or treated for drinking.

In tourism, water is an important commodity that ensures the successful operations within the hotels and other hospitality facilities especially in the catering and accommodation sectors. Any accommodation facility that aims at any success has to develop alternative water resource and manage them. Literature reviews, coupled with field observation, revealed that the two main alternative water sources that could be developed and used include harvested rain water and water from sunken boreholes. Having an alternative source of water for a hotel or restaurant would ensure that if the main source of water such as taps are interrupted, water would still be available in the hotel and common embarrassment due to lack of water avoided. Rainwater tanks which collect rain directly and as surface run off ensures that no water is lost.

To complement the use of rainwater, installation of low flow facilities can be valuable cost effective methods of substantially reducing water consumption. Study findings also revealed that having water saving gadgets is preferred much as a structural water resource management strategy where 59.2% of the respondents indicated to have implemented in their respective hotels. A study by Environment Canada (2008) indicted that the top three facilities that consume the largest volume of water in a hotel are showers (35%), toilets (30%), cleaning and laundry (25%). These gadgets include deppressible sink taps, low water volume flush toilet and low pressure showers that use less water and among others. All these gadgets are designed to at least reduce the normal water consumption by a great percentage if implemented and well maintained. Installing efficient toilets and shower heads can reduce water consumption by 35% (Brandes et al., 2006). A report on hotels in Barbados and St. Lucia indicted that guest rooms are fitted with water conservation devices and as such showerheads have flow aerators, and there are low flush toilets in. These devices were fitted two and one-half years earlier and there were dramatic reductions in the water consumption when the devices were installed. Changes totaled about 10,000 gallons in one month (Singh and Cloude, 1999).

Treatment of waste water and later recycling were the other structural water management strategies where 18.5% and 11.1% respectively of the sampled hotels had adopted do to lower costs in implementation. Many hotels use less than 5% for cleaning food and drinking. Water that has been treated and recycled is viable for the majority of other uses. Reuse of water for other areas such as irrigation makes water useful twice. Findings by Goodwin (2007; 23) revealed that Le Sport Hotel in St Lucia wastewater recycle system saved 1 million gallons per year. This therefore guarantees clean and consumable water in the taps of the residents in these countries and tourist destinations. However, the current study established that a majority of hotels in Kenya are yet to embrace the technology of converting waste water from sewers back to the taps to be drunk by humans. The main water resource that the country depends on is rivers and when they dry up, a water crisis of often looms. Other sources are boreholes, lakes and others that can be threatened especially in these times of severe climate change.

Reusing of waste water for irrigation and cleaning was mentioned as a structural strategy of water resource management by 14.5% of the respondents. Recycled water is a valuable resource. Instead of being thrown away, appropriately treated water can be recycled and used a second time to reduce the demand on high quality freshwater sources and improve environmental water quality. Water recycling increases the available supply of water and enables greater human benefit to be achieved with less freshwater. Therefore, water recycling can make a substantial contribution to meeting the world’s water needs and to lessening mankind’s impact on the world’s water environment (Anderson, 2001a; Anderson, 2001b).

This strategy in the study area and in Kenya as a whole is still at its introductory stage although reusing of waste water has made a contribution in drastically reducing operating costs and improved the environment by ensuring the vegetation is well watered and facilities are clean. Within the study area, results indicated that 81.5% of the sampled hotels registered a reduction of the water bill as shown on Table 4.7 while 66.6% indicated an overall increase in water supply.

Perceived effectiveness of the structural water resource management strategies
From the study results 40.7% of the respondents perceived the structural water resource management strategies as being very effective while a further 29.6% rated the strategies as being fairly effective as indicated by the reduced water bill. Indeed, 81.5% of the sampled hotels reported to have reduced their water bill by between 25-50%. Any
business or enterprise has an inbuilt mandate of reducing its general operating cost. In the wake of global economic crisis, every business enterprise always seems to reduce operating costs. Goodwin (2007;22) reveals the applicability of such measures where for example Hyatt Regency Sanctuary Cove installed low showerheads in guestrooms, reducing consumption from 27 litres to nine litres per minute and the Renaissance Reading Hotel in the UK adopted the waterless urinals which saved hotel 81,440 litres per urinal per annum. This is very suitable to the hotels in Naivasha because it would reduce pressure on the diminishing water reserves thus ensure sustainability of water in the region would be ensured.

Studies performed globally on factors that influence the quest to sustainably manage water resources more sustainably is cost rationalization due to increasing cost of utilities (Warnken et al, 2005; Paper III, Paper IV). This fact is further confirmed by key informants interviewed who indicated that cost reduction is the main reason that drives hotels to participate in water resource management. The larger the operating cost, the lesser the profit and vice versa. This assertion is supported by the sentiments of one key respondent who remarked that In this era of global economic hardship, every business venture and enterprise makes every effort to reduce cost and increase profit. The structural water management strategies according to the key informants may have a longer payback period but are most effective in reducing operating cost, thereby increasing the profitability of the hotels.

Key informants further indicated that improving water quality was a major reason for hotels to be involved in WRM. It was also clear that the declining water quality was a challenge experienced by hotels in the study area. Therefore, an effort to improve the water quality is what motivates most hotels in the study area to engage in WRM. Another reason was compliance with the laid down laws which relate to water and its management. NEMA was the body charged with the responsibility of ensuring that the environment is properly managed has the mandate of overseeing the implementation of some of these laws.

Reuse and recycling of waste water for irrigation and cleaning was however adopted by less than 15% of the sampled hotels despite other studies showing cases of success. For example in the water recycling and re-use scheme that was installed at Homebush Bay in Sydney, Australia where the Sydney Olympic Games were staged up to 7,000 m³ per day of recycled water from storm water and treated wastewater sources, was re-used for toilet flushing in sporting venues, irrigation of open space areas, and was also supplied to 2,000 residential houses for gardens and toilet flushing. Through the adoption of microfiltration and reverse osmosis treatment processes which was used to achieve the required water quality, the scheme reduced demands on Sydney’s freshwater supplies by about 850,000 m³ per year (Cooney, 2001).

**Perceived effectiveness of the non-structural water resource management strategies**

According to International Tourism Partnership (ITAP) (n.d) information in the hospitality industry is a key factor in ensuring sustainable management of water resources. This can be done through launching a responsible business programme to staff and solicit feedback, maintain staff awareness of the programme through regular meetings, posters and information on notice-boards encourage motivation through competitions, suggestion boxes and reward staff for successes each month.

In this study, the results indicate that provision of water saving manuals to guests and employees was adopted by 85.2% of the sampled hotels. This strategy involves educating guests and employees about saving water through provision of printed literature and awareness meetings to explain what the hotel is doing to reduce water use and how they can participate in the effort to save water resources. A study at Yokohama Grand Intercontinental Hotel Japan between 1992–1996 reduced water uses by 28% despite a 26% higher occupancy through setting up green teams among the workers which would meet and discuss issues and progress and ensure implementation of water resource management strategies as part of the green measures within the hotel (Goodwin, 2007).

The effectiveness of this strategy is confirmed by 85.2% of the respondents who reported a reduction of the water bill by a range below 25%. The key informants within the water management bodies interviewed support this view that hotel guests should always be reminded of water conservation through awareness creation since this approach is cost effective and customer friendly.

Raising the awareness on proper waste disposal was also cited in the research as the second most preferred non-structural strategy of water resource management by 48.1% of the respondents. Proper waste disposal ensures that the environment which is important in the tourism industry is not destroyed. Improper waste disposal will lead to environmental and ecological degradation. In order for environmental sustainability to be ensured, proper waste
disposal methods have to be utilized in the tourism industry. Other non-structural strategies considered in water resource management included conducting preventive water loss maintenance (26.0%), setting water use targets (18.5%) and water use monitoring and audit (14.8%) which the study established were not widely implemented.

The non-structural WRM strategies are generally cheaper and easier to implement when compared to the structural strategies but can be instrumental in ensuring that the sustainability of water is ensured in the tourism and hospitality industry. The importance of water in the tourism industry cannot be over-emphasized and every effort to conserve it is highly appreciated. When a water resource is properly managed, the operation costs of the tourism and hospitality establishment will be reduced. In Table 4.8, a proportion of 59.3% of the respondents in the study area contended that the non-structural strategies reduced water bills while 40.7% of the respondents had not experienced any change. Therefore it is evident from that non- structural strategies are not very effective since 85.2% of the respondents registered a change in the water bill below 25%. The key informant 1 interviewed argued that this could be due to the fact that such strategies are based on a conscious human effort which may not be very attractive to guests who have booked the hotels to enjoy the comfort that their money can buy and the workers who lack awareness may not be committed to water related issues. Schahn and Holzer (1990) agree that a number of personal attributes which would appear to be linked to environmental actions and behavior which includes gender, age and educational level which may limit the adoption of such strategies.

Comparison of the effectiveness of structural and non-structural Water Resource Management strategies

Structural strategies are optional technologies that enable recycling, reuse, conservation, and treatment of water which is aimed at reducing water loss and wastage among water users. Structural measures follow a particular structure stipulated by the organization and in comparison are more expensive to implement when compared to non-structural measures. Water conservation is crucial and important to a tourism establishment for example a hotel because water is an essential commodity. The availability of water to a hotel or a restaurant is important because it ensures the operations in catering, hygiene, entertainment and others are successful. Treating of waste water reduces the need of requiring new fresh water thereby reducing the operating cost in the long run.

Non-structural measures on the other hand refers to policies, awareness, knowledge development, public commitment, and methods and operating practices, including participatory mechanisms and the provision of information, which can reduce water use. The non-structural strategies adopted according to the findings of the study shows that the most widely implemented strategies included provision of water saving manuals to guests and employees, awareness on proper waste disposal, conducting preventive water loss maintenance, setting water use targets and water use monitoring and audits.

In this study, the researcher sought to establish how the respondents compared the two options on their effectiveness in addressing the challenges related to water resources. The results obtained from the comparative views shows that 70.4% of the respondents viewed the structural strategies as being more effective compared to a 29.6% who indicated rating the non- structural strategies as being more effective. This is further supported by the outcome of the two options on the percentage reduction in the water bill where 81.5% of the sampled hotels achieved a reduction of between 25-50% contrary to the 85.5% of the sampled hotels which attained below 25% reduction in the water bill through use of non-structural strategies.

The non-structural measures or strategies do not possess a particular structure and are much easier and less expensive to implement when compared to structural measures. Making the public to commit themselves to water resource management is an uphill task as some people are generally wasteful of water. This is made possible by constant enlightenment of the general public on issues of water and the dangers of the crisis related to the same. Having proper policies that are water-related is an important non-structural measure of WRM. Increasing awareness of the importance of WRM is probably cheaper compared to recycling waste water. According to the study, the structural strategies of WRM were having water saving gadgets, recycling waste water after treatment, reusing waste water for irrigation and cleaning, developing alternative water resources and treatment of waste water.

CONCLUSION

The study revealed that the major structural water resource management strategy preferred in the area was the development of alternative water resources. This is appropriate because overdependence on a single water resource may be jeopardized if it becomes unsustainable. Other structural measures either adopted or recommended included
having water saving gadgets, recycling waste water after treatment, reusing waste water for irrigation and cleaning and treatment of waste water.

The study also revealed that structural measures of water resource management are more expensive to implement compared to the non-structural ones. The results revealed that the main perceived effectiveness of the structural water resource management strategies adopted have been that they reduce operating costs thereby increasing profitability. Other reasons cited included reduction of negative environmental impacts, resolution of conflicts with other water users and guest satisfaction. These strategies are important to the success of the hotel and hospitality industry in relation to water resource management.

The non-structural measures included provision of water saving manuals to guests and employees, awareness on proper waste disposal, conducting preventive water loss maintenance, setting water use targets and water use monitoring and audits. Results on the effectiveness of non-structural water resource management strategies indicate a minimal impact on the water bill compared to the structural strategies. However they are cost effective since they are cheaper to adopt but are more dependent on the guest, customer or tourist for their effective implementation.

In conclusion, study results indicate that lack of finances and manpower are the main setbacks to the implementation of structural and non-structural water resource management strategies. This however can be addressed if cheaper water saving technology is made available and finances can be sourced from donors. Other strategies would include water imports from areas with surplus and legal redress where illegal water abstractors are penalized. Formulation of better water resource management policies and increased involvement of other stakeholder was also realized to an amicable solution to the setbacks.

**RECOMMENDATION**

**Structural Water Resource Management strategies**
The study results indicate that the sampled hotels within Lake Naivasha had fully embraced the use of structural water resource management strategies such as development of alternative water sources, use of water saving gadgets, water recycle and reuse and had made milestone achievements on reduction of water related challenges. However more achievements can be made if the following essential technology is adopted especially in the area of water conservation. The 21st century has been caught up in the technological advancement of literally all sectors including water. The hotels in the study area of Naivasha should embrace the use of technology as this would reduce their operating cost by a huge margin which includes;

a) Use of water saving devices including flow restrictors and aerators  
b) Use waterless urinals fitted and toilets fitted with infrared flush sensors.  
c) Reducing water consumption through placing ‘bottles’ and ‘hippos’ into cisterns  
d) Use of irrigation systems, moisture sensors and timers to reduce waste and evaporation loss  
e) Use of ozone treated purified water

**Non-structural Water Resource Management strategies**
The study results show minimal adoption of these behavioral related strategies in the sampled hotels within the environs of Lake Naivasha despite the fact that adoption of these strategies is quite cost effective though it is based on the guests’ or the hotel workers’ attitude towards the environment and other demographic characteristics.

Adoption of the following other non structural strategies is recommended;

a) Encouraging guests to reuse towels and bed linen to reduce water consumption and chemical discharge.  
b) Taking a shower instead of a bath, the shorter the shower the better.  
c) Be aware of and follow water conservation rules or guidelines.  
d) Conserve water because it makes sense, don’t waste water just because someone else if footing the bill in the end we will all be paying for it as water is a finite global resource.  
e) Remember that every drop counts especially in a region where competition for water resources is high.

**Other strategies**

a) **Better policies** – There should be a concerted effort from the various relevant stakeholders to ensure that better and applicable policies are drafted that would benefit the water industry and the study area as a whole.  
b) **Stiffer penalty on pollution** – Pollution of water resources has been a threat to the tourism industry especially in the accommodation and catering sectors. Water pollution leads to diseases and can even lead to death, so
NEMA as the relevant environment manager has to ensure stiff penalties and fines for those who pollute water in order to distract existing and potential polluters of water and its resources.

c) **Implement the Polluter Pay Principal** – This would be a deterrent measure to prevent any future pollution in the study area.

d) **Community involvement** – Involving the local community and other stakeholders in important efforts for example water conservation, planting of trees and others can guarantee the sustainability of water in a region. The local community is the backbone of a region and when local people are neglected or ignored, efforts towards water resource management could be threatened. The local communities are important stakeholders in the tourism and hospitality industry. When local communities are involved in WRM, the sustainability of water resources can be ensured.

e) **Developmental incentives** – The government should give incentives to both domestic and foreign investors who seek to invest in the development of the water industry. Among the incentives that can be given include soft loans, duty-free importation of technological gadgets related to water conservation and government subsidies. These developmental initiatives geared towards water resource management can impact positively in the tourism sector and ensure its sustainability.

**Areas for further research**
The following are areas for further research.

a) **Non-structural WRM strategies** – More research should be conducted on non-structural water resource management strategies since currently emphasis is placed mainly on the structural ones.

b) **Recycling of waste water** – More research should be conducted on the issue of water recycling and how this would benefit regions especially in the developing countries. These countries usually encounter a water crisis and local communities characterized by men and women walking for long distances daily in search of water. When waste water is recycled, this could be minimized.

c) **Desalination** – According to the researcher, desalination is an area of research that can be explored so as deal with the water crisis especially along the Kenyan coast. As previously indicated, desalination is an artificial process by which saline water generally from the sea or ocean, is converted to fresh water. Since ocean and sea water constitutes 97% of the worlds’ water reserves, fresh water can obtained through this process and supplied to areas experiencing water stress which would drastically reduce the global water crisis.

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ROLE OF RELIGIOUS STUDIES IN ENVIRONMENTAL RESOURCE MANAGEMENT FOR MITIGATION OF CLIMATE CHANGE TOWARD REALIZATION OF VISION 2030

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ABSTRACT
Attainment of Kenyan Vision 2030 heavily depends on climate-sensitive sectors, including agriculture, tourism and coastal zones. On the flipside, major rapid industrialization developments and urbanization anticipated to occur will affect pollution levels and generate larger quantities of solid waste, which will require effective disposal management. Kenya must begin climate change awareness creation to combat pollution and waste accumulation to ensure sustainable development. This effort demands greater resolve to use religious education’s socializing role to enforce the vision for the environment sector, which is “a nation living in a clean, secure and sustainable environment”. The present research was pegged on two theories: cognitive dissonance theory of attitude change, which states that inconsistencies between attitude and behaviour are uncomfortable, so people will change their attitudes to remove discomfort where dissonance is often removed by a shift in attitude, and the prior knowledge theory, which states that students who learn more at one level usually do better and are able to assimilate new knowledge at higher levels. Key findings were: Religious education that God placed man in the Garden of Eden to till and keep it at home; church and school are mirrors reflected by well kept environment is proved effective for attitude and behaviour change. Part of Kenyan culture is religious ‘notorious’ with over 75% population. Kenya should continue international efforts to promote sound environmental policies demonstrated by the country’s hosting of the United Nations Environment Programme (UNEP) headquarters by domesticating them using her strength in religious education systematically to create awareness of environmental issues and responsibilities concerning climatic change, waste management and pollution prevention to implement environmental management policy.

Key words: Climate change adaption, Environmental resource management, Religious education

INTRODUCTION
Environmental resource management is the management of the interaction and impact of human societies on the environment. It is not, as the phrase might suggest, the management of the environment itself. Environmental resources management aims to ensure that ecosystem services are protected and maintained for future human generations, and also maintain ecosystem integrity through considering ethical, economic, and scientific (ecological) variables. Environmental resource management tries to identify factors affected by conflicts that rise between meeting needs and protecting resources. It is thus linked to environmental protection and sustainability. Environmental resource management can be viewed from a variety of perspectives. Environmental resource management involves the management of all components of the biophysical environment, both living (biotic) and non-living (a biotic). This is due to the interconnected and network of relationships amongst all living species and their habitats. The environment also involves the relationships of the human environment, such as the social, cultural and economic environment with the biophysical environment. The essential aspects of environmental resource management are ethical, economical, social, and technological. These underlie principles and help make decisions. The concept of environmental determinism, probabilism and possibilism are significant in the concept of environmental resource management. It should be noted that environmental resource management covers many areas in the field of science: geography, biology, physics, chemistry, sociology, psychology, physiology, and Kenya Vision 2030 is the new long-term development blueprint for the country. It is motivated by a collective aspiration for a better society by the year 2030. The aim of Kenya
Vision 2030 is to create “a globally competitive and prosperous country with a high quality of life by 2030”. It aims to transform Kenya into “a newly-industrializing, middle-income country providing a high quality of life to all its citizens in a clean and secure environment”. Major developments anticipated by Kenya’s Vision 2030 will affect pollution levels and generate larger quantities of solid waste than at present. Anticipated growth in manufacturing activities will also give rise to an increase in effluents discharged, which will require effective disposal management. Urbanization will also occur at a rapid rate; by 2030, it is estimated that more than 60 per cent of Kenyans will be living in cities and towns. These changes are likely to impact adversely on the environment, which will require effective management to ensure sustainability. All these changes will exert immense pressure on the already declining natural resources base and on the country’s fragile environment. This necessitates a strong policy on the environment in order to sustain economic growth while mitigating the impacts of rapid industrialization. Kenya’s current institutional framework to manage the environment, however, is characterized by fragmentation. Various aspects of the environment policy cut across different institutions. Although the Environment Management and Coordination Act (EMCA 1999) was enacted with the primary objective of improving the coordination and management of the environment, legislation of relevant laws and regulations has not yet been completed. Policy and institutional reform for stricter enforcement, therefore, poses a big challenge that must be overcome by Vision 2030.

 Situation Analysis of the Kenya’s environment big picture

Kenya has in the past made considerable efforts, domestically and internationally, to promote sound environmental policies. This effort is demonstrated by the country’s hosting of the United Nations Environment Program (UNEP) and the United Nations Human Settlements Program (UN-Habitat) headquarters, the only UN headquarters in a developing country. Kenya cannot, therefore, afford to lag behind the rest of the world in environmental management policy. The country is a signatory to a number of Multilateral Environment Agreements (MEAs), including Agenda 21, the Montreal Protocol, the Basel Protocol, the Stockholm Convention, the Kyoto Protocol and CITES. Most of these conventions have financial mechanisms for addressing various environmental challenges for member states. Kenya will strengthen her capacity to meet international best practices contained in these documents.

The country faces the following challenges:

• Sustainable management of natural resources: Kenya’s main forests constitute five water towers (Mt. Kenya, Aberdares Range, Mau Escarpment, Cheranganyi Hills and Mt. Elgon), which cover more than 1 million hectares and form the upper catchments of all main rivers in the country. In the past two decades, Kenya’s forests have experienced severe destruction as a result several factors, the main one being increased demand for agricultural land. This has, in turn, affected the hydrological cycles in the water towers and resulted in water shortages across the country. Current forest cover is less than 3 per cent compared to the internationally recommended 10 per cent. Degradation of Mt Elgon and Cheranganyi catchment areas has resulted in flooding in the regions around River Nzoia (Budalangi). Further, continued degradation of the Mau escarpment, which supports the Mara reserve, will have adverse effects on the tourism sector in the future.

• Wild animals in their natural habitat: Wildlife accounts for 90 per cent of safari tourism and 75 per cent of total tourism earnings. The main challenges in wildlife conservation are: poaching; human-wildlife conflicts; habitat destruction; and, changes in land use patterns. The challenges are further compounded by incomplete information on wildlife census and species dynamics. These factors are aggravated by reduction in dispersal areas and blockage of migration corridors for areas bordering parks. Continued reduction in wildlife and critical habitats can undermine sustained growth in the tourism sector and reduce competitiveness with other countries. Coastal marine resources offer a great potential to sustain a number of economic activities, especially along the Coast, such as tourism, agriculture, fishing, mining and water sports. However these resources are currently largely untapped. The low capacity in the country to harness these resources poses a great challenge. To unlock the potential, an integrated policy on the management of coastal marine resources will be developed.

• Medical/Hazardous Waste: Due to lack of appropriate disposal facilities, medical and hazardous wastes continue to pose a challenge in environmental management. This waste is disposed together with general municipal waste i.e. without segregation. Currently, there are only two incinerators in the country (both located in Nairobi) for destroying medical and hazardous waste. With Nairobi expected to become a regional hub, there is a need to build necessary capacities, especially within the country’s medical facilities, to handle all types of wastes. This will also call for the use of market-based instruments to improve waste management, as well as public awareness measures to promote sound waste disposal practice.
• **Climate change and desertification:** Although Kenya has contributed little to the causes of global warming, it is one of the countries most affected by the disasters of climate change. The effects are likely to be more severe in the future, unless the international community demonstrates greater resolve. This could slow down Kenya’s projected economic growth for two main reasons. First, the economy is heavily dependent on climate-sensitive sectors, such as agriculture, tourism and coastal zones.

Second, the means to cope with climate hazards is weak. Already, changing climate conditions are responsible for the melting of glaciers on Mt. Kenya, which in 1900 had 18 glaciers but now has only 7. This explains the decline in water levels in Athi and Tana Rivers and subsequent interruption in electricity generation. Over 70 per cent of natural disasters affecting the country are weather-related. In the recent past, there has been an increase in frequency, magnitude and severity of disasters. The impacts include loss of life and property and destruction of infrastructure. The current approaches to disaster management are towards disaster response as opposed to disaster risk reduction.

• **Harnessing of strategic natural resources:** There exists great potential for Kenya to develop bio-resources for medicinal, industrial and other products. There is a need to develop capacity to undertake research and to regulate and develop products from these resources. Low innovation in utilization of natural resources coupled with inadequate capacity to commercialize scientific research and inability to adopt new technologies have had a negative impact on the development of natural resources for the benefit of Kenya. Kenya will need to strengthen her institutional capacity to collect data on land use, not just for urban and physical planning as stated elsewhere in this document, but also for environmental analysis and policy making. Inadequate capacity to adopt new technologies to detect the impact of resource exploitation has contributed to lack of information for planning. Only 30 per cent of the country’s land cover is planned and only three urban centres (50 per cent of Nairobi, Kisumu and Kitale) have land use data. Lack of appropriate urban planning partially explains the mushrooming of informal settlements in major towns, and poses a major challenge to the provision of utilities. The capacity to undertake land cover mapping is weak hence assessment and monitoring of strategic environmental resources remains a challenge. With the expected urbanization, there is a need to build data bases and analytical capacity for resource use and management.

**The vision for environment**

The vision for the environmental sector is “a nation living in a clean, secure and sustainable environment”. The vision is inspired by the principle of sustainable development and by the need for equity in access to the benefits of a clean environment. To realize this vision, the focus will be on four strategic thrusts:

**Conservation**

The country will intensify conservation of strategic natural resources (forests, water towers, wildlife sanctuaries and marine ecosystems) in a sustainable manner without compromising economic growth. Kenya intends to have achieved 10 per cent forest cover by 2030. In addition, specific measures will be adopted to promote bio-prospecting activities e.g. research and development of commercial products such as drugs, cosmetics and detergents.

**Pollution and waste management**

The extent of pollution and waste is correlated to GDP; in general, countries with high GDP levels tend to generate more pollution and waste than those countries with low GDP levels.

(This trend, however, is currently being reversed in many highly developed economies, such as Singapore, through environmentally-friendly policies and practices.) Despite the high rates of growth envisaged by Vision 2030, Kenya will progressively apply measures to guard against the adverse effects of increased pollution and waste experienced elsewhere. Under the Foundations for Kenya Vision 2030 Science, Technology and Innovation (STI) has a prominent place both in the achievement of the national development vision as well as in the advancement of the undesirable climate change: Vision 2030 proposes intensified application of science, technology and innovation to raise productivity and efficiency levels across the three pillars. It recognizes the critical role played by research and development (R&D) in accelerating economic development in all the newly industrializing countries of the world. The Government will create the STI policy framework to support Vision 2030. More resources will be devoted to scientific research, technical capabilities of the workforce, and in raising the quality of teaching mathematics, science and technology in schools, polytechnics and universities. **Human Resource Development:** Kenya intends to create a globally competitive and adaptive human resource base to meet the requirements of a rapidly industrializing economy. This will be done through life-long training and education. As a priority, a human resource data base will be established to facilitate better planning of human resources requirements in the country. Furthermore, steps will be taken to raise labour productivity.
to international levels. This training and education is one-sided and demands a new dimension of religious education in the Environmental Resource Management for mitigation of climate change towards realization of Vision 2030.

This new dimension of religious education in the Environmental Resource Management for mitigation of climate change should equally fall under the Social Pillar: Investing in the People of Kenya. This quest is the basis of transformation in some key social sectors, namely: Education and Training; Health; Water and Sanitation; the Environment; Housing and Urbanization; as well as in Gender, Youth, Sports and Culture. Under education and training, Kenya will provide a globally competitive and quality education, training and research. Kenya aims to be a regional centre of research and development in new technologies. This will be achieved through the religious education dimension of environmental resource management for mitigation of climate change beginning right from early childhood education into primary education up to reforming secondary school curricula: modernizing teacher training; strengthening partnerships with likeminded religious and faith based institutions of learning.

**Statement of the Problem**

In the struggle to separate “state and religion” the role of religion in environmental management and to be specific the indispensable role of Religious Studies in the Environmental Resource Management for mitigation of climate change towards realization of Vision 2030 was undermined foolishly and now that climate change has mutated to be a global dragon calls for the cooperation and collaboration of all stakeholders. Among the environmental managers Stakeholders religious organizations were despised as the spotlight was on public sector, private sector and the civil society and they alone seem to fail. It is shameful that the global efforts are forced to accept as a last resort that Religious organizations as equal stakeholders who have an indispensable dimension of mitigation efforts as equal Primary Collaborating Partner like the public, private and civil society. The word religion has its root from a Latin word ‘religare,’ which can mean “to reconnect,” but can also mean “to bind or fasten.” In this last interpretation, religion serves the state and society by binding its believers to social rules and norms which at this juncture is environmental resource management for mitigation of climate change towards realization of Vision 2030 by its studies. Paul Tillich who defines religion anything that deals with “ultimate concern.” Climate change cannot be accurately defined outside Tillich’s definition of religion as a matter of ultimate concern!

Religion can be described as a unified system of thoughts, feelings, and actions that is shared by a group and that gives its members an object (or objects) of devotion, someone or something sacred to believe in, such as a god or a spiritual concept it also involves a code of behavior or personal moral conduct by which individuals may judge the personal and social consequences of their actions and the actions of others. Some of the anthropological theories of the origin of religion postulate that religion may have developed in part out of human beings’ attempts to control uncontrollable parts of their environment. Scientists recognize two different ways that humans try to do this: manipulation, through magic, and supplication, through religion. Magic tries to make the environment directly subject to human will through rituals. An example might be drawing pictures of large numbers of animals on cave walls in hopes of assuring success in hunting. Hundreds of such paintings have been found all around the world. Religion, on the other hand, tries to control the environment by appealing to a higher power, gods and goddesses. “The sorcerer,” for instance, may represent a god who ruled the hunt, because he is shown with deer and bison.

**Limitations and Assumptions**

Although the study was based on the following assumptions that Kenya is dubbed as a notoriously religious nation man in general has an inclination towards religion and can be use this strength to leverage forcible environmental resource management it can equally enforce the same across the board by hosting of the United Nations Environment Program (UNEP) headquarters, the only UN headquarters in a developing country.

**Justification of the research**

Sustainability and environmental resource management involves managing economic, social, and ecological systems within and external to an organizational entity so it can sustain itself and the system it exists in. In context, sustainability implies that rather than competing for endless growth on a finite planet, development improves quality of life without necessarily consuming more resources. Sustainably managing environmental resources requires organizational change that instills sustainability values that portrays these values outwardly from all levels and reinforces them to surrounding stakeholders. The end result should be a symbiotic relationship between the sustaining organization, community, and environment. Recent successful cases have put forward the notion of integrated management. It shares a wider approach and stresses out the importance of interdisciplinary assessment. In this research the role of religion in enhancing...
Sustainability and environmental resource management is indisputable as a part of the integrated management. It is an interesting notion that might not be adaptable to all cases Religion in this research goes by Paul Tillich’s definition as that which deals with “ultimate concern.”

Climate change cannot be accurately defined outside Tillich’s definition of religion as a matter of ultimate concern! By definition religion can be described as a unified system of thoughts, feelings, and actions that is shared by a group and that gives its members an object (or objects) of devotion, someone or something sacred to believe in, such as a god or a spiritual concept it also involves a code of behavior or personal moral conduct by which individuals may judge the personal and social consequences of their actions and the actions of others. Some of the anthropological theories of the origin of religion postulate that religion may have developed in part out of human beings’ attempts to control uncontrollable parts of their environment. Scientists recognize two different ways that humans try to do this: manipulation, through magic, and supplication, through religion. Magic tries to make the environment directly subject to human will through rituals.

Objectives of the Study
The specific objectives of the study were to:
1. Establish need for missing link in the role of religion in environmental management and to be specific the indispensable role of Religious Studies in the Environmental Resource Management for mitigation of climate change towards realization of Vision 2030
2. Assess the effectiveness of this new dimension of religious education in the environmental resource management for mitigation of climate change under the Social Pillar which underlining investing in the People of Kenya
3. Ascertain the place and profitability of religious education dimension of environmental resource management for mitigation of climate change with religion being defined as that which deals with “ultimate concern.” where Climate change cannot be accurately defined outside this definition of religion as a matter of ultimate concern!

Theoretical frame work
The research was pegged on two theories; cognitive dissonance theory of attitude change, which states that inconsistencies between attitude and behavior are uncomfortable, so people will change their attitudes to remove discomfort where dissonance is often removed by a shift in attitude and the prior knowledge theory which states that students who learn more at one level usually do better and are able to assimilate new knowledge at next higher level.

METHODOLOGY
The methodology included observation and case studies with Kenya being the case study field and the church with its Christian / religious education.

LITERATURE REVIEW
Christian religious education paints man from his origin as an environment based creature. When he resonates with this it goes well with him and when the he transgresses it haunts him out. There is none other part of the world where religious education can best be used as a domestic policy for adaptation like in a country which is dubbed as notoriously religious. The secret of being better prepared as a climate changes is hidden in a nation’s ability to domesticate its foreign policy by being creative in inventing its knowledge based tools of creating awareness and Kenya is noted as being notoriously religious. Kenya can use its religious strength to create a more cohesive framework for environment resource management. The religious education and space enshrined in the constitution can be used to make the environment closed to destruction citing that the first environmental managers were placed in the Garden of Eden in the name of Adam and Eve who were responsible to till and dress the garden Genesis 2;15 (KJV). When man he felled he lost the garden, Genesis 3; 23-24(KJV).

When man was on course with his religious mandate to manage his environment life was sweet but when he failed life turned to be survival for the fittest, he was to be clothed with skin and gather fruits amongst thorns, hunting and being hunted by creatures who before were pets and now they too had survival for the fittest. Environmental management in Kenya and Africa requires a lot of thinking through on how to use its religious strength to be better prepared as climate changes just like the west has thought through in the reuse of technology waste management. A lot of natural forests are present in Kenya and a religious consolidated approach in planting more while maintains the present is what should
creatively be cultivated. The word religion according to Kasyoka (2008) has its root from a Latin word ‘religare,’ which can mean “to reconnect,” but can also mean “to bind or fasten.” In this last interpretation, religion serves the state and society by binding its believers to social rules and norms.

Paul Tillich (1886–1965), who defines religion anything that deals with “ultimate concern. Religion can be described as a unified system of thoughts, feelings, and actions that is shared by a group and that gives its members an object (or objects) of devotion, someone or something sacred to believe in, such as a god or a spiritual concept. Religion also involves a code of behavior or personal moral conduct by which individuals may judge the personal and social consequences of their actions and the actions of others. Religion may have developed in part out of human beings’ attempts to control uncontrollable parts of their environment. As with all management functions, effective management tools, standards and systems are required. An environmental management standard or system or protocol attempts to reduce environmental impact as measured by some objective criteria. Religion adds a set of tools which does an inside job on the attitude and conduct of man as a manger of his environment.

Scientists recognize two different ways that humans try to do this: manipulation, through magic, and supplication, through religion. Magic tries to make the environment directly subject to human will through rituals. An example might be drawing pictures of large numbers of animals on cave walls in hopes of assuring success in hunting. Hundreds of such paintings have been found all around the world. Religion, on the other hand, tries to control the environment by appealing to a higher power, gods and goddesses. “The sorcerer,” for instance, may represent a god who ruled the hunt, because he is shown with deer and bison.

The need for religion
One major theory about the human need for religion is that it grew both out of human curiosity about the big questions of life and death and out of the fear of uncontrollable forces. Eventually, religion transformed this human curiosity and fear into hope. Such hope involved several aspects: a desire for immortality or life after death, for a kind creator who would watch out for humanity, and for an ultimate meaning to life. There are several other theories as to why religion is such a universal concern. Humans are social animals, and religion in practice brings people together. In fact, for many modern people who profess a religion, the social element may be even stronger than the spiritual element. Many attend religious services for the sense of community they might receive from this experience. They take strength in sharing a commonly held belief system with others and also enjoy the weekly, sometimes daily, routine that religious services provide. For many believers, in fact, the simple act of attendance at church or temple and participation in ritual is religion, rather than its spiritual element. There are also scientific approaches. Psychologists, scientists who study the mind, argue that religion answers emotional and psychological needs in humans, such as the fear of death, or a need for a higher spiritual experience than is provided in the everyday world. Religion can thus give meaning and direction to a person’s life. Neuroscientists, those who study the brain and the nervous system, think that there is actually a part of the brain that has circuitry for an intense religious experience. in biology, the meme theory says that culture can be passed from generation to generation in the same way that genetic material, such as a gene for red.

Religion, whatever its origins or its reasons for being, is a universal fact of life. The 19th and 20th Century’s saw the rise of scientific and political theories (such as communism) that threatened the role of religion in daily life. However, religion has endured in all its various shapes. In the twenty-first century, religion is playing a more important role in world affairs than ever before.

The twin brothers who love to hate each other; Religion and science.
Science and religion are two ways of examining the world. The scientific method limits its examination to questions dealing with objective interaction with the world and according to Weisskopf (1963) when man contemplates of nature the question of how things were created arises and religion is the first to come on board science as always gives its answers which are more often partial. It uses experiments and the process of trial and error to arrive at conclusions about the world. It tries not to make assumptions without a body of facts and evidence to support the assumptions. Science, in its many forms, can deal with many different types of questions, ranging from what makes people behave the way they do to what a distant star is made of. Science, however, does not deal directly with questions of morality, such as how one should lead a good life or the nature of good and evil. Science can tell the reason for death, but not what happens after death. Religion, on the other hand, deals with what it calls absolute and eternal truth, and does so by generalization and by a leap of faith. This leap of faith, a belief in the un-provable, is perhaps the biggest distinction between science and religion. Modern science has its roots in the Christian traditions of Western Europe so the two should compliment and not compete each other.
The value of religion

Religion continues to be a vital force because it has value for people. For many, the value comes in the experience of something beyond the boundaries of day-to-day life. The religious experience is for them a valuable product of faith, linking them to a bigger universe and giving them hope of eternal life. Others find in their religion an opportunity for intellectual analysis of doctrines and teachings, while for others the value of religion comes in its teachings about leading a moral and ethical life. Most religions teach some form of moderation, and this in turn puts limits on believers and makes society more stable. Part of this social control comes from the figures of authority in provided by each religion. Still others find comfort in the traditions of their religion, including architecture and music. In practical terms, religions have at times been responsible for founding educational institutions, hospitals, and charities, forming the backbone of social welfare networks throughout the world.

Religion also plays a large part in regulating acceptable moral behavior, and in implanting a sense of ethics, or proper behavior, and justice not only in the followers of that particular religion, but also in society as a whole. In fact, many observers divide a religion into two categories: its ethical teachings and its spiritual teachings. Examples abound for the moral teachings of religions. In the Abrahamic religions of Judaism, Christianity, and Islam, which have a common source in the prophet Abraham, there are similar codes of ethical behavior contained in basic rules, such as the Ten Commandments. Religions with their origins in Asia also have codes of moral behavior for right living, as seen in Buddhism’s five precepts and eightfold path.

In addition to instructions for proper living, religions have also been responsible, in part, for the rule of law in society. Religious law was one of the early inspirations for secular or nonreligious legal codes. The code of Hammurabi, the eighteenth-century BCE Babylonian code of law, takes as its inspiration the gods who put Hammurabi in power. In some cultures, the secular legal system is still highly influenced by religious law, this is true in some Islamic states, where religious law, sharia, is practiced. Additionally, some religious historians believe that the development of monotheistic religions led to the creation of strong, centralized nation states, ruled first by kings, and later by elected officials. Thus, religion has had a major influence not only on the moral and ethical codes of societies, but also on their legal and governmental structures. To sample a few of them we have Deut 20:19 thou shalt not destroy the trees thereof by forcing an axe against them -- In a protracted siege, wood would be required for various purposes, both for military works and for fuel. But fruit-bearing trees were to be carefully spared; and, indeed, in warm countries like India, where the people live much more on fruit than we do, the destruction of a fruit tree is considered a sort of sacrilege. — Proverbs 28; 10 Whoso digs a pit — He that diggeth a pit shall fall into it; and whoso breaketh through a wall, a serpent shall bite him. Whoso hews out stones shall be hurt therewith; and he that cleaveth wood is endangered thereby. Eccl 10:8-9 (ASV) And if a man shall open a pit, or—dig a pit—That is, if a man shall open a well or cistern that had been before closed up, or dig a new one; for these two cases are plainly intimated: and if he did this in some public place where there was danger that men or cattle might fall into it; for a man might do as he pleased in his own grounds, as those were his private right. In the above case, if he had neglected to cover the pit, and his neighbor’s ox or ass was killed by falling into it, he was to pay its value in money. Exodus 21:33 and Exodus 21:34 seem to be out of their places. They probably should conclude the chapters, as, where they are, they interrupt the statutes concerning the goring ox, which begin at Exodus 21:28. Ex 21:33-34 (Darby) — And if a man open a pit, or if a man dig a pit, and do not cover it, and an ox or an ass fall into it, the owner of the pit shall make it good, shall give money to the owner of them; and the dead [ox] shall be his. These different regulations are as remarkable for their justice and prudence as for their humanity. Their great tendency is to show the valuableness of human life, and the necessity of having peace and good understanding in every neighborhood; and they possess that quality which should be the object of all good and wholesome laws—the prevention of crimes. Most criminal codes of jurisprudence seem more intent on the punishment of crimes than on preventing the commission of them. The law of God always teaches and warns that his creatures may not fall into condemnation; for judgment is his strange work, i.e., one reluctantly and seldom executed, as this text is frequently understood. Deut 23:12-14 (ASV) religious based waste management. Thou shalt have a place also without the camp, whither thou shalt go forth abroad: and thou shalt have a paddle among thy weapons; and it shall be, when thou sittest down abroad, thou shalt dig therewith, and shalt turn back and cover that which cometh from thee: for Jehovah thy God walketh in the midst of thy camp, to deliver thee, and to give up thine enemies before thee; therefore shall thy camp be holy, that he may not see an unclean thing in thee, and turn away from thee.
CONCLUSIONS
Key findings are; Man is an environment based creature who’s well or ill being is directly ties to either its management or mismanagement. Religious education that God placed man in the Garden of Eden to till and to keep it at home, church and school is mirror reflected by well kept environment is proved effective for attitude and behavior change. Part of Kenyan culture is religious ‘notorious’ with over 75% population.

RECOMMENDATIONS
This research makes the following recommendations on the part of the Kenya to realize its national development vision 2030 which shall enhance environment resource management. With religion as part of her strength the country should engage forcefully on the religious education based environmental management in both awareness creation as well as ethical and moral conduct building which is in resonance with environment management. Kenya having the United Nations Environment Program (UNEP) is at the best position to demonstrate the need and the way forward in adapting new dimension approaches in continuing her international efforts, to promote sound environmental policies demonstrated by the country’s hosting of the United Nations Environment Program (UNEP) headquarters, the only UN headquarters in a developing country, by domesticating them using her strength via religious education systematically to create awareness of environmental issues and responsibilities concerning climatic change waste management and pollution prevention to implement environmental management policy.

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PLANNING AND MANAGEMENT OF NATURAL RESOURCES: A CASE OF SUB-SAHARAN AFRICA

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ABSTRACT
The world population has been increasing over time, causing an increase in demand for natural resources and threatening their replenishment. Most natural resources are non renewable. Excessive and unplanned exploitation leads to extinction, acute scarcity, widespread pollution, and uncertain feedback loops. This raises a need to discover new techniques which can effectively help in exploitation without compromising the needs and desires of future generations. There have been attempts to formulate policies on the usage of natural resources for most developing countries, especially those in the Sub-Saharan Africa, but planning and management of these resources still remains a major concern. Existing policies need to be re-evaluated to determine the rationale behind their failures. New policies focusing on planning and management of natural resources also need to be formulated and effectively implemented to
improve economic growth and development. This paper reports on research, technologies and options for sustainable natural resource utilization and effective management of land, water, soil, wildlife, minerals and forests in the horn of Africa. It is possible to achieve sustainable development by controlling natural resources through proper management and planning.

**Key words:** Policy, Population, Natural resources management

**INTRODUCTION**

Natural resource management refers to the management of materials or substances (that occur in natural state and have economic value) such as land, water, soil and plants, with a particular focus on how management affects the quality of life for both present and future generations (stewardship) (Bojo, 2000). Natural resources are often characterized by the variety of their existence. They may be further classified in different ways depending on their chemical nature, their abundances and availability or their distribution (Moll, 2005).

Allocation and exploitation of natural resources has generated debate the world over. This is partly due to increasing scarcity due to over-exploitation and also because the exportation of natural resources is the basis for the expansion of many economies especially in the developed nations such as Australia. The basic characteristic of natural resources being finite means that if they are used them continuously without proper planning and management, they will eventually be depleted (Bojo, 2000).

Natural resources greatly contribute to the GDP of many sub-Saharan countries. They are especially an important share of export and government revenue for most of the countries in the region. This has prompted these countries to formulate policy strategies to enhance the management of their resources. Empirical evidence suggests that translating this resource wealth into stronger economic performance and a higher standard of living has been challenging (Lundgren, 2013). Among the major challenges facing these countries are the volatile and unpredictable nature of natural resource prices, the exhaustibility of these resources and the difficulty of transforming natural resource wealth into productive human, physical, and financial assets particularly due to lack of institutional and administrative capacity to manage public finances well.

The policies formulated to address the existing challenges have over time proved to be weak or poorly implemented. Natural resources therefore continue to be at the risk of depletion. Making the right policy decisions in managing these natural resources coupled with strong governance and fiscal regimes to ensure the right implementation will result in a high payoff so as to compensate for the lost opportunities for strong growth and economic development. The focus of this paper is therefore on closing the loopholes in the existing policies and formulating new policies to close the existing gaps for proper implementation in the planning and management of land, water, soil, wildlife, minerals and forests of sub-Saharan Africa.

**Water**

Water is a significant natural resource upon which agricultural production relies. Water is also a point of conflict as competing demands for a limited resource creates tension and conflict. These demands are fueled by the emergent need for water for urban use, industrial use and environmental use that competes with the existing need for water to sustain agricultural production (Rosegrant, 1997).

Water resources include surface and groundwater sources (blue water); rainfall (green water) and recycled wastewater (grey water). Whether or not water shortages occur is an issue depending on geographic location, season and demand for water. However, reducing the pressure on water can be considered of importance due to upstream and downstream consequences as well as associated impacts.

According to the United Nations Environmental Program (UNEP) water scarcity report (2007), roughly one-third of the world’s population lives in countries where there is moderate to high water stress. Most of the countries south of the Sahara are classified by the United Nations as chronically water scarce. A country is categorized as water scarce if its annual water supply is less than 1,000 cubic meters, the global standard benchmark for a country to be considered as adequately supplied with water (UNEP water report, 2007). Governments in sub-Saharan countries have over time developed strategies to address the water crisis with little progress. This has been through policy formulation and implementation. However, the process has not been as successful as they would have intended.
Major concerns on existing policies affecting water

The main problems regarding water in sub-Saharan Africa include: extremely limited per capita endowment of freshwater resources and high hydrological variability, both temporally and spatially, unreliable annual rainfall, droughts and when it rains; frequent flooding, poor management of water resources, rapidly growing demand for water for most sectoral uses and inadequate storage capacity. The water towers continue to be severely damaged through encroachment by human settlements, agricultural expansion, rapid human population growth, destruction of forest vegetative cover due to illegal logging, charcoal burning, poorly planned tourist facilities, water pollution, over/illegal abstractions by industries and urban settlements. Thus, the region is classified as a water scarce country.

The major policy statements in most of the sub-Saharan countries are based on:
- ensuring increased per capita water availability above the international benchmark of 1000 m³,
- ensuring progressive restoration and protection of ecological systems and biodiversity in strategic water catchment areas,
- maximizing use of trans-boundary water resources in coordination with other countries,
- encouraging storm water management and rainwater harvesting,
- improving inter-basin water transfer,
- improving pollution control,
- establishing sound research and development in the water sector,
- enforcing regulations,
- improving effluent waters treatment and recycle for use,
- ensuring sustainable groundwater resources for present and future generations,
- ensuring sufficient funds for sustainable development and management of water resources,
- resolving conflicting mandates by better cross-sectoral coordination and developing a water management system which contributes to the protection of the environment (Ministry of Water in Kenya, 2012).

In light of this, there is dire need for reforms in the water sector as most of the steps taken are not feasible while others have been poorly implemented. The following represents strategies to ensure effective management of the water resource for sustainable agricultural productivity:

Changes required in policies on water

Better integrate water priorities into agricultural Policies

Water priorities that have been articulated need to be more fully integrated into and well implemented through sectoral policies both at national and regional levels. Agriculture is a major user of water and impact water quality, therefore, within these sectoral policies negative incentives should be reduced and water issues addressed. Governments should seek to establish policies aimed at reducing water losses, increasing water savings and efficiency as this will have a greater impact on sustainable agricultural productivity.

Several complementary approaches must be promoted. First, water savings and more efficient use of water should be achieved through water metering, improving irrigation efficiency, reducing leakages to a sustainable economic leakage level, and irrigation scheduling. In particular, water metering should be introduced and enforced via water policies. Secondly, improved water availability should be achieved through water re-use, rainwater harvesting and storage. Standards should be developed for water reuse. Thirdly, improved land and soil management approaches will provide important water benefits.

Technologies such as drip and pivot irrigation can improve water-use efficiency and decrease salinization while maintaining or increasing yields. They have been used in industrialized nations on high-value horticultural crops, but their expanded use currently is not economically viable for staple food crops. In developing countries, 15 million hectares have experienced reduced yields owing to salt accumulation and water logging. Investment in such water-efficient technologies, however, is best facilitated when water is valued and priced appropriately (FAO, 2001). All these measures are meant to reduce the wastage of water therefore ensuring that much of it is used in irrigation practices leading an improvement in agricultural productivity. As a result future generations will be taken care of in terms of food security since less wastage ensures a continuous supply which is uninterrupted.

Improve decision-making through the provision of better information and improve water allocation rules

Water is, to a large extent, a local issue but with cross-border dimensions and subject to change in time, so the same activity in different catchments, years or seasons may not have the same impact. Improved tools that provide information at the right scales and resolutions are necessary for policy makers, businesses and farms. Decision support tools, for example irrigation scheduling for farmers, robust methodologies for accounting for water balances and ecological flows to inform water allocation and pricing, and a thorough cost-benefit analysis including externalities, should be developed and used more widely.
Irrigation scheduling will reduce losses in usage of water and introduce regulations which will seek to ensure that there is a proper utilization of available water depending on the needs and the farmer’s crops. Such effective management of irrigation water will lead to sustainable agricultural productivity.

**SOIL AND LAND MANAGEMENT**

While the over application of inorganic and organic fertilizers has led to environmental contamination in a number of areas in the developed world, insufficient application of nutrients and poor soil management coupled with harsh climatic conditions and other factors, have contributed to the degradation of soils in Sub-Saharan Africa.

**Climatic Conditions and Soil Management**

Harsh climatic conditions contribute to soil erosion in several parts of Sub-Saharan Africa. Rapid water evaporation and inadequate and highly variable rainfall, for instance, deprive plants of the water necessary for growth. High atmospheric temperatures, strong light, and heat-retentive, sandy soils can combine to make the local environment too hot for proper plant growth. Powerful, dry wind gusts may also damage plants through both lodging (which causes plants to fall over and die before harvest) and evaporation (Lawson and Sivakumar, 1991). Together, these harsh climatic factors, coupled with poor soil management, have reduced soil fertility by contributing to soil and water erosion.

Slight to moderate erosion slowly strips the land of the soil, organic matter, and nutrients necessary for plant growth. This degradation increases the opportunity for drought and further erosion because it reduces the water-infiltration and waterholding capacity of the soil (Crosson, 1986). Severe erosion may create gullies that interfere with farm machinery use. It also leads to the conversion of land to lower-value uses, or its temporary or permanent abandonment. Off-farm erosion can lead to siltation in watersheds and a decline in water quality (Scherr and Yadav, 1996). In such an environment, effective soil, water, pest, and crop management becomes absolutely essential. But economic and other pressures often make it difficult for farmers and their families to efficiently manage the soil for long-term profitability and sustainability.

**Property Rights, Land Constraints, and Demographic Pressures on Soil Fertility**

Insecure and crumbling tenure arrangements also contribute to declining soil fertility. Communal rights to graze land without any effort to maximize long-term returns have led to serious overgrazing, which is reported to be the main cause of human-induced degradation in Africa. Ill-defined property rights and insecure tenure rights have also reduced the incentive for farmers to undertake soil fertility-enhancing investments. Secure tenure arrangements can help induce investment in soil fertility to reap the long-term reward of sustained high crop yields and greater profits.

The effects of declining soil fertility on yield growth are particularly visible in Africa, where the most serious food security challenges exist and lie ahead (Badiane and Delgado, 1995). The low level of chemical fertilizer use, decline in soil organic matter, and insufficient attention to crop nutrient studies contribute the most to the loss of soil fertility in the region (Kumwenda et al., 1996). In comparison to the rest of the world, fertilizer use in Sub-Saharan Africa is low and declining. In 1996, Sub-Saharan Africa consumed only 1.2 million tons of fertilizer, (equivalent to 8.9 kilograms per hectare of arable land). By comparison, global fertilizer use reached approximately 135 million tons in 1996, equivalent to 97.7 kilograms per hectare (FAO, 1998 and 1999).

Fertilizer use would probably be even lower if foreign aid were not available. More than half of the nitrogenous, phosphate, and potash fertilizer consumed in developing Africa is imported in the form of aid. In 1990, 22 of 40 Sub-Saharan Africa countries received all their fertilizer imports as aid (Fertecon, 1993). High import prices contribute to the low level of fertilizer use in Sub-Saharan Africa. High fertilizer prices arise from small procurement orders (tenders for less than 5,000 metric tons are common), weak bargaining power, and high freight and international marketing costs. When coupled with high transportation costs due to poor infrastructure, the domestic prices of chemical fertilizer are such that one kilogram of nitrogenous fertilizer can cost the typical African farmer between 6 and 11 kilograms of grain, compared with 2 to 3 kilograms of grain in Asia (Heiney & Mwangi, 1997).

Continuous cropping and erosion reduce the level of soil organic matter (Woomer et al., 1994). Low-input systems can maintain and enhance soil organic matter through crop rotation and intercropping, the application of animal and green manures, fallowing, and reduced tillage (Kumwenda et al., 1996). But as pressure on land and crop intensification increase, these options do not remain practical. The adoption of intercropping and crop rotation technique is often constrained by the extent of land and technology available and by the lack of knowledge about optimal management techniques.
Government Commitment to Agriculture and Structural Adjustment

Although agriculture is increasingly recognized as the engine of economic growth in Sub-Saharan Africa, the level of government commitment to it is low. The lack of competition and heavy government regulation, along with structural factors such as inadequate institutional and physical infrastructure and underdeveloped research and extension systems, have often made fertilizer distribution systems inefficient and ineffective in meeting farmers’ needs (Bumb & Baanante, 1996). Structural adjustment programs (SAPs) have been instituted in many countries partly in response to these and other market failures.

SAPs seek to reallocate resource use in order to improve economic efficiency and social welfare. Among other things, the programs have devalued exchange rates, the immediate effect of which has made imports such as fertilizers more expensive, which in turn has often increased farmers’ costs markedly. Nitrogen-to-maize price ratios in Ghana, Tanzania, and Zambia, for example, were substantially higher during the 1990s, after the SAPs were instituted, than during the 1980s, when price controls and subsidies were in effect (Heiney and Mwangi, 1997). The SAPs and higher input prices have therefore reduced the profitability of using fertilizer to increase the production of foodgrains for domestic consumption.

The Way Forward

Plant Nutrient Application

Fertilizers need to be applied at the level required for optimal crop growth based on crop requirements and agro-climatic considerations (Smaling and Braun, 1996). Balanced application of fertilizers should also include secondary nutrients and micronutrients, both of which are often most readily available from organic fertilizers such as animal and green manures. Lastly, balance is necessary for sustainability over time. Coupled with other complementary measures, effective nutrient and soil management can help to reclaim degraded lands for long-term use in some cases. Heavy fertilizer applications on moderately degraded soil can not only replenish nutrients, but can produce about 7 tons per hectare of maize and about 6 tons per hectare of grain straw, which long-term studies in Iowa have shown can increase organic matter content in the soil (Ange, 1993). Experiments in Ghana and Niger have demonstrated that by increasing the longevity and productivity of suitable agricultural land, the application of inorganic and organic fertilizer reduces the need to cultivate unsustainable and fragile marginal lands (Vlek, 1990).

Untapped Nutrient Sources

According to Tandon (1992), if used appropriately, the recycling of organic waste from urban to rural areas is a potential, largely untapped, source of nutrients for farm and crop needs, especially on agricultural lands near urban centers. For example, environmentally undesirable wastewater has been used to irrigate fields and return nutrients and organic matter to the soil. Like organic manure, urban waste is a source of primary nutrients, although a relatively poor source when compared with commercial fertilizers. Stabilized municipal waste customarily contains about 3.3 percent nitrogen, 2.3 percent phosphorus, and 0.3 percent potassium, although some concentrations can reach as high as 10 percent nitrogen and 8 percent phosphorus on a dry weight basis (EPA, 1984).

Actual nutrient content, however, varies widely and depends on the source of the waste. Urban waste also has a number of other benefits. Like other organic manures, it helps improve soil structure by adding organic material to the soil. It is also a source of the secondary nutrients and micronutrients that are necessary in small quantities for proper plant growth. In addition, urban waste transforms material that would otherwise be slated for costly disposal into a useful farm product. Urban waste needs to be treated carefully because it may contain heavy metals, parasites, and other pathogens. The buildup of heavy metal concentrations in the soil can be a cause for concern.

While trace amounts of some heavy metals play a critical role in plant metabolism, excessive amounts have reduced crop yields and could be dangerous to public and grazing livestock (Conway and Pretty, 1991). To minimize these risks, the continuous application of urban waste needs to be monitored in order to ensure that heavy metal and overall nutrient concentrations do not reach toxic levels and do not damage the environment through leaching. One option to control urban waste is to compost the waste. Composting concentrates nutrients and helps to kill disease-causing organisms and slow the release of nitrogen that might otherwise percolate into groundwater (Kurihara, 1984). Another option is to use ionizing radiation to kill pathogens in and on food without affecting taste. Despite some public concern about the safety of food enhancement, this technique is likely to be adopted more in the future in order to protect public health, improve the shelf-life of food, and make it more beneficial to apply treated, nutrient-rich urban waste to farmland.
**Extension**

Farmers, with the aid of extension services, have to be given access to and choose the most appropriate and cost-effective technologies for their precise circumstances. Farmers also need to participate in the development of these technologies and become knowledgeable about managing soil fertility and capturing the opportunities offered by their diverse environments. Hence, successful soil management programs must strengthen farmers’ capacity to learn and shift away from the traditional practice of one-way technology transfer from researcher to farmer (Deugd, Roling, and Smaling, 1997).

Monitoring will help ensure that an environment conducive for optimal plant growth and crop yield can be established through nutrient application and soil restoration. Where practical and available, testing techniques such as plant-nutrient-deficiency diagnosis, plant tissue analysis, biological comparison tests across soils, and chemical soil analysis are needed to help the farmer improve crop and soil management. Together, monitoring, testing, and nutrient application recommendations that reflect crop needs and soil nutrient levels can enable extension agents to help farmers overcome the limitations arising from harsh agroclimatic and soil conditions.

**Participation**

According to Franzel and Van Houten (1992), the interaction of farmers, researchers, extension officers, nongovernmental organizations (NGOs), and the private sector involved in the distribution system is vital to the proper evaluation and wider dissemination of traditional technologies and the development and adoption of new ones. Farmers need to play a more important role in technology development. Plant breeders, for example, often focus narrowly on increasing yields and disease resistance. But farmers have other concerns as well. In particular, farmers want modern varieties that generate high yields for crops with high consumer demand, save labor and reduce costs, and produce plants that resist drought, pests, and disease. New technologies should also take into account the diversity, food security, and other risk concerns of smallholder farmers.

**FORESTS**

Forests are an important natural resource composed of either high density trees (tree forests), underwater vegetation such as kelp forests, or non-vegetation such as fungi and bacteria. The global area of forest of all kinds was approximately 3.4 billion hectares in 1990 but that has reduced by at least one-third due to extensive deforestation under human activity (Freedman, 2014). Africa as a whole leads the list of countries with the highest rate of deforestation; permanent loss of species, soil degradation, and impact of climate change (Naoto, 2006 as cited by Cunningham, 2010).

Forest resources are believed to make a major contribution to the livelihoods of forest-adjacent communities, yet this role is not adequately recognized and incorporated in planning and decision-making processes. Forests however, can also incur substantial economic costs to communities in that the presence of forests and woodlands interfere with other economic activities at the local level.

With Africa accounting for 17% of the world’s forests, it’s alarming to note that over half of global deforestation is in this continent; and more specifically the highest deforestation being in the tropical dry forests in East and Southern Africa. Kenya for example, is classified among the countries with low forest cover of less than 2% of the total land area. The forest cover lessened by 8% between 198 – 1988, 7% percent in the 1990s and an additional 7% since 2000. Kenya’s forests are rapidly deteriorating due to pressure from increased population and other land uses (Jervis, 2009).

Global deforestation has sharply accelerated. It has been estimated that about half of the Earth’s mature tropical forests between 7.5 million and 8 million km² that until 1947 covered the planet has now been destroyed. Some scientists have predicted that unless significant measures such as seeking out and protecting old growth forests that have not been disturbed are taken on a worldwide basis, by 2030 there will only be 10% remaining, with another 10% in a degraded condition 80% will have been lost, and with them hundreds of thousands of irreplaceable species (Michael, 2009).

The water cycle is affected by deforestation. Trees extract groundwater via their roots and release it into the atmosphere. When part of a forest is destroyed, the trees will no longer evaporate away this water and this will result in a much drier climate. Deforestation reduces groundwater and the content of water in the soil as much as atmospheric moisture. The dry soil results in lower water intake for the trees to extract. Deforestation reduces soil cohesion, so that erosion, flooding and landslides ensue (Rogge, 2009).
Rain water is vital for rain fed agriculture which is attributed to increased agricultural production. The reduction of this therefore is seen to contribute to lower productivity of the latter. Forest conservation should be taken seriously by governments and other stakeholders through encouraging tree planting initiatives with the sole aim of increasing forest cover.

Generally therefore, the activities causing this high level of deforestation include the expansion of agriculture into forest lands, population growth, poverty, high dependence on natural resources for subsistence and income, economic pressures to increase exports of agricultural produce, timber and minerals. Furthermore, the farming areas in sub-Saharan Africa are still being expanded in an attempt to increase yields and due to the rise in population. Without improved agricultural productivity, rising food demand alone will perpetuate deforestation and forest degradation. Most of these problems have tried to be addressed through policies by governments and ministries in individual countries without success. The existing policies have their shortcomings either in formulation or implementation. It’s important that new policies are formulated while still trying to close the gaps in the existing ones to ensure the protection of forests.

Existing policies on forests and their major concerns

Generally, existing policies on forests are aimed at ensuring that forests contribute to poverty reduction, assist in creating employment and improve the livelihoods of majority of the population. In specific, the policies are geared towards: ensuring poverty reduction, employment creation and improvement of livelihoods, contributing to sustainable land use through soil, water and biodiversity conservation, and tree planting, encouraging participation of the private sector, communities and other stakeholders in forest management to conserve water catchment areas, encouraging farm forestry to produce timber, fuel wood and other forest products, promoting dry land forestry to produce fuel wood and to supply wood and non-wood forest products, enhancing forest extension to enable farmers and other forest stakeholders to benefit from forest management approaches and technologies and the promotion of forest research, training and education to ensure a vibrant forest sector (Ndiritu, 2009). The main challenge affecting these policies is their application and/or implementation. Basically this is embedded in the poor planning and management of the policies and institutions charged with their formulation and implementation.

Governance

The forest sector has been characterized by ineffective regulatory mechanisms and inadequate law enforcement. Many Forests Acts that have been formulated have geared towards forest governance in the hope of bringing considerable change. The specific areas addressed in natural resource management have been public participation, community and gender rights, equity in benefit sharing and the need to increase the area under forest cover among others (Ministry of Environment, Water and Natural Resources in Kenya, 2004).

Majorly, the challenges here have been implementation since the forest land is still very much on the decrease. Furthermore, public participation means that forestry development has to expand into private and community land. This needs incentives and clear methods of engagement to encourage investments in commercial forestry on private land. Lack of these incentives and methods to engage has led to the failure of these laid-down measures.

Transparency and Accountability

The main constraints in this area relate to making information on forest resources, their use as well as related revenue streams available both internally within the governing institutions and externally to the wider public in a way that ensures transparency and accountability. The institutions that are supposed to implement the policies have created a bad image of the former with continued allegations of corruption and mismanagement of the forest resources. Availability of reliable information is a precondition of the functioning of the licensing/concession system of forest plantations in a way that creates the conditions for the markets to operate efficiently, and ensures that the governments involved get the best possible sustainable returns from the commercial use of the plantations.

Weak Forest Acts

The Forests Acts created at local level forest management institutions are weak and the financial incentives which will enable them to develop their capacity are yet to be defined. As a consequence, the institutions are forced to use a significant share of their resources in monitoring and law enforcement activities. The institutions are forced to organize multiple trainings as a way to cover the gaps left by the weak laws by ensuring their personnel have adequate information on forests. These trainings put further financial pressure on the institutions and increasing their dependence.
Quality of Forest Administration

Majority of the countries in Sub-Saharan Africa have one major institution that manages the forest resources. However, other institutions, especially at the local levels, are increasingly involved as partners and co-managers. For example, in Kenya, the creation of Kenya Forest Service in (KFS) was one of the major institutional innovations of the Kenya Forests Act (2005) to move the sector reform process forward. However, despite its importance, the process of establishing KFS is still incomplete with most staff working under inferior working conditions, and this is having a negative impact on staff morale. These institutions end up losing their key managers which affects the quality of their administration.

The move towards a more decentralized way of managing the forest resources in collaboration with community forest associations and local governments has for long been proposed in many countries but the process for a long time remains in its initial stages; many critical elements of the process remain undefined, and the capacity of these newly established structures remains weak. The role of the major institutions vs. other actors in the management of the forest resources remains still somewhat ambiguous and some current and/or envisaged tasks (e.g. law enforcement and extension) need rethinking given the financial burden they present to the forest service.

Remedies for the existing policies and the proposal of new policies focusing on planning and management of natural resources

Priority actions

The most urgent actions to move the governance reform process forward in the short-term involve fast tracking the revision of Forest Policy and/or Acts to establish a clear direction and basis for the continued implementation of the sector reforms. Key issues, that need to be addressed include: establishing the rules for the sharing of revenues between the different forest institutions, establishing the rules for access and use rights of local communities concerning the forest resources and avoiding regulatory overreach in legislating on these. Guaranteeing public information disclosure on forest resources and their use, including related financial flows to ensure that the public (including all sectors of the society) has sufficient information to fully participate in the sector and to monitor the developments is also important to increase transparency and community participation.

Quality of administration

To improve the basis for sustainable forest management, Kenya needs to develop a commonly agreed definition for forests, as well as agree on the Criteria and Indicators for sustainable forest management. This is urgently needed especially as KFS, together with development partners, is now intensifying the work on natural forest assessments, and assessments of trees outside of forests. This is also indispensable for the development of standards for SFM, and to move towards independent forest certification based on a national standard. A more systematic way of monitoring forests and forest activities will also be a necessity, both to improve forest administration and governance, and to respond to the requirements of REDD+. This is closely related to how information management and dissemination is handled, both within KFS and to the Kenyan public.

Coherence of Forest Legislation and Rule of Law

The Forests Acts provide a solid foundation for the forest sector reform process. Effective enforcement of the Forests Act requires addressing both internal factors within the forest sector and external ones. Challenges remain to maintain the cost of enforcement at acceptable levels, to ensure that the actions do not disproportionately target poverty-driven illegal activities and to implement effective institutional cooperation e.g. with the police and judiciary. Eventually, more of the enforcement activities will need to be taken care of by the local-level actors which will require that sufficient incentives are in place (e.g. through revenue sharing). Resolving undefined property rights; where land adjudication processes are not complete, or where community rights are unclear - is also a prerequisite for effective law enforcement.

CONCLUSION

From the discussion it is evident that natural resources play a critical role in sub-Saharan Africa or in any geographical location therefore the need to plan and manage them at all cost. This then requires an integration of all the stakeholders involved for impacts to be realized. In Kenya for instance, the central government needs to closely work with county governments, Non-Governmental Organizations (NGOs), local communities and other interested parties in ensuring...
that all natural resources are planned and managed accordingly. Collaborations can be created among different countries and regions to try and borrow a leaf from the other party on how to plan and manage natural resources. These collaborations could involve regular visits among parties involved to learn from each other.

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FAO (Food and Agriculture Organization). 1998. FAOSTAT agricultural data, land use domain.
ADAPTATION AND UTILIZATION OF ZAI PITS FOR IMPROVED FARM PRODUCTIVITY IN THARAKA-NITHI COUNTY, KENYA

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ABSTRACT
Smallholder farmers in low midland zones of Tharaka-Nithi County are facing challenges in improving agricultural productivity and livelihoods. Low crop yields due to low erratic rainfall, high evapotranspiration, and deteriorating soil health in smallholder farmers’ fields have led to a quest for sustainable production practices with greater resource use efficiency. To alleviate these challenges, impact of zai pits was assessed in terms of factors that influence adoption in Tharaka-Nithi County, located in low midland zones of eastern Kenya. Interview schedules were used to elicit information from 290 farmers. A descriptive statistical analysis approach was used to analyse data. There was significant relationship between farmers who had been visited by an agricultural officer and adoption (χ²=6.019, P=0.05), where a higher percentage of farmers who had adopted had been visited by non-governmental extension agents. A significant difference existed between the average farm size of adopters and non-adopters (t=2.7, df=285, P=0.05). There is need to re-evaluate the role that socio-economic variables and farm characteristics contribute in adoption of Zai pits as a water harvesting technology.

Keywords: Low erratic rainfall, Non-government extension agents, Socio-economic factors, Water harvesting

INTRODUCTION
The present food insecurity and projected population growth in Sub-Saharan Africa (SSA) demand change from low yielding farming systems towards greater production and sustainability (Rockström et al., 2002; Cai and Rosegrant, 2003; Kauffman et al., 2003), particularly in semi-arid tropics where food security is threatened by frequent droughts, dry spells (Steiner et al., 2003) and infertile soils (Sanchez, 2002). Approximately 82% of Kenya landmass is characterised as arid and semi-arid (Abbass, 2009). The threat of increasing dry spell occurrences (Rockström, 2003; Enfors and Gordon, 2007) suggest an urgent need to change from the traditional cultivation practices in sub-Saharan Africa to more efficient and robust approaches which promote soil and water conservation (Ngigi et al., 2007). Soil fertility management research and outreach programs have been conducted in the SSA countries by several institutions, generating several knowledge-intensive technologies that have proven themselves successful for managing soil fertility (Bekunda et al.2010). However, according to Woomer, (2007) few “modern” soil management technologies have been adopted by the smallholder farmers, partly because of their high cost relative to crop price, and economic returns to farming have remained low (Woomer, 2007). While promoting water harvesting technologies as one of the feasible options for improving agricultural productivity in semiarid environments, there is need to understand the factors that influence their adoption.
MATERIALS AND METHODS
The study was conducted in Tharaka-Nithi County in Eastern Kenya. Tharaka-Nithi County borders Meru County to the North and Northeast, Kitui County to the East and Southeast, Embu County to the South and Southwest and occupies an area of 2,638.8 km². It lies in the Lower Midland 4 and 5 (LM 4 and 5) and Inner Lowland 5 (IL 5) agro-ecological zones (Jaetzold et al., 2006). Temperatures range from a minimum of 11°C to a maximum of 25.9°C and rainfall ranges between 200 mm and 800 mm per annum. The predominant soils are the highly weathered and leached acid infertile soils- ferrasols (Jaetzold et al., 2006). The area experiences a bi-modal pattern of rainfall. The main source of livelihood for the Tharaka people revolves around marginal farming and livestock rearing which are greatly affected by long spells of drought, which at times lead to total crop failure and massive loss of livestock (Jaetzold et al., 2006).

Structured interview schedule, was used to generate from 291 respondents. To facilitate the data collection process together with the researcher, seven enumerators were recruited based on their education level in addition to their ability to communicate the local “Kitharaka”.

Data analysis
Data was analyzed using statistical package (SPSS version 16) and presented quantitatively using different statistical methods such as percentage, frequency, tabulation, Chi-square test (for dummy /discrete variables) and (t-test for continuous variables). The description was made using mean, minimum as well as maximum values, percentage and standard deviations.

RESULTS AND DISCUSSIONS
The study was conducted in Tharaka Central and Tharaka South in Tharaka Nithi County. The males composed 76.6% while female farmers composed 32.4%. About 51.9% of the respondents were non-adopters while 48.1% were adopters. Most (63.8%) of the farmers had attained primary education. Out of the 31 farmers who had attained primary education, 20 of them were non-adopters. About 14.7% had no formal education. A higher percentage (85.2%) of farmers were involved in farming as an occupation while only 6.7% were in business (Table 1).

Table 1: Social demographic characteristics of adopters and non-adopters

<table>
<thead>
<tr>
<th>Sub-Counties</th>
<th>Non-Adopters</th>
<th>Adopters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tharaka Central</td>
<td>10(6.6)</td>
<td>13(9.3)</td>
</tr>
<tr>
<td>Tharaka South</td>
<td>141(93.4)</td>
<td>127(90.7)</td>
</tr>
<tr>
<td>Total</td>
<td>151(100)</td>
<td>140(100)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gender</th>
<th>Non-Adopters</th>
<th>Adopters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>115(76.2)</td>
<td>108(77.1)</td>
</tr>
<tr>
<td>Female</td>
<td>36(23.8)</td>
<td>32(22.9)</td>
</tr>
<tr>
<td></td>
<td>151(100)</td>
<td>140(100)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level of education</th>
<th>Non-Adopters</th>
<th>Adopters</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Education</td>
<td>22(15.9)</td>
<td>17(13.4)</td>
</tr>
<tr>
<td>Primary Education</td>
<td>84(60.9)</td>
<td>85(66.9)</td>
</tr>
<tr>
<td>Secondary Education</td>
<td>12(8.7)</td>
<td>14(11.0)</td>
</tr>
<tr>
<td>Tertiary Education</td>
<td>20(14.5)</td>
<td>11(8.7)</td>
</tr>
<tr>
<td></td>
<td>138(100)</td>
<td>127(100)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Non-Adopters</th>
<th>Adopters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farming</td>
<td>124(83.2)</td>
<td>118(87.4)</td>
</tr>
<tr>
<td>Business</td>
<td>7(4.7)</td>
<td>9(6.7)</td>
</tr>
<tr>
<td>Employed</td>
<td>18(12.1)</td>
<td>8(5.9)</td>
</tr>
<tr>
<td></td>
<td>149(100)</td>
<td>135(100)</td>
</tr>
</tbody>
</table>

Majority (60.1%) of the farmers had attained 1-5 times non- formal trainings on agricultural practices. There was a significant relationship ($\chi^2=31.339 , df=3, P=0.001$) between attendance of non formal trainings and adoption where a higher percentage of those who had attended more than 10 trainings were adopters (Table 2). On the other hand 36.7% of the non-adopters had never attended any non- formal trainings which is an indication that non-formal trainings have
a significant training on adoption of zai pits in the region. Similar studies denoted significant and positive association between training and adoption of water harvesting technologies (Kihara, 2002).

The results from cross tabulations showed that membership in groups and associations had a significant relationship with adoption ($\chi^2=31.339, df=1, P=0.005$). The rationale is that a farmer belonging to an association or a group is most likely able to access information from other farmers on the benefits of zai pits. Some non-governmental organization such as Catholic Diocese of Meru have been promoting water harvesting techniques in Tharaka Nithi using cash for asset model. The external support given to the farmers by the NGOs had a significant and positive ($\chi^2=31.339, df=1, P=0.005$) effect on the adoption of Zai since a higher percentage of the adopters were beneficiaries as compared to the non-adopters.

There was a positive significant relationship between adoption and steepness of the land ($\chi^2=7.912, df=1, P=0.003$) where a higher percentage (64.7%) of the farmers who were adopters reported that their land was slopy (Table 2). The steepness or flatness of a plot affects the use of rainwater harvesting technologies. This is because zai pits are associated with collection and storage of runoff water for later use.

Farmer adoption of zai pits was also influenced by access to information. The $\chi^2$ analysis showed a significant association between visits by non-government extension and adoption ($\chi^2=6.02, df=1, X=0.05$) (Table 2). This is in line with research finding by Melaku (2005) who found a positive and significant association of extension service and adoption of rain water harvesting technology. In another study by Marsh et al. (2000) extension as a source of information has shown to influence adoption of agricultural technologies.

**Table 2: Case summary showing results of dummy explanatory varibles that affect adoption of zai pits**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Adoption</th>
<th>Total</th>
<th>Chi-Square Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Formal trainings</td>
<td>Non-Adopters</td>
<td>Adopters</td>
<td>Total</td>
</tr>
<tr>
<td>None</td>
<td>55(36.7)</td>
<td>22(15.9)</td>
<td>77(26.7)</td>
</tr>
<tr>
<td>1-5 times</td>
<td>87(58.0)</td>
<td>86(62.30</td>
<td>173(60.1)</td>
</tr>
<tr>
<td>6-10 times</td>
<td>8(5.3)</td>
<td>14(10.1)</td>
<td>22(7.6)</td>
</tr>
<tr>
<td>More than 10 times</td>
<td>0(0)</td>
<td>16(11.6)</td>
<td>16(5.6)</td>
</tr>
<tr>
<td>Total</td>
<td>150(100)</td>
<td>138(100)</td>
<td>288(100)</td>
</tr>
<tr>
<td>Member of Association/ farmer group</td>
<td>Non-Adopters</td>
<td>Adopters</td>
<td>Total</td>
</tr>
<tr>
<td>No</td>
<td>28(18.7)</td>
<td>10(7.1)</td>
<td>38(13.1)</td>
</tr>
<tr>
<td>Yes</td>
<td>122(81.3)</td>
<td>130(92.9)</td>
<td>252(86.9)</td>
</tr>
<tr>
<td>Total</td>
<td>150(100.0)</td>
<td>140(100)</td>
<td>290(100)</td>
</tr>
<tr>
<td>Beneficiary of NGO</td>
<td>Non-Adopters</td>
<td>Adopters</td>
<td>Total</td>
</tr>
<tr>
<td>No</td>
<td>75(49.7)</td>
<td>31(22.6)</td>
<td>106(36.8)</td>
</tr>
<tr>
<td>Yes</td>
<td>76(50.3)</td>
<td>106(77.3)</td>
<td>182(63.2)</td>
</tr>
<tr>
<td>Total</td>
<td>151(100)</td>
<td>137(100)</td>
<td>288(100)</td>
</tr>
<tr>
<td>Land sloppy</td>
<td>Non-Adopters</td>
<td>Adopters</td>
<td>Total</td>
</tr>
<tr>
<td>No</td>
<td>78(51.70)</td>
<td>49(35.3)</td>
<td>127(43.8)</td>
</tr>
<tr>
<td>Yes</td>
<td>73(48.3)</td>
<td>90(64.7)</td>
<td>163(56.2)</td>
</tr>
<tr>
<td>Total</td>
<td>151(100)</td>
<td>139(100)</td>
<td>290(100)</td>
</tr>
<tr>
<td>Visited NGO Worker</td>
<td>Non-Adopters</td>
<td>Adopters</td>
<td>Total</td>
</tr>
<tr>
<td>No</td>
<td>137(54.8)</td>
<td>113(45.2)</td>
<td>250(100)</td>
</tr>
<tr>
<td>Yes</td>
<td>14(34.14)</td>
<td>27(65.85)</td>
<td>41(100)</td>
</tr>
<tr>
<td>Total</td>
<td>151(51.9)</td>
<td>140(48.1)</td>
<td>291(100)</td>
</tr>
</tbody>
</table>

Most of the farmers (76.3%) who have adopted zai pits got the information from the non-government extension agents. About 10.8% and 7.2% of the farmers got the information from government extension agent and other farmers respectively while 5.8% used their own experience (Figure 1). This is in line with the cross tabulation done on the same study which showed a positive significant relationship between visit by non-government extension agents and adoption. However it disagrees with the findings of Kimaru-Muchai et al., (2013) who reported that most of farmers receive information on integrated soil fertility management practices from other farmers.
Among the farmers who have adopted zai pits, 95% use animal manure as a soil fertility amendment. Only 2.1% of the farmers combine animal manure plus fertilizer as input to zai pits. About 6.4% reported that they do not use any input at all on zai pits (Table 3). According to Liniger et al. (2011) combining soil fertility amendments with soil and water conservation is more suitable. A combination of manure application with zai pits in Burkina Faso resulted in a more than two fold grain yield compared with that without manure (Fatondji et al., 2006).

Table 3: Combination of zai pits and soil fertility improvements

<table>
<thead>
<tr>
<th>Practice Zai and ISFM</th>
<th>ZaiPits+ISFM</th>
<th>Zai pits +animal manure</th>
<th>Zai pits + green manure</th>
<th>Zai pits + fertilizer</th>
<th>Zai pits +Animal manure +Fertilizers</th>
<th>Zai pits +vegetation +Fertilizers</th>
<th>Zai pits +Animal manure +vegetation</th>
<th>Zai pits alone</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>7(5)</td>
<td>116(82.9)</td>
<td>134(95.7)</td>
<td>137(97.9)</td>
<td>136(97.1)</td>
<td>101(72.1)</td>
<td>131(93.6)</td>
<td>762(77.8)</td>
</tr>
<tr>
<td>Yes</td>
<td>133(95.0)</td>
<td>24(17.1)</td>
<td>6(4.3)</td>
<td>3(2.1)</td>
<td>4(2.9)</td>
<td>39(27.9)</td>
<td>9(6.4)</td>
<td>218(22.2)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>980</td>
</tr>
</tbody>
</table>

The average age of the non adopters was 46.3 years while the average age of the non adopters was 44.7 years. The result of the t-test showed there was a significant difference (t=2.707, P=0.007) between house hold size of the adopters (6.06) and the non adopters (5.34). In addition there was also significant difference (t=2.707, P=0.007) of household members working on the farm among the adopters and the non adopter. This implies that adopters have more labour sources compared to the non-adopters. The number of groups a farmer belonged also influenced the adoption of zai pits in that a significant difference existed between the adopters and the non adopters at less than 1% probability level (-4.835). The implication is that majority of the adopters had joined many groups as compared to their counterpart. The total farm size for the adopters was higher (6.81) while for non adopters was 5.45, hence a significant difference exist at less than 5% probability level (-2.237) (Table 4). This agrees with research findings that Buyinza et al.(2008) who reported that farmers who had bigger farm size were likely to adopt rain water harvesting techniques.

There was a significant difference at (t=2.594, P=0.01) on ownership of cattle as the average number of cows owned by adopters (2.3) was higher compared to the non adopters(1.7). At the same time a significant difference was experienced on the number of goats owned by the adopters(5.67) and the non adopters(4.04) at less than 5% probability level (t=-2.26) (Table 4). This implied that the adopters had more livestock resources than the adopters even though there was no significant difference in ownership of sheep, donkeys and hens. The findings agree with the study of Musaba (2010) who reported positive association between herd size and technology adoption.
Table 4: Case summary showing results of continuous variables that affect adoption of zai pits

<table>
<thead>
<tr>
<th>Variable</th>
<th>Adoption</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AgeHH</td>
<td>Non-Adopters</td>
<td>148</td>
<td>44.77</td>
<td>14.5172</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adopters</td>
<td>132</td>
<td>46.30</td>
<td>12.0729</td>
<td>-0.964</td>
<td>276.681</td>
<td>0.336</td>
</tr>
<tr>
<td>YearsFarmingExperience</td>
<td>Non-Adopters</td>
<td>150</td>
<td>20.19</td>
<td>12.6196</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adopters</td>
<td>139</td>
<td>22.50</td>
<td>13.3321</td>
<td>-1.514</td>
<td>282.146</td>
<td>0.131</td>
</tr>
<tr>
<td>HouseholdSize</td>
<td>Non-Adopters</td>
<td>146</td>
<td>3.54</td>
<td>2.0787</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adopters</td>
<td>136</td>
<td>6.06</td>
<td>2.3844</td>
<td>-2.707</td>
<td>268.514</td>
<td>0.007</td>
</tr>
<tr>
<td>HouseMembersWorking</td>
<td>Non-Adopters</td>
<td>123</td>
<td>3.02</td>
<td>1.6791</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adopters</td>
<td>138</td>
<td>3.60</td>
<td>1.8105</td>
<td>-2.709</td>
<td>258.583</td>
<td>0.007</td>
</tr>
<tr>
<td>Number of Groups</td>
<td>Non-Adopters</td>
<td>147</td>
<td>1.66</td>
<td>1.1010</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adopters</td>
<td>135</td>
<td>2.37</td>
<td>1.3424</td>
<td>-4.835</td>
<td>259.729</td>
<td>0.001</td>
</tr>
<tr>
<td>Total Farm Size</td>
<td>Non-Adopters</td>
<td>147</td>
<td>5.45</td>
<td>5.3914</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adopters</td>
<td>140</td>
<td>6.81</td>
<td>4.8378</td>
<td>-2.237</td>
<td>284.005</td>
<td>0.026</td>
</tr>
<tr>
<td>Cattle</td>
<td>Non-Adopters</td>
<td>151</td>
<td>1.34</td>
<td>1.6887</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adopters</td>
<td>140</td>
<td>1.95</td>
<td>2.2706</td>
<td>-2.594</td>
<td>255.787</td>
<td>0.01</td>
</tr>
<tr>
<td>Goats</td>
<td>Non-Adopters</td>
<td>151</td>
<td>4.04</td>
<td>6.0728</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adopters</td>
<td>140</td>
<td>5.67</td>
<td>6.2184</td>
<td>-2.262</td>
<td>286.163</td>
<td>0.024</td>
</tr>
</tbody>
</table>

DISCUSSION AND CONCLUSION

Agricultural investments, especially in the semi-arid environments are risky. Hence, most farmers are risk averse and reluctant to invest in new technologies that would improve agricultural production and livelihoods (Ngigi et al., 2005). According to Pannell et al. (2006), adoption is principally influenced by the characteristics and circumstances of the farmer, and the characteristics of the practice, especially its relative advantage over existing practices and landholder’s ability to trial the practice. Farmers adopt an innovation if they expect that the practice will help them achieve their goals, which may include economic, social and environmental goals (Ngigi et al., 2005).

The findings of this study suggest that number of non-formal trainings, beneficiaries of NGOs, membership of group, steepness of land and visits by non-governmental extension agents play an important role in adoption of zai pits. Other factors such as farm size, number of cows and goats owned by the farmer and number of groups a farmer belonged also played a significant role in adoption and utilization of zai pits. In regards to these findings farmers should be encouraged to join farmer groups or association and attend non-formal training on agricultural practices. In addition, both non-government extension agents and government extension agents should be encouraged to visit the farmers and have more interaction with them in dissemination of benefits of zai pits.

Most farmers in Tharaka Nithi have learnt the art of combining zai pits with manure as a soil fertility amendment. However they should be encouraged to use other technologies such compost, organic fertilizers and green manure in addition to animal manure. At the same time it is essential to scale up both water harvesting technologies combined with soil fertility management practices. Organic materials such as compost and manure need only be added to the planting holes instead of spreading them over the entire field area. The improved efficiency makes it easier for farmers to obtain and apply the fertility inputs needed to maintain productive soils.

REFERENCES


**SMALLHOLDERS’ PERCEPTIONS OF CLIMATE CHANGE IMPACT ON BIODIVERSITY: A CASE STUDY OF FARMERS IN VARIED AGROECOLOGICAL ZONES IN KENYA**


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ABSTRACT

The current global warming has resulted in persistent droughts in Kenya. Farmers are now changing their agricultural practices to cope with the drought, which is usually accompanied by variation in biodiversity. This study determined how farmers perceive the changes over a period of 30 years. Data was collected using semi-structured questionnaires in Bungoma, Nakuru, Kajiado, Embu (Mbeere) and Kilifi counties. Climatic data was collected from weather stations and corroborated with that of Kenya Meteorological Department. Rainfall fluctuated considerably, amount increasing slowly over time, rainy season decreasing and storms becoming frequent. Dry periods were frequent and annual temperatures were increasing. Some animals, plants, birds and insects had either disappeared like elephants and lions in Mbeere; reduced like butterflies, and termites in all sites, or either increased in numbers (mosquitoes, weevils and red mites in all sites, tortoise and scorpions in Mbeere, *Jatropha curcas* and *Lantana camara* in Mbeere) or emerged (great grain borers in Mbeere and Kilifi, black Indian crow in Kilifi, *Ipomoea* sp in Kajiado and *Prosopis juliflora* in Kilifi). Farmers are now harvesting and conserving water in water pans, zai pits, and terraces. Some invasive plant species such as *Prosopis juliflora* were out-competing crops and pasture, predators were invading homesteads, carnivorous birds were becoming omnivorous and insect vectors and pests like mosquitoes and weevils were increasing their habitats to former cooler areas. Consequently, farmers were planting fast-growing multipurpose trees such as *Senna siamea*, rearing diverse animals and growing drought-tolerant crops.

Key words: Biodiversity, Adaptation, Climatic Information, Alien Species

INTRODUCTION

Kenya is endowed with a variety of ecosystems which support a variety of biodiversity making the country a custodian of unique heritage of diverse natural resources. The country’s biodiversity is estimated to include 24,375 species of animals, 6,817 species of higher plants and 1,841 species of micro-organisms (including viruses, monera, micro-fungi, protista excluding macro-algae). This biodiversity and sustainable development are intricately linked and people value biodiversity for various reasons such as, spiritual, ecological, aesthetic, cultural, economic, scientific, sources of food, medicine, fuel, shelter and industrial products (Almquist et al., 1993; Stuart et al., 1990). The biodiversity potential varies with the type of ecosystem. For instance, the grasslands, arid and semi-arid areas which comprise about 80% of the country with potential for pastoralism also act as gene pools of wild relatives of domesticated crop varieties such as sorghum, rice, tef, and peas. However about 10% of these grasslands and 5-20% of asals have been lost due to agricultural expansion, thus losing some species diversity (Ogola, et al., 1997). Plants especially in the forests have been noted to be more sensitive to small fluctuations and changes in rainfall patterns than mean annual rainfall, as this affects flowering patterns and seed dispersal resulting in heavy mortality. The ecological interface is affected more by climatic changes and it is at this area where the impact is more evident. As the temperatures increase ecological zone boundaries shift mainly with distance from the sea and altitude with plants, animals, birds and insects also shifting their range from hotter to cooler regions and lower to higher altitudes. Selective grazers are the first victims of climate change among animals, while herbaceous plants die faster than trees. In general, classualacean acid metabolism plants respond better to temperature and carbon dioxide increase than Calvin cycle plants (Olindo, 1991).

This climate change impact on biodiversity is getting aggravated as people clear more land for crop production, infrastructure, buildings and mining; over-exploitation of some economic species; application of pesticides, herbicides and fertilizers that eliminate some organisms such as soil borne micro-organisms, pests and weeds or cause eutrophication resulting in some succession. Consequently some alien species have become opportunistic where some have impacted negatively by decimating the former species. These include, cactus, (*Opuntia vulgaris*), sage (*Lantana camara*), Maques (*Prosopis juliflora*) and (*Ipomoea* spp.).

A number of climate change hazards have already been experienced in Kenya, such as frequent droughts, dry spells and increased heat stress (IPCC, 2007). These hazards are accompanied by more outbreaks of pests and diseases of crops, livestock and human beings adversely impacting on food, health, water, energy and the sustainable livelihoods of the poor. Some animals, birds and insects that are incapable of tolerating such changes either die or migrate to other areas. Plants on the other hand either die off or develop protective features. General Circulation Models (GCMs) indicate that future climatic changes in Kenya would result in an increase of annual temperature of 2.5 to 5.0°C with an increase of 0-25% in precipitation (Ogola, et al., 1997). Although past climatic variations were attributed mainly to natural processes, the observed changes are now due largely to anthropogenic causes (Watson, 2010), especially, increased emissions of and subsequent concentration of Green Houses Gases (GHGs) in the atmosphere which cause global warming accompanied by a shift in rainfall patterns. This has resulted in changes in frequency, intensity, duration of extreme events such as more hot days, heat waves, heavy precipitation events and fewer cold days. The extent to which these climatic changes affect biodiversity is not easy to predict with precision as there are many variables involved.
In general, climate change affects biodiversity and ecosystems and it is important to conceptualize that higher temperatures are not necessarily associated with negative effects, as coupled with more rainfall may support better plant yield. These changes of temperature and rainfall have been noted to cause population oscillations of animals and birds. For instance, Flamingoes of Lake Nakuru fluctuate with lake water salinity which on the other hand determines the amount of algae, *Spirulina platensis* their main food.

The majority of the rural communities are unable to cope, mitigate or adapt to continued climate change due to dependency on rain-fed agriculture and other activities (Watson, 2001). They are unable to access appropriate climate information and services because of the weak institutional and policy support and therefore take time to realize implications on biodiversity changes (UNDP, 2008). Vulnerability of the poor to changing climate is therefore, a priority development agenda for policymakers and development agencies (World Bank, 2008). Farmers in Kenya have noted that high temperatures coupled with high humidity as in coastal areas and Lake Region favour high populations of insect pests and high incidences of pathogens, though increased temperatures and rainfall have increased crop yields in some regions. Some animals are more tolerant to climate changes than others. Eland and oryx can withstand temperature fluctuation of 7°C, while staghorn and elkhorn corals are favoured by the rise of temperature at the expense of normal star corals. Herbivores decrease if the precipitation is between 200–1200 mm and selective grazers are the first to be affected. About 44% of fauna has succumbed to climate change (Ogola, *et al*., 1997). In general pests and diseases respond to very narrow temperature and precipitation fluctuation ranges. Humidity and high temperatures favour outbreaks of diseases as it is suitable for vector breeding, such as mosquitoes while some plant diseases such as coffee berry disease (CBD) is enhanced by strong winds.

There are several efforts to support adaptive research and actions related to climate change, though capacities remain limited (Chakeredza *et al*., 2009). Climate Adaptation Project (CAPro) of Egerton University is funded by the Rockefeller Foundation to support smallholders including pastoralists in five agro-ecological regions of Kenya. To do this, reconnaissance surveys were done to document the biophysical, climatic and biodiversity changes within the five study sites. This study provides a summary of findings on information collected from the field.

**METHODOLOGY**

**Reconnaissance survey**

This work was done by a team of 7 researchers with the assistance of extension officers and five masters students. The study sites are shown in Figure 1 and represent different agro-ecological zones in Kenya. The researchers collected information pertaining to location, topography, soils, vegetation cover, climatic information and farmers’ perceptions of the impact of climate change on biodiversity for a period of about thirty years. The information also included adaptation strategies practiced by the farmers towards climate change. All this information was collected from the documents in relevant government offices and focus group discussions. The offices visited included, agriculture, forestry, wildlife, and weather stations.

**Climate change adaptation strategies data collection**

Participatory rural appraisal methods were used where a PRA protocol was developed to guide farmers in group discussions. The PRA was divided into two phases:

a. In phase one, semi-structured questionnaire was used and participants divided into groups where they freely discussed issues and ideas on a variety of topics such as causes, indicators and effects of climate change, adaptations and resources and their sources needed to implement them.

b. Scoring and ranking of key or major adaptive measures that are likely to be implemented in each site.

**Climatic data analysis**

The parameters analysed were mean annual rainfall amounts, rainfall amounts in blocks of years, intensity of rainfall and onset of rainfall during the rainfall season. The intensity considered the total amount of rainfall in a selected month per day during those days with rain. Analysis of onset focused on the first day of rain in the selected month. Unfortunately not many sites were keeping good temperature records with the exception of Bungoma.

**Biodiversity Change Information**

This was done through farmers’ group discussions using structured questionnaires. Farmers reported diverse biodiversity including plants, animals, birds and insects that have disappeared completely, reduced in numbers, increased or emerged as new species in the area.
RESULTS
The results indicate that in most of the sites, the rainfall shows a defined trend, marked by increase over time. The trend was the same for temperature for the stations, where this data was available. At the coast where records were taken from three stations one of the station was in agreement with the general trend of increasing rainfall with time whereas the other two stations showed a decrease (Figures 2-24).

Kilifi area
In Kilifi area at the Coast, data was taken from three stations. These are Mtwapa, Malindi and Msabaha.

Mtwapa station
Rainfall data for Mtwapa station was available for the years between 1980 and 2008. Rainfall data showed a general increase over time. The rainfall was bimodal although one peak was much higher than the other (Figures 2-4).
Malindi
The rainfall data for Malindi was available from the year 1962-2011. The general trend was a slight decrease over time. This is unlike most of the other sites where rainfall increased over time. The rainfall was also bimodal with the difference between the peaks being very large (Figures 5-7).
Msabaha
At Msabaha station, there was also a noticeable decreasing trend of rainfall amounts over time. The data represent the year 1980 to 2008.

12: Mean annual rainfall for Msabaha since 1980
The data for Kajiado was obtained from Isinya station from the year 1962 to 2010. The data depicted an increasing trend over time. The two rainfall peaks were distinct and the difference not very large as compared with the data obtained from stations at the coast.

Figure 13: Mean rainfall for msabaha since 1981

Figure 14: Monthly mean rainfall for Msabaha

**Kajiado**

The data for Kajiado was obtained from Isinya station from the year 1962 to 2010. The data depicted an increasing trend over time. The two rainfall peaks were distinct and the difference not very large as compared with the data obtained from stations at the coast.

Figure 15: Annual rainfall since 1962 in Kajiado
The intensity of rainfall increased in the months of March and December as the number of days of rainfall reduced. In the month of April, the intensity of rainfall decreased as the rain came later, the number of days of rainfall decreased and the rainfall amounts also decreased.
Mbeere
The data for Mbeere site was sourced from Kiritiri station. The data covered the shortest period of all the sites, a period of only ten years from the year 2001 to the year 2010. The main rainfall peak was received at a time different from the other sites. This was in the month of November when the other sites had the lower peak.

![Figure 17: Annual rainfall amount in Mbeere](image)

Nakuru
The data for Nakuru site was taken from Menengai station. The data covered the longest period of all the sites, from the year 1927 to the year 2011. The general trend in rainfall was an increase with time. The annual rainfall at this site was tri-modal with the largest peak in April, the second largest in August and the smallest in November.

![Figure 18: Month to month rainfall amounts for Mbeere (Kiritiri station)](image)
Figure 19: Annual rainfall amount since 1927 at Nakuru

Figure 20: Rainfall amount at Mengengai since 1927
Bungoma
The climate data from Bungoma site was obtained from Nzoia station. It covered the years 1983 to 2011 with a break of three years; 2003, 2004 and 2005. Unlike the other sites, temperature data was available in addition.

Rainfall
The rainfall data did not show much fluctuations although it peaked every 4-5 years. The rainfall received was high with about 1500mm being the minimum over the period when data was available. The trend showed an increase over time. The annual pattern was bimodal although the difference between peaks was not very big. The peaks were not sharp but smooth.
The intensity of rainfall was found to be increasing for the months of April and December where the rainfall was coming later in the month and for a reducing number of days. In the month of March, the rainfall was coming earlier and the number of days has been increasing leading to a reducing intensity.
Temperature

The temperature data at Nzoia showed an increase over time during the period of analysis. The annual pattern also showed two peaks and like with rainfall patterns they were also not sharp but smooth.

**Figure 25: Intensity of rainfall in March, April and December in Bungoma**

**Figure 26: Annual temperature means for Bungoma since 1983**

**Figure 27: Temperature means for various years since 1986 in Bungoma**
Figure 28: Mean monthly temperature

The tables 1 to 4 show the impact of climate change on biodiversity and its implication on farmers’ livelihoods, stakeholders involved in biodiversity issues, the kind of support farmers get from these stakeholders and finally how different organisms have changed over time in their populations within different agro-ecological zones.

Table 1: Impact of climate change on biodiversity and its implication on farmers’ livelihoods

<table>
<thead>
<tr>
<th>Biodiversity changes</th>
<th>People affected</th>
<th>Why they are affected</th>
<th>How they are affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changes in forest</td>
<td>Women, young girls, men, all</td>
<td>Collect firewood, collect building materials, purify air</td>
<td>Take more time to collect firewood, building materials, polluted air</td>
</tr>
<tr>
<td>Changes in plant species</td>
<td>Herbalists</td>
<td>Medicinal plants destroyed</td>
<td>Have to source from far</td>
</tr>
<tr>
<td>Changes in animals and birds</td>
<td>All</td>
<td>Animals &amp; birds used as food</td>
<td>Food is expensive</td>
</tr>
<tr>
<td>Changes in insects</td>
<td>All</td>
<td>Some eaten e.g. termites, others disease vectors e.g. mosquitoes, others crop pests e.g. aphids and predators e.g. lady birds</td>
<td>Food security affected, disease outbreaks</td>
</tr>
<tr>
<td>Changes in human/wildlife conflicts</td>
<td>All</td>
<td>Destroy food crops, livestock and human life</td>
<td>Food security affected, human life loss</td>
</tr>
<tr>
<td>Changes in land terrain, water courses</td>
<td>Women and children</td>
<td>Search for water, food and firewood</td>
<td>Time to search for water, food and firewood increases</td>
</tr>
</tbody>
</table>

Table 2: Stakeholders involved in biodiversity issues

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Activities</th>
<th>Support provided</th>
<th>Timelines of support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmers</td>
<td>Plant trees, crops and keep animals</td>
<td>Protect trees, crops and animals</td>
<td>+</td>
</tr>
<tr>
<td>Extension officers (MOALF)</td>
<td>Sensitize farmers on biodiversity issues</td>
<td>Organize farmer groups, training</td>
<td>-</td>
</tr>
<tr>
<td>Herbalists</td>
<td>Use plant and animal resources</td>
<td>Plant trees and keep animals for medicine</td>
<td>-</td>
</tr>
<tr>
<td>Environmental officers</td>
<td></td>
<td>Enforce laws</td>
<td>-</td>
</tr>
<tr>
<td>NGOs and CBOs</td>
<td>Encourage tree planting</td>
<td>Provide tree seedlings</td>
<td>+</td>
</tr>
</tbody>
</table>

Legend: + timely, -not timely
Table 3: Ranking of stakeholders in order of support provided per site

<table>
<thead>
<tr>
<th>Site</th>
<th>Stakeholder /MOA</th>
<th>KFS</th>
<th>KWS</th>
<th>NGO</th>
<th>ENV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bungoma</td>
<td>+++</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nakuru</td>
<td>+++</td>
<td>++</td>
<td></td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Kajiado</td>
<td>+++</td>
<td>++</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mbeere</td>
<td>+++</td>
<td>++</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kilifi</td>
<td>+++</td>
<td>++</td>
<td>+</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend: +++ number one, ++ number two, + number three

DISCUSSION

The climatic changes have shown different trends within inter and intra-site of study areas. These have consequences on biodiversity dynamics within different regions of Kenya. From the figures 2 -24, it is evident that rainfall is generally slightly increasing, but this trend can even have a local variation causing different perceptions within same community. In Kilifi which is coastal Mtwapu that is next to the sea does not show change may be due to the influence of land and sea breezes and therefore, natural factors have less impact on biodiversity compared with anthropogenic effects. However, Malindi which is still coastal shows a slight decrease in trend due to the direction of rain prevailing winds while Msabaha which is further interior shows a slight increase and this is the trend with all other sites which are further from the sea such as Kajiado, Mbeere, Nakuru and Bungoma. Looking at the annual totals the wet years are usually followed by dry periods.

The effects of these fluctuations in annual rainfall distribution on biodiversity are intensified by changes on the onset of rainfall and duration. Most of these study sites receive Long Rain Season (LRS) in March-May period which is showing a shift towards coming late and ceasing earlier. In sites like Nakuru, this rain water fluctuations cause oscillations of the flamingoes in Lake Nakuru being more than 2million during dry years and just in few thousands during wet years due to presence or absence of their major food component, the Spirulina pratensis, a blue green algae whose population is more in alkaline than in dilute water. The black crow is disappearing and Black Indian Crow is emerging in Kilifi as the first one depends on rare worms and the latter on green maize which is available. Mouse birds and quelea quelea birds have increased in Kajiado and Mbeere respectively due to introduction of crops such as tomatoes and rice . Amls, eglets and weaver birds were reported to be reducing in numbers in Mbeere due to reduced forest cover and millet cultivation. Locusts and army worms were reported to disappear in both Bungoma and Mbeere mainly due to human control, while butterflies, grasshoppers, termites, ticks, jiggers, and bees have been affected by deforestation, reduced surface water and application of pesticides by man. Insects that were reported to have increased include mosquitoes, cockroaches, aphids, red mites and weevils due to rising temperatures making habitats more suitable for their breeding.

A number of animals have been affected by climate change, those favoured by dry conditions increasing in numbers. Turtle has moved to nearby water dams in Mbeere, while elephants and hyenas have moved to national parks. Other animals that have followed same pattern by decreasing in numbers include eland, lions, and rhinos in Mbeere; dik diks and wild pigs in Kilifi. Tortoise and scorpions were reported to be increasing in their frequency in Mbeere what was attributed to rising temperatures.

Table 4: Species fluctuation over time due to climate change

<table>
<thead>
<tr>
<th>Insects</th>
<th>Species that have disappeared</th>
<th>Species that have decreased</th>
<th>Species that have increased</th>
<th>Species that have emerged</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bungoma</td>
<td>Armyworms (Spodoptera exempta), locusts (Shistocerca gregaria)</td>
<td>Butterflies (Rhopalocera spp), grasshoppers (Caelifera spp), termites (Termioidae spp), (Rhipicephalus appendiculatus), jiggers (Tunga Penetrans)</td>
<td>Mosquitoes (Culicidae spp), cockroaches (Blattaria spp)</td>
<td></td>
</tr>
<tr>
<td>Nakuru</td>
<td>Locusts (Shistocerca gregaria)</td>
<td>Termites (Termioidae spp), butterflies (Rhopalocera spp)</td>
<td>Mosquitoes (Culicidae spp), weevils (Curculionoida spp), aphids (Aphidoidea spp),</td>
<td></td>
</tr>
</tbody>
</table>
Some plant species were reported to have either been reduced in numbers, increased or emerged mainly in three counties, Kajiado, Mbeere and Kilifi. These are the counties with low and unreliable rainfall. As some plant species decrease in numbers when the conditions are not favourable they create space for the invasive species such as *Ipomoea* sp. in Kajiado which is reported to have emerged since 1993 and is now overshadowing grasses, so threatening grazing areas. Other species include *Prosopis juliflora* that emerged in Kilifi in 1973 after being introduced in Tana River and Baringo counties to combat desertification. This alien species is so evasive that it has formed some impenetrable pockets of thickets in Kilifi. However, unlike *Ipomoea* sp. that is not economically utilized by the pastoralists of Kajiado, *Prosopis juliflora*’s wood is used for posts, charcoal, firewood and pods for livestock fodder. Other species reported include those reduced through overharvesting such as *Osyris latifolia* (illegal exports to Asian countries for perfumes) and *Carrisa edulis* (herbal medicine) in Mbeere, while some have increased due to deliberate propagation such as *Moringa oleifera* (herbal medicine and vegetables), *Jatropha curcas* (biofuel) and *Lantana camara*.

**CONCLUSION**

The smallholders were noted to be aware of climate change and all they need is timely support to adapt to the changes. It was evident from this study that climate change has a more severe impact on biodiversity within the already stressed habitats and some species are being replaced by alien species.
ACKNOWLEDGEMENTS
We acknowledge Rockefeller Foundation for supporting this research project; Egerton and Laikipia Universities for providing facilities, and the research team, extension officers and farmers in the research sites for their cooperation.

REFERENCES

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EFFECT OF DEVELOPMENT AND HUMAN SETTLEMENT ON BIRD SPECIES RICHNESS, ABUNDANCE, DIVERSITY AND DISTRIBUTION: A CASE OF CHUKA UNIVERSITY AND SURROUNDING AREAS

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ABSTRACT
Different land use practices affect birds differently and create micro-climates, which avail different resources to birds, thereby affecting distribution abundance, richness and diversity. This study determined how development and human settlement impact avifauna by comparing three habitat sites with differing land use practices (developed/settlement area, farmlands and forest) against diversity, distribution and abundance of birds therein. The study area was near the University and recently developed, while study sites were based on their uses. Data collection used line transects randomly laid on the ground, and opportunistic visual encounters. Species richness of 72 birds resulted, with 40 species in the forest, 34 in the farmlands and 33 in the settled and developed areas. Species diversity was highest in the forest (H’=3.45) and was lowest in the settled areas (H’=2.91). Species abundance was highest in the farmlands (432 species), followed by settled area (395 species) and forest (198 species). Development in settled area was a major threat to avian community due to habitat destruction and fragmentation, collisions with buildings which obstruct bird movement and road kills. Human settlement and development have a potential of contributing to extinction of native species through habitat fragmentation and loss. Engaging scientists, managers, environmentalists, community and developers will identify ways that development can better incorporate maintenance of ecological integrity and sustainable development.

Key words: Birds, Developed areas, Habitat loss, Land use

INTRODUCTION
Biodiversity conservation has widely been viewed as an effort focused mostly on natural areas (Marzruff and Ronald, 2008). This has however been hampered by increase in human population and pursuit of land for agriculture and settlement (Brown et al., 2005). Development especially associated with human settlement has been found to be a
major source of land use change throughout the world (Berry, 1990; United Nations Centre for Human Settlements, 1996; Cohens, 1997; Marzluff, 2001) with human settlement contributing to reduction in richness and abundance of birds (Ferna´ndez-Juricic, 2000; Mallord et al., 2007).

Land development, human settlement and urbanization poses a great challenge to biodiversity conservation efforts. Land use practices such as for development and conversion of natural habitats to built environments, have over time created micro-climates that offer different resources to birds than previously been the case. The diverse eco-climatic conditions so created produce different living conditions in terms of type, quantity and quality of resources for birds, thus affecting their distribution, abundance and diversity (Sala et al., 2000). Moreover, land use change is known to be a key driver of biodiversity change (Sala et al., 2000), enabling some species to colonize new habitats and to increase their densities while making others to decline, move towards extinction or to go extinct in some areas (Donnelly and Marzluff, 2006). It has long been recognized that the structural complexity of vegetation influences the structure of bird communities, including the number and diversity of niches available, and therefore local bird abundance and guilds (Wiens, 1989; Diaz et al., 1998; Soi et al., 2012) but human activities have been found to profoundly modify these conditions and consequently affect the composition and abundance of bird species (Blondel & Aronson, 1999; Marzluff 2001; Heikkinen et al. 2004). Urbanization on the other hand is the largest threat to biodiversity worldwide (Ricketts & Imhoff, 2003) as it endangers more species than any other human activity and is one of the leading causes of species extinction (Czech, Krausman & Devers, 2000). When an area becomes urbanized, it’s covered with buildings and pavements thus reducing the original vegetated area available to plants and animals, causing both fragmentation and habitat loss. For many taxa species richness decrease with decreasing vegetation cover (McKinney, 2002) and this is true for birds (Goldstein, Gross & DeGraaf, 1986).

Human settlement, land development and Urbanization are expected to grow substantially in coming years due to ever increasing human population and their needs. In developing countries like Kenya, land is valued for human settlement, agriculture and other economic developments, including building of infrastructure. The need for space for building settlement and agriculture has profoundly interfered with required bird habitats. Mt. Kenya East regions and areas surrounding the lower slopes of Mt. Kenya are rich agriculturally and had been intensely farmed. In addition, a section of this region such as areas around Chuka, has of recent times experienced influx of increased human population following the establishment of Chuka University, with the need of additional infrastructures such as settlement areas (housing) and roads. The emerging needs for land coupled with farming activities has greatly changed the bird habitat conditions availability in the area, hence the need to provide a documented effects of all these development activities on birds.

Chuka region, especially areas next to the Chuka University has gone through a series of development/urbanization which is attributed to the fact that Chuka University has seen an increase in population at an approximate rate of 20% annually owing to students’ intake every academic year alongside increase of staff members. It is against the above background that the present study is trying to bring into fore the impacts of development ventures and various land use practices on bird species richness, abundance, distribution and diversity in Chuka University surrounding areas. The consequences that results from such human activities on ecological integrity of affected areas need to be understood and documented to assist managers, developers and decision makers on natural areas and environmental matters and to advice on maintenance of ecological integrity in the face of any development activities.

MATERIALS AND METHODS

Study area

This study was carried out in the month of January 2014 in Tharaka-Nithi County. The county is situated in former Eastern province bordering Meru County to the North and North east, Kitui County to the East and South East, and Embu County to the south and south west. Tharaka-Nithi County covers an area of 2638.8 km² and has a population of 365 330, with 48% males and 52% women (KNBS, 2009). The county has a population density of 138 people per km² and has three constituencies: Tharaka, Chuka-Igambang’ombe and Nithi.

Chuka University is located in Chuka-Igamba-Ng’ombe Constituency on the eastern slopes of Mt. Kenya in Meru south sub-county and has a population of about 13000 with an annual increase of about 15%. It is situated 186 km from Nairobi city along Nairobi-Meru highway at an altitude of 1,500 meters above sea level.

Chuka University is characterized by built and paved environment to greater extent and high population of people.
Outside the University is surrounded by settlement consisting mainly of houses of different built and designs. The settlement near the university though interspersed with small farms, is now characterized by more concrete houses built as private student hostels and has seen increased human populations. Further from the university are farms dotted with homesteads with intensive small scale farming around the homes. There is also a section of Mt. Kenya forest (Kiang’ondu forest) which is an extension of the lower parts of extensive Mt. Kenya forest which was used as a control in this study due to its more or less pristine nature as compared to other study sites.

Study design

Selection of the study area

The study area was selected due to its proximity to the university, the witnessed development of the area of focus over the years and presence of other study sites that could enable comparison of data collected. This is an addition to the fact that no previous research has been conducted relating to birds in this area and how development could have impacted bird community, and the need to provide a basis for other related research in the coming years.

Selection of the study sites

Chuka University, settlement around the university, farmlands and the forest was chosen as study sites to fulfill the need for assessment of how development impacts on bird communities. Chuka University at present is an institution that is experiencing development at an increasing rate. This is mainly manifested by the increased number of students and intensity of building structures within the university. Additionally, the growth of the university has seen the neighboring areas developed with more businesses and settlement structures being established. These have resulted to habitat fragmentation and land use changes thus creating a need for research to be done to help assess the impact of this development using bird communities as indicator.

Selection and laying of transects

After selection of study sites, three transects were randomly placed at each site to enable collection of data. Considerations were made to ensure that all transects cover a kilometer length in each site with consideration of configuration and accessibility of the site. The first transect was laid aided by the compass where the direction of the magnetic north was followed at each site for 1 km. To ensure uniformity of all the transects a specific angle used in the first transect was applied for all other transects within that study site as used by Soi et al., (2012).

Avifauna identification and categorization

Identification and categorization of birds followed the one in Birds of East Africa (Stevenson & Franshawe, 2011) and Birds of Kenya and Northern Tanzania (Zimmerman et al., 2001). Classification of bird species into forest-dependent categories shall follow that of Bennun et al. (1996). Birds were identified by use of visual traits and vocalization (song and call).
Research instruments
An established data sheet was used to gather information about birds where visual survey and use of songs and calls to identify birds was conducted and the information so achieved recorded. Oral interviews with community members and area assistant chief was used to help in coming up with the history of the study area in terms of development and remarkable changes over the years since the establishment of the University. Instruments used included: a bird guide book (Birds of East Africa by Birds of Kenya and Northern Tanzania by Dale A. Zimmerman et al., 1999) a binoculars (bushnell, 8*25), a Bushnell range finder, a stop watch, data sheets and a pencil.

Data collection and methods
Bird data were collected on Thursday mornings between January and February 2014. This was done during early mornings starting at 6.30 am and ending at 9.30 am. These times was chosen because the birds were very active and vocal, which allowed correct data recording of all bird contacts.

Line transect
Line transects was used as a primary data collection method and involved the observer continually walking and recording all bird contacts on either side of the transect (Bibby et al. 1998). A 2 km long transect was covered at each study site. On both sides of the transect, bird count was done within a width of 50 m were bird presence were noted and counted, bird species noted and a perpendicular distance to the birds were estimated using range finder. All birds seen or heard along these transects was recorded except the one on flight.

Timed species count (TSC)
In order to obtain a comprehensive bird species list of the study area, 6 TSC (Pomeroy & Dranzoa, 1997) was used to supplement the line transect method. Using this method, data was collected in a span of one hour and species received a cumulative score according to when they were first recorded on each count. This period was divided into ten minutes block and a score was allocated to each block as follows: the first minutes a score of 6 points, second ten minutes a score of 5 points, and the third ten minutes a score of 4 points all the way to the sixth ten minutes which was allocated a score of 1 point. A species that was recorded in the first ten minute was not recorded again in that hour. Counts were undertaken at different times of the day to cover species activity. In total, six counts was made in all study sites (two TSC count in each site and a mean figure for each was calculated). The above methods were also supplemented with opportunistic survey and basic counts. This helped in developing a comprehensive bird checklist within Chuka University and its environs.

Observation and interview with local community members
In addition, community members who involved local leaders were also engaged in informal interviews to shed more light on development and settlement history of the study sites and likely impacts of settlement on birds and bird community. Personal observation of the researcher was also used for the purpose of ground-truthing. Selection of these members was random. Only the area chief was purposively chosen to give history of the study area.

Study assumptions
This study was undertaken under the following assumptions that: there was an equal chance to sight a bird during the chosen time, biasness was reduced significantly when lying transects and timing of surveys, transect points were representatively placed, birds directly on each transect line and width or at each point were always detected and birds were always be detected at their initial location prior to their natural movement or movement in response to observer’s presence.

Data Analysis
Species richness was measured by species number and diversity with Shannon-Weiner’s index (H’) (Shannon –Weiner 1949). It is estimated as $H' = - \sum (P_i \ln P_i)$ where $P_i$ is a proportion of the total number of birds belonging to species i and $\ln (P_i)$ is the natural logarithm of that proportion, and summation is over all species. Bird abundance was defined as the number of individuals of a given species. Birds were also categorized by forest dependency (Bennun et al., 1996).

RESULTS
Species richness
The total bird species richness in all the study sites was 71. The forest had the highest number of species with 40 species followed by farmlands with 34 species while the settled/developed area had 33 species (Figure 3.1).
Species diversity
The highest recorded diversity was in the forest ($H' = 3.45$) and the settled areas with the least diversity index ($H' = 2.91$) (Figure 3.2).

Bird species abundance
The farmlands had the highest bird abundance with 432 individuals, settled area followed with 395 birds and forest lowest with 198 birds (Figure 4.3).

Bird distribution
Passerine birds were mainly found within the settled/developed areas and a few of the group in the farmlands while majority of non passerines were mainly distributed in the forest habitat. Parrot billed sparrow (*Passer gongonensis*), speckled mouse bird (*Colius striatus*), ruppels starlings (*Lamprotornis purpuroptera*) and ring-necked dove (*Streptopelia capicola*) were sighted across all the habitats but with deferring abundances. The barn swallows (*Hirundo rustica*) for example were only sighted in the settled areas while Hartlaub Turacos (*Tauraco hartlaubi*), Trumpeter hornbills (*Bycanistes bucinator*), Tambourine doves (*Turtur tympanistria*) and Northern brownbul (*Phyllastrephus strepitans*) were only sighted in the forest. Raptors and especially the black kite (*Milvus migrans*) were sighted across all the habitats. African pied crow (*corvus albus*), house sparrow (*Passer domesticus*) and speckled pigeon (*Columba guinea*) were commonly sighted within the human settlements and rarely seen in the other habitats.
Land use practices within the study areas

Through personal observations and an in-depth interview with the area chief revealed that the area around Chuka University has undergone tremendous development ranging from building construction to infrastructural development. Intensity of roads for example, at the moment is higher above what was there eight years ago when Chuka University was in its initial stages of development. Much land use changes have been observed as land owners convert their lands to settlement areas, hostels and business centers. These have increased the need for road networks to connect one place to the other resulting to further fragmentation of the bird habitats.

Impact of settlement and development on bird communities

In this study, development was given an important consideration in accounting for variation in habitat use by birds. Bird species richness was lowest in the settled/developed areas. This habitat was marked by increased habitat fragmentation, high intensity of buildings and a large area of impervious surface resulting from roads and pavements that connected an area to another. This particular site had the highest human population size of the three study sites owing to the fact that majority of university students and staff members reside here. As such, the intensity of buildings, infrastructure and businesses was highest here. This was in contrast with the forest and farm habitats, where settlements, buildings and infrastructure were lowest.

Threats to bird communities

According to observation made during the study period and information given by community members during data collection, according to them, major threat to birds within Chuka University and its environs is road kills and collisions with building structures.

DISCUSSION

Bird species richness decreased when an area becomes urbanized. This is evidenced by the fact that species richness increased as one moved from the settled/developed areas to forest area. This is in agreement with previous urban ecology studies done to evaluate the effect of larger human settlement on bird communities (Chace and Walsh, 2006; Evans et al., 2009; MacGregor-Fors et al., 2009). It agrees with a study done by Krohm (2000) who found a relationship to exist between bird species richness and woody plants where species richness was highest in habitats with a high percentage of woody plants, representing diverse niche for birds. The bird diversity also increased from the settled/developed areas to the forest areas. This can be attributed to the fact that forest still has a pristine environment providing a more or less ideal habitat for most diverse bird species. Low species richness in the settled/developed areas may be attributed to increased development, which has resulted to some form of urbanization, and therefore, increased impervious surface and reduced vegetation cover due to habitat loss and fragmentation. As a result of this also, birds that are urban avoiders will tend to disperse away while urban adapters will start colonizing the urbanized area. Since urban avoiders are mainly the majority in any given habitat, their dispersal from the given habitat results to reduction in species richness.

Tworek (2002) showed similar observation and pointed out that responses of birds to habitat changes differ depending on their life strategies and that some birds benefit from habitat change, while for others it is a principal threat. Urbanization therefore, tends to favour urban adapters for example house sparrows and African pied crows, while it’s a threat to urban avoiders. These findings is further supported by a study done by Rottenborn (1999) who studied the relationship between development and the composition of bird communities at multiple sites and included measures of local habitat and the surrounding landscapes in the analysis. He found that bird species richness and overall density were lower at more urbanized sites as were the density of most individual species. James Miller et. al., (2001) on the other hand in his research, “effects of human settlement on low land areas of colarado” also found that birds are likely to be affected not only by structural changes to riverine habitats but also by an increase in human population there in.

Species abundance was highest in the farmlands and lowest in the forest habitat even though the forest had the highest species diversity. This finding is comparable to the one by Tworek (2001) who pointed out that even though birds may occur in some non-forest habitats with densities markedly exceeding those in forests, this does not entail greater species diversity. He stated that non-habitat density with low species diversity is attributed to great population numbers of one or two dominant species. Farmland in the current study area are probably attractive to many individual of birds of a given species owing to the presence of food such as seeds from crops or insects owing to suitability of these farms to insects which can attract large numbers of insectivorous birds.
Development in the settled areas was marked by an increased establishment of building structures and increased road networks. Roads are a threat to avifauna as they may turn source habitats into sinks by increasing mortality rates (Mumme et al., 2000). This tends to agree with information gathered from the community members during the data collection where major threat was attributed to road kills and collisions with tall building structures. The presence of the main road and other major road networks in the university, which is frequently used by vehicles and human traffics, is believed to pose a major threat by causing noise thus moving birds further away from the road and by road kills. Noise has been reported to interfere with bird communication leading to their population declines (Reijnjen et al., 1995; Forman et al., 2002). Building structures cause obstruction to birds on flight and through collisions; some are injured to death while some avoid such premises by moving further away from the site consequently contributing to a decline of such species. Czech, Krausman & Devers, (2000) found that urbanization is a major factor that contribute to species extinction. This is because urban development produces some of the greatest local extinction rates and frequently eliminates the large majority of native species (Vale and Vale 1976, Luniak, 1994, Kowarik 1995, Marzluff, 2001). Urban-gradient studies showed that, for many taxa, for example, plants (Kowarik, 1995) and birds and butterflies (Blair and Launer 1997), the number of nonnative species increases toward centers of urbanization, while the number of native species decreases.

The increasing development of the region has resulted to an increase in human population. This is evidenced from the progressive growth of the University resulting to increased number of students and staff members besides the community members who operate businesses. Increase in human population is a source of threat to avian community due to disturbance and persecution. This is similar to findings by Fernandez-Juricic (2000) and Mallord et al. (2007) who from their research on local and regional effects of pedestrians on forest birds in a fragmented landscape found human presence to reduce richness and abundance of birds due to human disturbance caused by their presence, their activity levels and domestic animals. Bird decline in urbanized habitat have been attributed to vulnerability of small birds to predation from large species in addition to the fact that small birds cannot compete with large birds for resources.

Land use changes over the years have resulted to land fragmentation as land owners subdivide their lands to cater for the growing need of settlements and establishment of businesses. According to McCallum & Dobson (2002), fragmentation of habitats affects the connectivity in the landscape thus affecting ecological processes such as migration and dispersal thus posing a threat to avian communities. In Chuka University and surrounding areas, land use change has been attributed to the fact that as the university grows, more building structures have been established either as lecture halls or offices. In addition, the community has been increasing their settlement structures to cater for the increasing number of students resulting to closure of dispersal corridors for birds, and therefore collisions with the building structures. Increase in road networks connecting one location to another especially within the settled areas and the busy meru-isilo highway have resulted to avian disturbance and road kills. As a safeguard measure, much of the avian community tends to avoid the roads. Alternatively, infrastructural development is in its self a threat to avian composition as it tends to reduce the original vegetated area resulting to reduction of bird species. Besides disturbance, birds tend to avoid the roads and places with high human settlement due to noise.

In the farmlands, land cultivation and subdivisions pose a threat to avian communities. This was mainly due to loss of natural habitat and fragmentation. A few of the avian communities were reported to be persecuted by the community members since they preyed on their chicken while some grainivorous posed a nuisance to the community members by feeding on their grains in the farms. This had human persecution as a form of avian threat. Farmers had also increased their cultivation areas for purpose of increasing their yields. This results to loss of the natural habitat hence contributing loss of bird species agreeing to studies by Siriwardena et al. (1998) on the relationship of farmland birds and agriculture, who found modern day agricultural practices to cause decline in population of many farmland bird species. Raptors represented by goshawk had the lowest relative abundance in the farmland. This can be attributed to human persecution since raptors are considered a nuisance by farmers due to preying on their poultry. Due to their ability to explore resources across all the habitats, generalists’ birds were present in all habitats for example, speckled mouse bird, while some species due to their specialized use of resources (such as Hartlaub turacos and Hornbills) could only be located on specific habitats and never recorded elsewhere.

The presence of resources across habitats resulted to an overlap of resource use in more than one habitat with the result of some birds being sighted across all the study sites. Raptors for example, have home ranges that extend beyond the urban boundary and therefore do not need to meet all their ecological requirements within urban areas thus raptors were found across all the habitats under study. The black kites were common in the settled areas during the time of study.
but were also recorded in the farmland. Their presence in both habitats is attributed to its dietary requirements; in the settled area it can prey on chicken from homesteads and the same is possible in the farmlands.

In the settlement areas, urban exploiters are common due to their ability to colonize such a habitat in pursuit of food resources especially as seen in house sparrows and the African pied crows. In addition to their foraging behavior, human settlements have been shown to provide ideal conditions for invasive and exotic species due to high levels of disturbance which tends to favor non-native species at the expense of native species. The removal of native species and their replacement with non-native species drastically alters the composition of urban biological communities; the ecology of cities is therefore very different to the surrounding undeveloped areas (Hardman, 2011).

Overall, Bird diversity was highest in the forested habitat and lowest in the settled areas. This is attributed to the complexity of forest habitat with differentiated niche hence ability to provide varied resources to varied species of birds. Bird species abundance was highest in the farmland and lowest in the forest as most bird species move in large groups which increase the abundance of any given species. Development results to tremendous changes in habitats and vegetation complexity which produces gradual decline of species richness and diversity. This is because development results to extinction of local native species while creating a conducive habitat for invasive bird species, urban invaders and exploiters to increase in numbers.

Scientists, managers and environmentalists in a university setting or any urbanized setting, need to work closely with home owners and developers to identify ways that urban development can better incorporate the maintenance of ecological value. This can be addressed in part by designing and managing landscapes in an ecologically sensitive fashion. Retention of open spaces and natural habitats for example in a university, will generally improves the ability of urbanizing areas to contribute to biodiversity conservation besides urging the communities to maintain native plant communities. Cluster developments helps reduce road construction hence allow access and space for more natural areas.

The public should be well informed about conservation through mobilization programmes and community sensitization programmes as this is an important application of promoting effective conservation of native species.

REFERENCES
CONSEQUENCES OF LARGE-SCALE LAND USE CHANGES ON ENVIRONMENT, LIVELIHOOD AND FOOD SECURITY IN THE YALA SWAMP ECOSYSTEM IN KENYA

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ABSTRACT
African wetlands are among the most productive ecosystems and as such play an important role in ameliorating the effects of global warming, biodiversity conservation, as well as natural resources provision, which drives many rural economies. Yala swamp is a large fresh water wetland, a recognized biodiversity hotspot that supports local livelihoods in Lake Victoria basin. This study evaluated the socioeconomic and environmental impacts of converting large parts of the swamp to farming to support perceived food security. Primary qualitative data was collected using semi-structured questionnaires and in-depth interviews of randomly selected stakeholders. One hundred questionnaires were administered to the stakeholders who included men, women and youth. Secondary data was collected from published work, books, print and electronic media. Although conversion of the Yala swamp wetland is contributing in Corporate Social Responsibility, there exists a strong conflict with the local community. Overall the local community and the environment have been negatively impacted and there will be long-term negative consequences regarding environmental degradation, food security and livelihood opportunities. The Kenyan government should commission a new Environmental Impact Assessment and enact and implement a strong wetland policy. There is need for awareness creation to enhance participation of local communities in decision-making. Other livelihood diversification programmes to reduce dependence on the wetland are also recommended.

Key words: Wetland conversion, Livelihoods, Environmental Impact Assessment, Multi-national Corporation, Corporate Social Responsibility, Dammed and Damned?
INTRODUCTION
Developing countries rely heavily on exploitation of natural resources like forests and fisheries for their economic development. This often leads to a conflict between the need for economic development and sustainable management of natural resources and conservation of biodiversity. Wetlands are some of such highly exploited resources (Maltby, 1986). Wetlands in Africa are an important source of water and other resources necessary for survival of local communities. Wetlands are complex ecosystems with multiple values, including ecological, socio-esthetical, intrinsic and economic values. For example over 2,000 known species of indigenous freshwater fish and several wildlife species live in African wetlands (Roggeri, 1995). Socio-esthetical value is reflected, for example, in the tradition of some tribes to have initiation rites in wetland areas, while intrinsic value is the value residing in the wetlands themselves. Further ecological functions of wetlands include hydrological cycle and flood control, pollution and eutrophication abatement through sediment trapping as well as carbon sequestration hence mitigating global warming (Turner et al., 1994). Economically, wetlands play an important role as a source of livelihood to local communities for example through supporting subsistence agriculture and commercial fisheries.

Despite their significant ecological, economic and social functions, wetlands are still among the least understood and appreciated ecosystems. The failure to account for the economic value (i.e. assign a ‘Dollar equivalent’) of tropical wetland benefits derived by local communities dependent on natural wetlands means that tropical wetlands are prime targets for ‘reclamation’ by national governments and, more recently by Multi National Companies (MNC’s) for agriculture and other economic activities because they are often viewed as ‘wastelands’ (Mitsch and Gosselink, 1993). Sustainable management and utilization of wetlands is therefore critical to the long-term health, safety and welfare of many African communities. Despite their highlighted importance, wetlands are being modified and degraded, often driven by economic and financial motives at alarming rates in Africa in disregard to their long term sustainability and their important ecological functions (Schuyt, 2005; Mwakaje, 2009).

Study Area
The Yala Swamp, a 17,500Km² wetland located along the North-Western shores of Lake Victoria, Kenya covering the administrative districts of Siaya, Bondo and Busia, is one of the most extensive freshwater wetlands in East Africa (Fig 1). The wetland supports local communities that derives livelihood directly from activities like fishing, hunting, construction material production and agricultural production (Abila 2002). In addition, Yala Swamp has also been recognized as a biodiversity hotspot and an important refugium for conservation of cichlid fish diversity threatened by introduction of the exotic Nile Perch (Lates niloticus) and other anthropogenic impacts in the Lake Victoria basin (Abila et al., 2008). In 2003, a US based multinational company, Dominion Group of Companies (herein referred to as Dominion Farm (K) Ltd), obtained a 25 year lease from the Kenya Government to convert part of the wetland for among other activities rice production and aquaculture. The activities of Dominion Farm (K) Ltd have since distorted the ecosystem utilization scenario and are likely to give rise to new socio-economic scenarios in the Yala swamp.

While the traditional economic utilization patterns of the Yala swamp wetland have been discerned and economic valuation of the wetland resources have been attempted (Abila, 2002, Mwakubo et al., 2007), there is urgent need to assess the potential short and long term ecological and socio-economic consequences of the large scale land use changes as envisaged and currently being undertaken by the Dominion Farms (K) Ltd. The goal of this study was therefore to critically examine the contributions and consequences of activities of the Dominion Farm (K) Ltd on land tenure and food security, environment and socio-economic development in the Yala swamp.
MATERIALS AND METHODS

Sampling
Data for this study was collected from the field at the Yala swamp, Kenya, between 1st May and 30th June 2008. The local communities who are the fundamental stakeholders in Yala Swamp were interviewed. During the first two days, a reconnaissance survey was done to map and identify suitable villages for selecting the respondents. Village elders and local administrators provided a list of households in their areas of jurisdiction. Thereafter, a meeting was organized with the village elders where the aim of the research was explained and approval sought for interviews to be conducted in their areas. Time and cost factors contributed to determination of sample size. Purposive sampling was used to get the sample size. Finally, one hundred respondents were selected based on proximity to the swamp, utilization of the swamps resources, and those relocated to pave way for Dominion Farm’s (K) Ltd activities.

A structured and open ended questionnaire was developed by the research team and administered by three local residents. The interviewers had been trained to administer questionnaires during previous HIV/AIDS, gender and poverty study in the area and were therefore familiar with administration of questionnaires. The questionnaire was written in English language and administered in the local Dholuo language for respondends who did not know how to read and understand the English language. This was to get the local communities’ views about the socio-economic roles the Yala swamp played/plays as a source of their livelihood as well as the impacts of Dominion Farm (K) Ltd activities on their livelihood and the ecosystem.

The open-ended unstructured questions were administered in order to obtain more in-depth responses from the primary stakeholders about their experiences, perceptions, opinions, feelings and knowledge about the emerging issues surrounding the activities and impacts of the Dominion Farm (K) Ltd on respondent’s lives. Secondary data relevant to the study were obtained from policy documents, published work and reports.

Data Analysis
Data collected from this study was analyzed quantitatively and qualitatively using the Statistical Package for Social Sciences (SPSS). Pie-charts and tables were also drawn to represent an analysis of socio-economic activities and access to the swamp. Qualitative data was classified into themes and categories and analyzed descriptively to determine the impacts of Dominion’s activities on local communities’ livelihood, food security and the environment.

RESULTS AND DISCUSSION
Traditional patterns of utilization of Yala swamp wetland
Yala Swamp wetland plays a vital role in local communities’ livelihoods. Nearly all respondents depended directly or
indirectly on the wetland for their livelihood (Table 2). Before the Dominion Farm (K) started its activities, 84% of the respondents indicated that they depended entirely on the swamp and they had no other means of earning an income and survival. However, 13% did not know the importance played by the swamp in their livelihoods while only 3.1% of the respondents reported that they did not depend on the swamp for survival and had other employment opportunities.

<table>
<thead>
<tr>
<th>Activity</th>
<th>% of people involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grazing</td>
<td>61</td>
</tr>
<tr>
<td>Fishing</td>
<td>44</td>
</tr>
<tr>
<td>Fuel wood</td>
<td>60</td>
</tr>
<tr>
<td>Building and Construction materials</td>
<td>23</td>
</tr>
<tr>
<td>Agriculture</td>
<td>82</td>
</tr>
<tr>
<td>Water for domestic use</td>
<td>93</td>
</tr>
<tr>
<td>Brick Making</td>
<td>14</td>
</tr>
<tr>
<td>Others (Beeking, traditional vegetables, wood fuel)</td>
<td>12</td>
</tr>
</tbody>
</table>

Fishing

Some 44% of the respondents carry out fishing activities for survival. The fishermen use the ox-bow lakes found in the swamp, namely Lake Namboyo, Sare and Kanyaboli to harvest fish for sale and consumption. Most of the fish caught (43%) by the locals is taken to the local market for sale, 7% is used for household consumption only while 50% is shared between trade and consumption. This shows that the fishing activity is very important to the locals as it generates income as well as food for consumption.

Building and construction materials

The swamp provides building materials used for construction. The Yala swamp is a papyrus (Cyperus papyrus) dominated wetland but large areas also contain reeds (Phragmites) and other vegetation which local people use for thatching, making chairs, doors, mats and basket weaving. The products are sold in the local markets in Kenya. The study found that 23% of the respondents depend on papyrus harvesting and products to earn a living. Brick making for house construction is also an important economic activity and 14% of the respondents indicated that they are directly involved in this activity.

Agriculture

A total of 82% of the respondents carried out farming activities and grew crops and vegetables mainly for domestic consumption and sale. Crops and vegetables grown included maize, beans, potatoes, rice, tomatoes, onions and citrus (oranges).

Grazing

The swamp was identified as an important grazing area and serves as a refuge especially during the dry season. Some 61% of the respondents directly depend on the wetland as a source of pasture for livestock. Animals kept include cattle, sheep and goat.

Water source

Access to water for domestic use and safe drinking is a fundamental human right as stressed by the World Summit on Sustainable Development (2002). Nearly all respondents (93%) depend on the swamp for supply of water for domestic use, facilitation of transportation between different parts of the swamp and various villages.

Others

Other benefits derived from the swamp by the locals include wood fuel for cooking and traditional vegetables which grow wild in the swamp. This is also used to supplement the locals’ diet. Local residents also use the swamp for bee keeping. They construct home-made bee hives which are placed in different places within the swamp and honey harvested is used for consumption and sold in the local market.

Impact of Dominion Farm (K) Ltd activities on Livelihoods and Food security

Overall, the survey found out that with the entry of Dominion Farm (K) Ltd, most of the local communities’ sources of livelihood have severely been curtailed due to restricted access to the swamp. As a result there seem to be a concomitant increase in poverty due to lack of alternative livelihood sources.
Nearly all (94%) of the respondents were aware of the activities of the company in the area. Activities identified include cotton farming, crop growing (soya beans, maize, and sunflower), rice farming and milling, bee keeping, dairy and fish farming. Some 28.6% of the respondents said that they approved all these activities carried by the company and did not object the expansion of the activities. However, 49% approved some of the activities which they felt were beneficial but felt that other activities carried out were negatively impacting on their livelihood and/or the environment. The study revealed that 94% of the respondents have been denied entry to the swamp since the company began its activities while only 6% had access to the swamp (Fig 3). Access routes and roads had been blocked making movement within and between villages more difficult. This study shows that 58.1% of the respondents believed that their livelihood had changed negatively and the level of poverty has increased due to loss of opportunities while 41.8% reported no change in the level of poverty in the area. The respondents attributed the increasing poverty levels to loss of livelihood opportunities like fishing, grazing and loss of land for cultivation.

Since the acquisition of the wetland, Dominion Farm (K) Ltd gives members of the local community whose farmlands have been taken two bags of maize after every harvesting season. This makes the local community entirely dependent on the company for food hand-outs yet many households have large and extended families to feed, a culture in many African communities. According to the respondents, this has resulted in lack of food for the local community leading to increased food insecurity in the area. Although the residents responded that they were being provided with free maize and cheap rice, this was not enough to cater for their large families. They added that they needed to be allowed to grow their own crops to supplement the little food they were getting from the company.

![Figure 3: Access to the swamp after entry of the Dominion Company](image1)

![Figure 4: Utilisation of Yala swamp before and after Dominion Farm](image2)

**Land tenure and use rights**

Land tenure and use rights have been one of the most sensitive and emotive issues in Yala swamp. Since Dominion Farm (K) Ltd started its activities, Yala swamp ownership has been dogged by a series of conflicts with different stakeholders claiming ownership. The Swamp is a ‘trust land’ owned by the Bondo and Siaya County Councils on behalf of the community (Trust Land Act Cap 288). It has no formal protection and has been a free access land used...
by the community to eke a living. However, with the arrival of the Dominion Farm (K) Ltd, this perception has drastically changed and only 7.1% of the local community still believes they still own land in the swamp. Some 49% reported that Dominion Farm owns the swamp while 6.1% believe that the local County Council owns it. According to 14.3% of the respondents, the Kenya government has the right of ownership while the same percentage said they didn’t know who owns the swamp.

The laws of Kenya recognise private land ownership (RLA, CAP 300) and the local residents feel that their rights have been infringed on this issue and that the Dominion Farm (K) Ltd has altered land rights as local residents were forced to abandon their ancestral land with little compensation. The respondents hold high value to their ancestral homes as they believe that they connect with their dead ones through spirits. The overall feeling by members of the local community is one of disfranchisement from their traditional heritage by a foreign organization working in cahoots with the government. Land tenure and use rights in the Yala swamp thus still remain a very divisive issue.

Environment
In this study, 61.2% of the respondents said and enumerated the activities of the company that had altered the ecology of the swamp while 36.8% felt that the company had not interfered with the swamps ecosystem. 50% of the respondents reported that the company was using aerial spraying using toxic pesticides and herbicides which killed their livestock and fish species. There were also reports of loss of indigenous vegetables which withered due to the effects of the toxic chemicals. Oil spillage and polythene paper pollution is also another problem respondents attributed to the company. Due to the digging of canals and building of dykes, the area has become permanently water logged and this has created a conducive environment for the breeding of mosquitoes.

There has been regular flooding since the drainage of the swamp was carried out as the wetland’s ability to act as buffer has been heavily compromised. The loss of papyrus which absorbs nutrients may eventually lead to eutrophication of Lake Kanyaboli.

Dominion farm’s Corporate Social Responsibility (CSR)
The following were identified as tangible corporate social responsibilities of the Dominion farm (K) Ltd:

- Infrastructure development including construction of access roads, improving existing schools and putting up a health facility.
- Employment. According to the local residents interviewed, the company has created several job opportunities especially for women who are employed as casual labourers when opportunities are available. Major complaints against the company were that employment opportunities did not target ‘locals’ and corruption and nepotism were rife when recruiting.
- Tsetse fly control and supply of mosquito nets. According to the local residents, the company is involved in free distribution of treated mosquito nets to households. This will go a long way towards combating malaria within the community. In addition, the company has also been involved in the spraying of the area around Yala swamp with insecticides to control tsetse-fly.
- Increased business opportunities and market for goods. The company has established a trading centre near the swamp which has improved business opportunities in the area. This has created opportunity for members of the community to venture into self employment.

DISCUSSION AND CONCLUSION
Developing countries depend heavily on natural resources- agriculture, forestry, fishing and mining for their economic prosperity (Turner et al., 2000). Majority of people in these countries live near or around the natural resources and they depend on them for survival. The large MNC’s have found their way into developing countries targeting the same resources to carry out development projects. This study found that Dominion Farm (K) has impacted negatively on the livelihood of the local community and has contributed to environmental degradation in the area. The reduced livelihood opportunities in terms of access to the swamp, loss of land and apparent pollution of water bodies may in the long run lead to higher poverty levels and precarious food security situation within the Yala Swamp community. The barrin of the community from growing their own food crops which makes them depend on food hand-outs from Dominion Farm (K) Ltd and other Aid Organizations may not be sustainable in the long run. This would make the community vulnerable to hunger, malnutrition and high mortality rates. Sub-Saharan African populations have been noted to be especially vulnerable to drought, famine and disease (Downing, 1996) and current studies suggest that ecosystem changes caused by anthropogenic activities as found in Yala Swamp will have particularly severe negative impacts on livelihoods of rural African communities (Kangalawe, 2009). To make a worthwhile and meaningful contribution to the welfare of the local community in Yala Swamp, Dominion Farm (K) Ltd must involve in the activities and approaches that are of benefit to the community. Dominion should instead encourage formation of farming cooperatives and
contract the local community to grow rice while it provides extension and technical support. This approach has worked successfully with sugarcane processing companies in Kenya. This would go a long way towards addressing the issue of land tenure and land rights in the wetland.

The short-term, the local community has lost a substantial amount of their livelihood support and the long-term effects of Dominion Farm’s activities will have far reaching negative consequences. Land is highly valued by many people in Africa who depend on it for agriculture, settlement and grazing animals among other activities. The arrival and activities of Dominion Farm has drastically changed the use rights of the people by blocking free access to the wetland. Moreover, there has been a change in perception on the resource ownership. The acquisition of the wetland by the multinational company appears not to have involved members of the local community. Land is a very sensitive issue in the area and the local community strongly feels that they were shortchanged and are not benefiting from the development activities carried out in their midst. To address this, Dominion Farm should enlist the support of the population, integrate poverty alleviation in its CSR initiatives and consider the needs and rights of the community. In addition, the process of compensation should be reviewed and adequate compensation given which should be equal to the value for their land. Dispossessing indigenous people of their land will lead to creation of ‘land squatters’, a phenomenon common in many Kenyan large scale irrigation projects with serious socio-political consequences. The perceived change in land tenure and ownership is therefore a major source of conflict and long term sustainability and success of the project lies largely upon resolving this conflict.

To achieve sustainable development, The World Summit on Sustainable Development (2002) stressed the need to take environment and natural resources into account in development projects by promoting those activities that utilize natural resources wisely. Dominion Farm (K) Ltd has carried out development projects in Yala swamp without integrating environmental protection and management in its strategic plans. It is evident from the analysis that environment has been compromised at the expense of development leading to loss of species and habitat, pollution, floods, change of river course system and compromised health of the local community. In the long run, it is the local community who will bear the costs associated with destruction of the environment. While it may be argued that Dominion Farm has contributed positively on creation of job opportunities and infrastructure development among other benefits to the local community, the costs and long-term consequences associated with the swamp’s destruction outweigh these benefits. The costs associated with loss of habitat and species, genetic resources, loss of recreational and tourism opportunities, water pollution, disruption of local’s livelihood and rural societies in the area may change the swamp to an irreversible state making it unfit for human settlement and species survival. Majority of the local population are aware of the environmental consequences posed by Dominion Farm and the future of their only source of livelihood seems bleak.

Although it has been argued that “some deterioration in environmental quality is a necessary and justifiable cost of economic growth” and that “the management of natural resources for sustainable use is a luxury which poor developing nations can ill afford” (Welford, 1995), carefully planned and executed projects can greatly mitigate the potential environmental impacts. This seems not to have been the case with the development project studied. ‘Development and progress’ may have different meanings to local communities and investors like Dominion. Progress and development for multinational corporations and many national governments means foreign investment, industrialization and wage labour jobs (Welford, 1995). However, to many rural communities and indigenous people, ‘progress’ means land rights, formation of co-operatives, fair trade partnerships, and protection of communal resources like forests, rivers and wetlands. This difference in what constitutes development and progress may explain the high occurrence of conflicts and protests especially in developing countries against MNC’s as is evident in the case of Yala swamp.

To promote sound development, plans and mitigation measures to reduce the level of pollution and rehabilitate degraded land must be put in place. Many current environmental problems have arisen from over-exploitation of natural resources or poor planning and design of development projects, coupled with inadequate assessment of potential impacts. While Dominion Farm commissioned an Environmental Impact Assessment (EIA) report to identify, quantify, predict and evaluate the impacts of their activities, it now appears that the EIA may have been of a compromised standard. Within a span of five or so years, there have been enormous risks posed to the environment. Sound EIA is a tool that allows proper analysis of development projects and identifies mitigation measures in the case that projects are perceived to pose risks to the environment (Dixon et al, 1986). Therefore, the EIA conducted has failed to address risks posed by the company’s operations. A new EIA should be commissioned to exhaustively address all the contested issues.

The lack of proper enforcement and weak environmental laws and regulations may have also contributed to environmental pollution and degradation in the swamp. This may be as a result of lack of awareness on the importance
of natural resources like wetlands, lack of resources to formulate and enforce sound environmental policies coupled with high level corruption. Environmental protection in Kenya is regulated by Environmental Management and Coordination Act of 2002 (EMCA) and is enforced by National Environment Management Authority (NEMA) whereby the organization enforces the ‘polluter pays principle’ which authorizes companies and industries to meet the cost of polluted habitat and rehabilitate the degraded area. This study has therefore identified strengthening governance and enacting and enforcing a strong environmental policy as key to successful management and utilization of the Yala swamp resources.

The study has further revealed presence of serious and sensitive environmental issues caused by Dominion activities. These need to be specifically and urgently addressed. In developed economies, just one of these environmental issues raised would be adequate to institute legal action against the company. The study further reveals that the local community is highly aware of and sensitive to environmental issues.

There is evidence of CSR programmes carried out in the area which includes infrastructure development, training and provision of social services. Despite these benefits, Dominion Farm (K) has faced protests and strong opposition from the local community. This may be as a result of the communities’ high expectations and perceptions to help them fight poverty and improve their socio-economic well-being. The creation of employment opportunities, infrastructure development and provision of social services has contributed in capacity building and community empowerment and this may in the long run help in reducing poverty levels and improve the general standards of living for the local population. Dominion Farm (K) Ltd can therefore be a critical partner to the Kenya government in meeting the Millennium Development Goals (MDGs). However, despite the potentially social uplifting undertakings by Dominion, the local community appear not to have fully embraced the presence of this MNC in their midst. This could have resulted from unmet expectations and poor or nonexistent coordination and communication between the various stakeholders.

To address this, the company needs to understand the culture and practices of the local community and learn and understand how they have interacted with the swamp and the surrounding environment. Dominion Farm should include representation of the community in planning and decision making process and improve communication and public relations with the local population. This will create a harmonious relationship and co-existence with the local community, promote a sense of respect and honour for the community who in turn will have a sense and feeling of ownership of the project. Such initiatives can be undertaken through government, Dominion or NGO supported educational programmes through community based organizations (CBOs).

The education programme should specifically target the role of governance in natural resource management to address issues of transparency, accountability, favouritism and nepotism. The programme should further target the role of local community in environmental protection as well as development of business and entrepreneurial skills among the youth and women. Business opportunities could be enhanced through credit provision, improved extension services and strengthening local institutions for example through formation of cooperatives and Trust funds. Such undertakings would empower the community and would reduce the overdependence on the wetland as a source of livelihood. Finally, a programme targeting HIV awareness, education and prevention should be initiated.

This work has successfully produced an evidence based assessment of key stakeholders and their relation to the Yala swamp, a significant step towards designing an acceptable management programme for the wetland. Such a management plan should be holistic, integrating the divergent needs and views of the principal stakeholders.

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ABSTRACT
Corporate Social Responsibility (CSR) fosters development. Sufficient and effective action by the corporate world has resulted in development. The African continent has however not experienced commendable economic development through CSR. In some situations, communities have been exposed to health risks and greater poverty as companies expropriate community resources and claim to practice CSR for development. This study systematically reviewed literature on CSR and development in Africa over the last 10 years to identify the themes, incentives and challenges in the practice of CSR. Good governance, economic incentives, contextualization of CSR action, appropriate and robust legal and institutional frameworks are essential for CSR to play a meaningful role in developing the continent. This has been hampered by CSR initiatives being uncoordinated and failing to be integrated in core functions of organizations. It is also necessary to contextualize CSR to the needs and environment of Africa. Governments ought to provide a facilitative environment to encourage CSR for development in terms of policy formulation and setting in place oversight bodies to monitor and coordinate CSR activity. Corporate establishments need to form partnerships to reduce the overall cost of CSR and impact greatly on the development. Countries need to encourage companies to disclose their policies and practice so that they are held accountable to governments and communities adjacent to their establishments.

Key words: Corporate Social Responsibility, Developing countries, Sustainability

INTRODUCTION
There is an increasing emphasis on the positive role business can play in development through Corporate Social Responsibility (CSR) (Commission for Africa 2005). Business associations such as the World Business Council for Sustainable Development (WBCSD) view businesses as having the ability to contribute to development. CSR is also perceived to be the “social Strand” to achieving sustainable development (Morimoto, Hope and Ash 2004). The extent to which CSR initiatives have succeeded or failed to bring about development has been the subject of many researchers in CSR. However, according to Hamman (2006), impediments to CSR in achieving development have not been clearly identified despite the enormous level of CSR activities in Africa. There is need to review and consolidate these research findings in literature in order to identify barriers inhibiting CSR in achieving development and also recommend means of overcoming the impediments to CSRs role as a means to development for Africa. By examining different strands of literature in Africa for the last 10 years, we argue that for CSR development initiatives to make any meaningful impact on development, they must be contextualized and respond to the needs of the target population. Further, CSR must work in partnership with communities and African governments for better coordination and accountability.

The definition of CSR is an important starting point bearing in mind that there is none that is universally agreed upon (Morimoto, Hope and Ash 2004). In literature though, the definitions of CSR incline towards two general assertions. In one CSR is seen as an ethical stance entailing “giving back to Society” and the other is where CSR is undertaken as a business strategy and is practiced to accomplish strategic business goals. (Wan, 2006, Moore, 2003, Goyder, 2003, Jones 2003, Lantos 2001 and 2002,). These definitions underline the motivation of businesses to undertake CSR. Development on the other hand is a complex term and is sometimes viewed as human development and “a process of enlarging people’s choices” (UNDP, 1990). Encompassed in this “development” term would be the reduction of poverty and the improvement of health care, social welfare and educational opportunities which are main areas of focus in CSR as identified by GTZ 2009. It is therefore plausible to link CSR to development in Africa since the development challenges in Africa relate to “deepening poverty, high levels of unemployment and increasingly vulnerable livelihoods, high levels of urbanization, severe housing backlogs, lack of basic services, environmental degradation and the spread of HIV/AIDS and other diseases” (Hamman 2006). These problems have been the focus of CSR initiatives.

This paper examines the relationship between CSR theory and practice to effect development with the main objective of identifying the role of CSR in fostering development in Africa. This is achieved by identifying the key themes in...
CSR practice and proceeding to enlist the challenges that get in the way of achieving development through CSR. Arguably, different organizations get involved in CSR for varied reasons and incentives and these dictates the level to which these actions would foster development. We explore challenges faced in the implementation of CSR for development with an aim to inform policy formulation for stakeholders and governments in order to boost sustainable development in Africa.

**Themes and Debates**

One of the debates on CSR centers on the definition of the term. The theory and practice of CSR is riddled with misunderstandings as the definition of the concept denotes a myriad of meanings to organizations undertaking CSR. CSR is context-based and applies differently to organizations depending on which understanding they base their activities upon. Whatever the definition one subscribes to, CSR can be broadly taken to refer to the activities that serve the needs of appropriate stakeholders. This agrees with Hopkins’ (2003) definition that “CSR means treating the stakeholders of the firm ethically or in a responsible manner”. This definition combines both the ethical stance and the business strategy views. However, CSR actions have to be contextualized and encompass the needs and aspirations of the target population in order to give rise to development.

Mintzberg (1993) considers motivation for undertaking CSR activities in four broad forms. Firstly, CSR is practiced for its own sake and a company does not expect anything in return. Secondly, CSR is undertaken with the understanding that it pays whether tangibly or intangibly. Thirdly, CSR is practiced as a form of investment and finally CSR is undertaken in order to comply with expectations. These motivations are internally constructed and CSR will need much more external incentives to influence development. In regard to the practice of CSR as an investment, Foote et al (2010) agrees that CSR has a significant impact on the corporate performance.

The British Department for Trade and Industry differs from these arguments and would rather define CSR by what organizations do than what CSR is by defining it as management of an organization’s impact on the stakeholders and the society in which it operates (Hopkins 2007). This agrees with The World Business Council for Sustainable Development (WBCSD, 2005) definition of CSR as “business commitment to contribute to sustainable development, working with their employees, their families, the local community and society at large to improve their quality of life” which dwells on what organizations do.

Three themes stand out in Africa with regard to CSR discourse and could partly explain the failure of CSR in effecting development in Africa according Idemudia (2011).

1. CSR agenda neither addresses issues like tax avoidance, unsustainable investment and poverty reduction nor does it attempt to address the structural and policy determinants of underdevelopment. Most companies interviewed by the GTZ in Kenya were of the opinion that the country lacked national and local guidelines towards ‘CSR strategy, policy and practices’ (GTZ, 2009)

2. CSR agenda universalizes a set of conditions that do not exist in Africa. Activities are controlled and dictated from a northern perspective disregarding the unique conditions faced by the African continent which are not represented in setting the CSR agenda. It is important that conditions unique to the African continent be identified in order for CSR to fit in the African context. This calls for contextualization of CSR agenda.

3. CSR ignores the big picture for the developing countries. The developmental levels of countries are different and CSR activities need to address specific needs of the country and the community that they serve.

There is thus a call for a south-centered CSR agenda that can help highlight and direct CSR activities to the needs of the continent by directly involving the African stakeholders in identifying and prioritizing the developmental needs of the communities. Moreover, developed countries are quite different from developing countries - which are rapidly expanding economically and therefore provide many business opportunities highly impacted by social and environmental crises, and face CSR agenda challenges that are unique from the developed countries (Arli and Lasmono 2010). Ironically, CSR actions in Africa have not enlisted target populations in redefining their needs.

Adewuyi and Olowookere (2010) state four broad theories that summarize the application of CSR activity to development. These include instrumental theories, in which the corporation is seen only as an instrument for wealth creation, and its social activities are henceforth a means to achieve economic results; political theories, which concern themselves with the power of corporations in society and a responsible use of this power in the political arena; integrative theories, in which the corporation is focused on the satisfaction of social demands; and ethical theories, based on ethical responsibilities of corporations to society. In practice, each CSR theory presents four dimensions.
related to profits, political performance, social demands and ethical values (Garriga and Mele 2004). Although it can be argued that these factors of CSR cover the three areas of sustainable development: economic, social and the environment, CSR actions need to embrace and be propelled by a genuine desire to improve the living conditions of target population who are also their clients.

Sustainable development although largely elusive was defined by the Report of the World Commission on Environment and Development in 1987 as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Clugston and Calder, 1999). Thus sustainable development in three dimensions in which the environmental dimension provides the foundation, economic dimension provides the tool, and the social dimension gives the ultimate goal of discussions on sustainable development. It is under the social dimension that Corporate Social Responsibility (CSR) is linked with sustainable development. This is because the voluntary contributions of corporations are done to create a better society where the needs of the society in which they make their profits are met. The environmental dimension is addressed in CSR initiatives that mitigate the impact of organizational activities on the environment and communities in which they operate. Admittedly, CSR benefits organizations in creating a health balance between profits and responsibility to the communities.

This is the approach taken by Cronje and Chenga (2009) as they examine sustainable social development in the South African mining sector. This approach steers away from looking at development using the modernization theory and blames the underdevelopment on dependency of the mining communities on the mining companies. Human-centered development is reiterated by Akpan (2006) when he considered the communities’ perspective of community development and established that they perceived community development as not just “projects” but “everything” they “cherish” and “everything that gave them a sense of worth as a community”. Akpan’s study found that “CSR practices in the communities were often driven by extreme economic expediency” illustrated by oil companies viewing communities around the oil company as squatters and therefore had no rights to demand protection against hazards caused by the corporate activities. The corporate organizations were found to “fragment communities and devalue the contributions of communities so that they save money by spending less in the provision of amenities”. This fragmentation was also used in the appointment of employees leaving other communities out. This implies that there is need for serious dialogue between target communities and organizations undertaking CSR to harmonize expectations. CSR actions must be grounded on a desire of improving standards of living and not just legitimizing expropriation of profits.

**Incentives for investment in CSR**

Cronje and Chenga (2009) cite government policy as a major incentive for CSR in South Africa. The government in South Africa had the following policies to guide the operations of mining companies which affect the corporations’ participation in CSR for sustainable development:

1. Organizations were required to increase the number of disadvantaged South Africans in management to 40% and also increase the women in mining to 10%.
2. The South African government also required organizations to be involved in infrastructural development and poverty eradication projects in their area of operation.

The South African government had however not spelled out what this policy meant in practical terms and this was a major contributor to the gap between policy and practice. Companies may only have been involved in CSR for fear of losing licenses to operate. This in Hamman’s (2006) view is the practice of CSR as a result of forces beyond the organizational boundary. DRC case presented a different picture on meeting conditionality set by governments on involving natives in the company management. In this case, 97% of the employees were Congolese but none of these were in senior management. The company was however offering training to Congolese engineers to take this position three years from then (Maria 2011). This would ensure sustainable development by empowering the natives with knowledge to continue in the mining industry. Arguably, even when enlisting local people in employment, deliberate efforts must be made to engage them in decision-making level and in jobs that bolster transfer of skills.

The government is presented as a key player in providing a suitable environment for practice of CSR. The governments in Africa have not facilitated the contribution of corporate companies in the process of development through CSR when compared with other countries in the developed world (Idemudia 2011). This calls for a rethink of government policies in Africa on CSR with an aim of creating an enabling environment for communities to get an equitable share from these actions. Hamman (2011) identified several ways in which the public sector can facilitate the practice of
CSR for development and outlined several ways of doing so using a document sourced from Fox (2004) represented in the table below:

<table>
<thead>
<tr>
<th>Governments’ Role</th>
<th>Specific Activities to be enforced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandating</td>
<td>laws, regulations, and penalties and associated public sector institutions that relate to the control of some aspect of business investment or operations</td>
</tr>
<tr>
<td>Facilitating</td>
<td>setting clear overall policy frameworks and positions to guide business investment in corporate responsibility; development of non-binding guidance and labels or codes for application in the marketplace; laws and regulations that facilitate and incentivise business investments in corporate responsibility by mandating transparency or disclosure on various issues; tax incentives; investment in awareness raising and research; facilitating processes of stakeholder dialogue</td>
</tr>
<tr>
<td>Partnering</td>
<td>combining public resources with business to leverage complementary skills and resources to tackle issues within the corporate responsibility agenda – whether as participants, convenors, or catalysts</td>
</tr>
<tr>
<td>Endorsing</td>
<td>showing public political support for particular kinds of corporate responsibility practice in the marketplace, or for individual companies; endorsing specific metrics, indicators, guidelines or standards or award schemes, and ‘leading by example’, for instance through public procurement practices</td>
</tr>
</tbody>
</table>

**Source:** Fox (2004) adapted from Hamman (2011)

Okoye (2012) suggests that though CSR in general refers to business and society relationships, its content and targets need to be defined in context. The attempt to pass CSR laws hint at a need to concretize objectives particularly to link CSR to development. This can be done through frameworks which include the use of law in all its forms. The implication of this is that for CSR to work, there is need for governments to prepare a legal policy framework to guide and monitor CSR activity so that this results in sustainable development. On this, the WBCSD (2010) point out that business engagement is critical in achieving sustainable development and poverty alleviation. However, good governance, economic incentives and appropriate and robust legal and institutional framework conditions are essential for business to play a meaningful role.

There are attempts by African governments to adopt a structured approach to CSR by providing legislation. However, there is need for frameworks and concrete objectives for it to be actualized in an African context. Further the debate around the structuring of CSR activity in legal frameworks is paradoxical. CSR is meant to be voluntary yet developing legal frameworks would be mandating the organizations to carry out CSR as defined in the framework and hence robbing them the will to voluntarily participate in CSR. A clearer balance between voluntarism and legal obligations must be sought.

Ethics was also cited as another incentive to CSR with the argument that because economic transactions rely on social norms and values, it was important to adopt an ethical approach to business (Hamman 2003). A good reputation was considered a means to enhance companies’ performance from the local project level, through improved community and worker relations, right up to the international level through improved access to mining concessions and finances. Thus CSR was fundamentally about how social, environmental and ethical values were incorporated in the core business of a company- rather than add-on philanthropy. CSR was also driven by economic incentives as it had positive impacts on the profitability and competitiveness of an organization. Hamman (2003) in his critique of Friedman (1970) who opined that the sole purpose of business was making profits stated that CSR was good for profits and cited profit as an incentive for corporate organizations to engage in CSR.

Globalization and the increased demands and expectations on CSR were found to be another incentive. Corporate organizations were embracing CSR because of a global change in perception of the business roles from philanthropy and impact mitigation. CSR could be seen to have progressed from philanthropy and impact mitigation through community investment and eco-efficiency to social partnership. Globally, CSR was receiving greater focus attested by the many initiatives in place to address CSR. Among these were: UN’s global Compact, European Commissions’ CSR initiative and the World Business Council for Sustainable Development and Business for Social Responsibility. A plethora of CSR principles and reporting guidelines have been established such as the global reporting initiative. This motivates organizations to be involved in CSR in order to be ranked.
Globally, businesses wanted to be seen to be taking on a more responsible and interactive role in social transformation and sustainable development. However responding to this incentive presented companies with significant challenges, as well as opportunities. Companies ignoring these developments risked losing their license to operate and their international competitiveness.

**Challenges of CSR**

Integration and coordination were the biggest challenge, given that implementing the various sustainable development policies was too big for any one individual organization. There was need to find out how best to integrate, and also identify when it was beneficial for organizations to operate in parallel. Within the organizations, it was found that departments lacked coordination, there were multiple and overlapping reporting and performance management systems, and limited capacity in management and implementation of CSR (Hamman 2006). Corporate organizations needed to be aware of initiatives surrounding CSR. They needed to develop corporate policy on CSR supported by top management. Such policies should have a set of principles and policies. They should have a set of targets linked to measurable performance indicators. There should be clear management, accounting and reporting structure to ensure ongoing improvement in the implementation of the policy at site level. There was however criticism that there was excessive emphasis on reporting and too little on performance, yet it was in performance that the challenges of CSR lie. In Nigeria for instance, Shell’s failure was attributed to the following three causes; failure to involve the beneficiaries of CSR, lack of human resource, and failure to integrate CSR initiatives into a larger development plan (Adewuyi and Olowookere 2010).

Despite South African business society having come together and made three declarations to guide their business and role in CSR, organizations faced a number of constraints. The declarations included adherence to principles of good governance, commitment to environmental sustainability, upholding positive stakeholder relationships, supporting universal human rights, fighting corruption and establishing effective and transparent accounting systems. The constraints were that the content of these declarations were not specific and lacked public sensitization across the continent. Hence, the implementation of the guidelines had been limited (Hamman and Cleene 2005).

CSR initiatives’ failure was attributable to culture shock where most communities around mines were rural communities which made them not to respond effectively to the development changes (Cronje and Chenga 2009). This was as a result of the “occupational needs requirements and the rapid change from agricultural society to a cash dependent one”. Cronje and Chenga (2009) labeled this a problem of acculturation. Hamman (2003) also opined that cultural differences were at the heart of these declarations were not specific and lacked public sensitization across the continent. Hence, the implementation of the guidelines had been limited (Hamman and Cleene 2005).

The “communities’ voice” was another challenge in terms of who would speak on behalf of the community to get the community’s consent and whether these people represented the communities view or their own interests. The communities lacked the “media and public concern… an organized civil movement with enough finance and commitment and an adequate level of competence and the genuine commitment of all the parties to the relationship process”. Communication was yet another challenge cited in the articles as responsible for failure in CSR initiatives. The mining corporations required a communication strategy to enable communication between the community, government and other stakeholders.

Ignorance on the part of communities surrounding copper mines in the DRC frustrated CSR efforts to shield them from the negative environmental effects of copper mining. For instance, a polyethylene basin had been built to store the acids and solid wastes used to stop pollution of local aquifers yet some of the natives would steal bits of polyethylene at night to roof their huts, unaware of the damage they were causing (Maria 2011). These calls for sensitization to enable communities’ understand and accept CSR initiatives meant to shield them from negative environmental impact.

Political power relationships were cited as causes of CSR project failure. Mining companies were forced to get skilled labor from without and the white skilled workers felt their job security would be jeopardized if the locals got involved and trained. The whites thus imposed a system of “colour bar banning blacks from settling permanently in the mining towns”. The mining corporations were seen to wield more power than the governments of the countries in which they operated. This placed the local communities in awkward position of vulnerability when negotiations were required. The same was reiterated by Hamann (2003) who stated that “in the context of globalization, the power of nation states is widely perceived to be diminishing relative to that of big companies in the wake of technological developments and
global trade connections that create huge companies and government policies that often decrease the extent to which companies are regulated”. This lack of regulation and the desire to maximize profits discourages the multinational companies from incurring the costs of training locals to take up key positions in the organizations.

Inability to prioritize development projects was found to be another challenge. Hamman (2006) opined that the development projects needed to be prioritized from the communities view on what they felt was urgent. The communities viewed the mining corporations as responsible for community development yet review of literature showed that the responsibility lied “between government, mining corporations and the communities”. It was supposed to be in collaboration with all stakeholders. Pasco-font (2001) opined that there was need to have a clear split on who was responsible.

A lack of integration into core business was apparent in the manner in which some companies called themselves good corporate citizens, with reference to their education and health programmes, while at the same time continuing to neglect some of the negative consequences of their core business activities. (Hamman 2006). The lack of knowledge about communities obscured development because CSR initiatives that were implemented may have not been tailored to meet the community needs. Marginalization was found to be a major factor contributing to a lack of knowledge about the communities. This led to cutting out of traditions and connections with them. This was predominant in the mining communities and resulted in poor identification of community needs and implementation of CSR projects. According to Kambalame and Cleene (2006) some of the

Challenges were company related such as:

i. Perceived cost involved in implementing CSR programmes
ii. Lack of expertise on CSR within the organizations
iii. Problem of aligning CSR strategy with core business practice

Consequences of CSR
According to Sharp(2006) “Contributors to the recent discussions in international affairs (2005) were unanimous in their judgment that CSR in its current form did not meet the development goals spelt out in 2000 in the United Nations’ Global Compact” (Kuper, 2004). However, Sharp held the opinion that CSR benefits were unpredictable. CSR may have unintended consequence of resistance to development because development involved disrupting the lives of millions of people. Stakeholders and host communities were to be treated differently from those who had no claim of involvement in particular interventions. CSR was also capable of delivering a variety of benefits in unpredictable ways.

Akpan (2006) is of the opinion that when business corporations are allowed to define developmental needs of a people, instead of the government, CSR takes a “dysfunctional character”. CSR appeared to cause psychological dependence on multinational companies. This was a serious impediment to sustainable development. In Maria’s (2011) view beneficiaries of a public service must contribute to its funding. Otherwise, historically rooted dependence on paternalistic mining companies would be perpetuated and the communities surrounding such mines cannot sustain the development initiated after the exit of the multinational companies. Execution of CSR actions must be clearly thought out and linked to government programs for fostering sustainability.

METHODOLOGY
This section outlines the research design undertaken to write this paper and gives the criteria for selection of the articles considered. A brief description is given for the process used to identify the themes and challenges in implementing CSR for development in Africa.

A literature review was conducted on journal articles that contain the key words: Corporate Social Responsibility, Development, developing countries, as well as sustainable development and Africa. This literature was then examined to identify the key themes, the main gaps, and areas where future work could usefully be undertaken in CSR. A particular emphasis was on the incentives and challenges encountered in CSR initiatives and responses to them. The article is descriptive since descriptive studies are used to document the phenomenon of interest in the real situation (Marshall and Rossman 1995) and the main objective was to relate the theory to practice of CSR in Africa. The paper examined the debates, identified the general discourse in CSR in Africa and analyzed these based on what the articles communicated relative to the theory of CSR. The discussions and conclusions are aimed at linking CSR to development.
Selection of the articles for analysis was purposive to represent CSR activity across regions in Africa. Though subjective, this non-probability method of sampling has been applied in qualitative researches to obtain samples that represent the population (Nachmias and Nachmias, 1996). It is however important to note that literature on CSR in Africa is limited and skewed to South Africa (Idemudia 2011). Other articles were selected to enable an objective analysis of CSR by providing theory and definitions on which the analysis was done.

Findings were classified under the objectives of the study and efforts were made to summarize the content of the articles considered. The discussions stemmed from the theory to identify the extent to which it meets practice and a linkage was drawn to achievement of sustainable development in Africa. This was done in line with the debates on contemporary issues pertaining to the practice of CSR as highlighted in the literature review.

**DISCUSSION**

CSR projects are capitalist driven and like Milton Friedman (1970) argued the “social responsibility of business is to increase profits. There is therefore no link between philanthropy and development. Thus, CSR projects are bound to fail in addressing the issue of development more so eradicating poverty. Newell (2005) rightly remarked that “most CSR initiatives are not intended to tackle the question of poverty and exclusion. They aim at less ambitious goals of performance enhancement and image management”. The main question is whether CSR is systematically managing the corporate image or tackling poverty. If CSR is to be embraced as a development tool, then a different narrative that leverages the benefits to communities concerned needs to be pursued. Discourse on development intervention entitlement is ubiquitous. There is debate on who the beneficiaries of CSR are: stakeholders or the community “whose entitlement stems from the fact that they are directly affected by or in some way involved in the core business of the corporations concerned” (Sharp 2006). In this light CSR limits what can be expected of corporations in development or in fighting poverty. It focuses on those who possess something or some characteristic that can be exploited by the corporation. Those who possess seem be the ones entitled to receive some development in return. This limits the extent to which CSR can bring about development to the majority of citizens in a country. Interests of CSR actions must be clarified for any meaningful development to take place.

In the same level CSR is criticized as “largely driven by the concerns and priorities of western countries and therefore tends to be insensitive to local priorities as well as inadvertently harm prospects for sustainable livelihood in developing Countries” (Idemudia 2011). The ability of CSR therefore to spark economic growth in Africa is pegged on the priorities of the multinational companies and depends on the exploitable resources a community has. The CSR activities that they implement may not be commensurate with the benefits that they derive from the community resources and can therefore be argued that CSR leaves the communities worse than they found them. CSR may therefore be seen as a cover for exploiting the continent that has no capacity to effectively use its resources. Consequently, there is need to re-evaluate the motivations of CSR if target communities are to benefit.

The stakeholders discourse goes further and has the effect of creating hostility amongst the communities. There is a desperate scramble among communities for resources channeled through CSR initiatives. This creates hostilities between benefiting communities and their surrounding communities. There is need for genuine discussions on equitable distribution of resources according to needs. The states need to intervene by ensuring that development brought through CSR is replicated countrywide. The intentions of CSR appear to be grounded on image management and to woo public opinion and not poverty reduction.

The tendency for oil operating companies in Nigeria to prioritize social investments in social infrastructure provision, such as roads, hospitals and community centres (that is, micro-level CSR issues) in their community development efforts, often overshadows the real problems they are causing such as environmental degradation, corruption, lack of accountability and declining manufacturing and agricultural sector production. Unfortunately, it is these macro-CSR issues that are critical for community development and poverty reduction in local communities in Niger Delta.

Partnership between companies, the government and the civil society were cited as a more efficient and effective way for companies to contribute to sustainable Development. (Business Partners for development, 2002). They were a means of providing quality as opposed to quantity because of “complimentary core competencies”. In Malawi, CSR provided a platform for stakeholders to come together to manage Malawi’s supply and value chains so as to improve livelihoods (Kambalame and Cleene 2006).
The following were listed by Kambalame and Cleene (2006) as benefits of partnerships:

1. Relationships between all role players would be improved with high levels of trust and better channels of communication.
2. There would be a high developmental impact, in terms of tangible results such as infrastructure provision, training or land access, with comparatively low costs for all role players.
3. Due to increased participation in the development process and higher levels of skill development, local communities would be less dependent on the mining companies.
4. The company’s reputation would be enhanced at the local, national and international level resulting from tangible development benefits and improved community relations.

CONCLUSIONS AND RECOMMENDATIONS

CSR actions are being implemented in various countries in Africa with the aim of boosting development. However, it is still debatable whether CSR activities are genuinely bolstering development because of underlying motivations by corporations to participate in CSR. These range from maintaining good public opinion, providing a conducive environment to expropriate resources and profits to improving standards of target population. There has not been a genuine dialogue between all stakeholders and communities involved in CSR to prioritize actions and link them to development. It is incumbent upon the governments to play a leadership role in order to safeguard rights and interests of communities. To this end, we recommend that:

1. The African leaders and organizations operating in Africa need to adopt a “south-centered” CSR agenda. Idemudia (2011) argues that CSR ought to be contextualized and in Africa the values of ‘Ubuntu’ are of essence. This agenda should be one that articulates and promotes aspirations of the South.

2. The governments in Africa need to develop Africa’s CSR policy frameworks and the build institutional and technical capacity to govern CSR activities. Local priorities are often not reflected in the CSR policies and practices. This should be linked with research to address the complex relationships that link CSR to development. The emphasis should be on contextual factors (Social, economic, cultural and political), the dynamic stakeholder relationships, and responsibilities and how they mediate CSR contribution to development.

3. The governments should mandate disclosure on companies’ policies and practices with regard to CSR. Such regulations exist in some European countries, including the United Kingdom and France. This would facilitate awareness-raising among a broad spectrum of companies and provide self-imposed benchmarks against which companies’ performance could be monitored by a range of stakeholders. (Hamman 2006). Hamman and Cleene (2005) also advocate for an inclusive ‘stakeholder approach’ which requires that ‘every company reports at least annually on the nature and extent of its social, transformation, ethical, safety, health, and environmental management policies and practices’.

4. Partnerships in CSR projects between governments, civil society, the private sector and organizations should be formed to synergize. This will also promote transparency and accountability among all stakeholders in development.

5. Corporations should initiate genuine dialogue with communities and civil society organizations as well as take into consideration the local context in order to narrow the differences and harmonize development objectives before implementing CSR actions. Community input and interests must be safeguarded at all times in the design and implementation of CSR activities and the government should play an arbitration role in case of conflicts.

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ROLE OF PEACE COMMITTEES IN PEACE BUILDING AND CONFLICT MANAGEMENT: A CASE OF TRANSMARA SUB-COUNTY

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ABSTRACT
Peace Committees programme in Kenya was rolled out in all districts in 2009 following the 2007/2008 post-election violence to aid in peace-building and conflict management. The programme has not made major breakthroughs in peace sustenance, which calls for its evaluation. This study determined the effectiveness of peace committees in peace building and conflict management, involvement of women and youth in peace building initiatives, and local measures in place to prevent recurrence of ethnic conflict. Systematic sampling was used to select households in each division from where respondents were derived. A total of 120 respondents were sampled for the study. The researchers purposively sampled DCs, DOs, OCSs and OCPDs. Simple random sampling was used to get 10 representatives from 5 organizations (Civil Society and Faith-based Organizations) working for peace in the area. Majority of the people involved in ethnic conflict were aged between 18 and 30 years. The main cause of conflict was ethnic/clan animosity (61.1%). Peace campaigns yield much in peace building. Thus peace resolution initiatives such as meeting people in churches, schools and campaigns should be adopted. Provincial administrators were the first to respond during times of conflict because they lived among the community and had the logistical capacity to reach scenes of crimes to assist affected individuals. Peace affects all spheres of life including achievement in education at all levels.

INTRODUCTION
In pursuit of sustainable peace, the international community through the United Nations (UN) has constantly employed political tools of diplomacy and mediation to help nations prevent and resolve conflicts peacefully to avert the suffering
and destruction of war (Annan, 2005). Though conflicts are sometimes viewed normal and part of life as espoused by many scholars of conflict management including Dahrendorf (1969), Achoka (2010) and Okoth (2010), its effects on society is often rising to abnormal proportions which therefore calls for rigorous peace building aimed at sustaining peaceful co-existence. According to Allchin (2011), Burma’s National Parliament approved the creation of a ‘peace committee’ to attempt to solve the country’s ongoing and seemingly intractable ethnic conflicts. In Bangladesh, peace committee was majorly established to restore normalcy and confidence among the citizens during times of conflict (Chandan, 1971).

The committee model has come to be the preferred peacebuilding and making initiative for many nations facing recurrence of conflicts or those immediately coming out of conflict. According to Odendaal et al. (2006), peace committee is defined as a generic name for committees, or structures formed at the level of district, town or village with the aim to encourage and facilitate joint, inclusive peacemaking and building process within its own context. The context in this case is determined by the circumstances and conditions leading to formation of local peace committees. For instance, Cartwright and Jenneker (2005) while undertaking a study on peace committee in South Africa, noted that peace committee was designed to enable people manage their own affairs while giving priorities to disputes. It engaged in among other things; mediating and resolving disputes, promoting tolerance within ethnically diverse society and also educating citizens in alternatives to violence (Ball, 1998).

In Nepal, local peace committees have demonstrated capacity to reduce levels of violence especially when there is sufficient early warning. Odendaal et al (2006) argues that it proved beneficial when the country was experiencing transition from one constitutional dispensation to another. Peace committees helped in problem solving and community building by facilitating a common forum where disputants could meet and have issues addressed. This helped to restore community confidence and thus contributed to peace building.

Peace committees are by no way, perfect institution guaranteed of success. They are mechanisms to build peace at local level under trying moments. In Uganda for instance, the Mercy Corps through the Pader Peace Program (PPP), successfully addressed the gaps in current peace building and conflict mitigation through its trained peace committees at sub-county and parish levels and also on monthly radio broadcasts (USAID, 2009). The Mercy Corps who are operating in Pader district of Northern Uganda where there had been long standing conflict of nearly 20 years between Lords’ Resistance Army (LRA) and Uganda government, observed that peace committees have earned trust and respect from the communities that other government institutions such as courts have not been able to do due to corruption, high fees and lengthy bureaucratic processes (USAID, 2009).

Until very recently, security in Kenya was a preserve of government with stakeholders not given chance to be part of the process (Modagashe Declaration, 2005). Local peace committees therefore had their roots to the failure of the state to provide security and justice to its citizens. The community members in return took the initiative to manage their own conflicts since they could not also access the formal judicial system for lack of trust in government led conflict prevention interventions (Adanand Pikalya, 2006:3).

However, in the recent years, broader and holistic approach has been developed through the national steering committee (NSC) which became functional in 2003. This testified the government commitment to enhance and inculcate participatory approach in all realms of life. Former provincial commissioner of North Eastern John Nandasaba was quoted saying “it is true that the government can indeed enforce peace however it is the responsibility of the community to create peace (Modagashe Declaration, 2005). It is in this context that peace committees have been established at various levels, including National, District, Divisional, Locational and Sub Locational levels (GOK, 2009). Since the inception of peace committees in Kenya, the committees have however performed with minimal success which therefore calls for evaluation of its effectiveness in peace building especially in Trans Mara district which has been facing sporadic ethnic clashes in the recent past.

Statement of the Problem
Occasional conflict between farming and pastoral communities, rampant conflict over dwindling internal resources, coupled with the collapse of traditional pasture management practices, in Trans Mara sub county is in dire need for urgent attention (Vision and Strategy, 2005). As a result of conflict, many educational institutions are left vandalized or totally destroyed; people are left homeless, landless, abused, injured and even dead. For instance, in February 2008, a total of 385 houses and 8 schools were torched in Kirindon and Pirrar divisions of Trans Mara Sub County following
a clash between Maasai and Kipsigis communities (KRCS, 2008). Most government reactionary interventions through the security agencies and provincial administration have done little to salvage the deteriorating situation. For instance, the Maasai clans of Moitanik, Siria and Uasin Gishu and Kuria clans of Nyabasi and Bwirege most often do resort to violent conflict over land ownership and grazing areas, (Conflict mapping: An Insider’s perspective, 2011).

For a long time, women and youth form majority of those affected by conflict yet according to Adan and Pkalya (2006), the existing peace building mechanisms including peace committees have remained insensitive to incorporate gender and age in peace building initiatives. The semblance of peace building that has been witnessed in the recent past has been largely urban-centric and one-time event with much pre-occupation in media campaigns and youth exchanges (Klopp et al, 2010). This therefore has neglected the rural folk together with the peace building mechanisms in those localities.

Following the 2007/08 post-election violence, the government signed the national accord and embarked on peace building programs. Klopp et al (2010) acknowledges that though peace building has been undertaken by the government, the program has been highly unsuccessful owing to the fact that even out of the fraction of Internally Displaced Persons (IDPs) who have returned and settled, many still do not have improved relations with their neighbours. And that even other government peace building operations such as “Operation Rudi Nyumbani (Operation return home), Ujirani Mwema (Good neighbourhood) and Tujenge pamoja (let’s build together)” have in several occasions run into problems which therefore calls for evaluation into the effectiveness and capacity of peace committees in peace building and conflict management in Kenya. The research question was: Are women and youth sufficiently involved in peace building initiatives in Trans Mara sub county? This study adopted both descriptive and historical research design. Since the study is majorly concerned with describing such things as attitudes, values and behavior, descriptive design therefore becomes adequate for the study. The researchers employed both quantitative and qualitative approaches in data collection, analysis and presentation. Historical design assisted in exploring, explaining and understanding the past. The aim was to collect relevant information that provided baseline data upon which, the situation in post peace committee peace building was compared.

Trans Mara Sub County is located in the south western part of Rift Valley in Narok County. It consists of five administrative divisions namely; Kilgoris, Pirrar, Lolgorian, Keyian and Kirindon. In total it covers an area of approximately 2900 km². The district lies between 00 50’ South and 10 50’ North and 34°35’ East and 35°14’ West. It borders the Republic of Tanzania to the South, Migori and Kuria districts to the West, Gucha, Nyamira and Bomet districts to the North and Narok district to the East (Trans Mara district annual report, 2009).

The study population specifically comprised of the Provincial administration officers (DC’s, DO’s, and Chiefs), Civic leaders, senior security personnel (OCS, OCPD), representatives of Civil Society Organization and Faith- based groups and local residents.

Sampling refers to the process of selecting a portion of the population that conforms to a designated set of specifications to be studied. Kendall and Kendall (2005) observes that sampling is advantageous for it allows the researcher to draw generalization and reduce bias. According to NachmiasandNachmias (1996), sampling is necessary because it is extremely expensive and nearly impossible to collect data from all members of the study population. The study employed both probability and non-probability sampling procedures. Simple random sampling was used to get 10 representatives from about 5 organizations (Civil Society and Faith-based organizations) working for peace in Trans Mara district of Narok County. The organizations include Trans Mara Peace Net, Pro Mara, Catholic Justice and Peace Commission, National Council of Churches of Kenya and Trans Mara Human Rights Network.

The researchers wrote all the names of the organizations in small pieces of paper, folded and put in a container, shake and later pick the first two pieces of paper to reveal names of the 2 organizations that qualified to have their representatives in the study. The selection of 10 representatives ensured equal number of males and females.

Civic leaders and chiefs also selected using simple random sampling whereby out of the 18 civic wards and 32 locations, 9 civic leaders and 16 location chiefs were sampled for the study. Purposive sampling ensures that only participants who are knowledgeable about an issue in question are selected (Brink, 1996). The researcher therefore purposively sampled DC’s, DO’s, OCS and OCPD. The greater Trans Mara district currently has 5 administrative divisions each under a DO, 2 Police Stations each headed by OCS, 1 Police division headed by OCPD and 2 DC’s one representing the newly created Dikirr (Trans Mara West) and the other Trans Mara East.
Systematic sampling was used to select households in each division from where respondents were derived. To ensure representativeness of the sample, the researcher employed stratified sampling method so as to ensure that each of the 5 divisions of Trans Mara Sub County had a fair share of participating in the study. Simple disproportionate sampling however, was equally be used alongside the strata (divisions) to allow stratum with greater variation in terms of population and ethnic orientation a fairly higher number of representatives in the study. The study utilized questionnaires, interviews, Focus Group Discussion and content analysis as the main tools for collecting data. The sources of data were primary and secondary. Primary data was collected using questionnaires and interview schedules. Secondary data was derived from books, journals, internet and other publications by employing content analysis.

Qualitative data from FGD’s and Interviews was analyzed by coding common themes and presenting in form of generalized statements while Quantitative data from questionnaires was analyzed using descriptive and inferential statistics. Measures of distribution, percentages and frequencies were applied in analyzing the data with the aid of Statistical Package for Social Sciences (SPSS).

RESULTS
From the findings on the gender of the respondent the study found that majority of the respondent as shown by 60.3% were male whereas only 39.7% of the respondent indicated that they were females, this shows that both genders in this region were almost equally represented. On the respondent age, the study found out that 44.6% of the respondent indicated that they were aged between 18 to 30 years, 31.7% of the respondent indicated that they were aged between 31 to 40 years, 15.8% of the respondent indicated that they were between 41 to 50 years, 5.9% of the respondent were between 51 and 60 years, 1.4% indicated to be between 18 to 20 years and finally 0.7% indicated to be above 60 years. Majority of the respondents were in their youthful age and this was the best group to interview since they play the huge role in conflict scenarios.

Highest level of education attained
On the level of education of the respondents in this study, the study found out that majority of the respondents had reached the primary level as shown by 47.9%, 22.6% of the respondents indicated that they had reached secondary level, 17% indicated to have reached the university level while as only 12% indicated to have reached college level as their highest level of academic qualifications. This shows that majority of these respondents were people who had dropped out of school due to conflicts in the study area.

Peace Building and Conflict Management
The study was keen to investigate the likely cause of conflict in Trans Mara Sub County, from the study, majority of the respondents indicated that the main cause of conflict in the region was ethnic animosity as shown by 61.1%, 33.6% stated that the cause of conflict was resource based causes and finally 4.8% stated that crime has also been a source of conflict in the region. This indicates that ethnicity had contributed much to the conflict witnessed in the area. These findings concurs with the findings of Adan andPkalya (2006) who observed that in most communities especially pastoralist communities where scarcity of resources was the main cause of conflict, resource management agreement helped to do reduce tensions among the many ethnic communities co existing together.

Figure 1: Conflict in Trans Mara Sub County
Table 1: Immediate institution that responds to resolve conflict

<table>
<thead>
<tr>
<th>Immediate institution</th>
<th>Frequency</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>Provincial administration</td>
<td>65</td>
<td>44.5</td>
</tr>
<tr>
<td>Religious leaders</td>
<td>21</td>
<td>14.4</td>
</tr>
<tr>
<td>Council of elders</td>
<td>42</td>
<td>28.8</td>
</tr>
<tr>
<td>Peace committee representatives</td>
<td>18</td>
<td>12.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>146</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

The study also wanted to establish the most immediate institution that responded to resolve conflict whenever it occurred, from the study, majority of the respondents indicated that provincial administration played significant role in conflict resolution as shown by 44.5%, 28% of the respondents indicated that council of elders were always involved calm down the occurrences as shown by 28.8%, 14.4% indicated religious leaders and finally 12.3% indicated peace committee and representatives. This shows that all representatives in the community were in involved in resolving conflict but the government played the significant role since it had resources and man power to bring volatile situations back to normalcy.

The research also wanted to establish the reason behind the institution mentioned in the previous question being the first to respond in times of conflict, from the study majority of the respondents indicated that the reason behind the provincial administration being the first to respond during these calling times is because they lived among the community as shown by 56.8%, 37% of the respondents indicated that it was because they had the logistical capacity required to reach the scene of crimes and assist the individuals affected. Others indicated that they were not aware as shown by 6.2%. This is a clear indication that much more is desired from the government. The government should increase the number of police posts and fully equip the police officers will all required equipments be it guns, vehicles, surveillance machines and high powered communication gadgets. This would assist in earlier detection of the few that may decide to cause conflict and deal with them appropriately rather act when it’s too late.

On assigning the position of Peace committee representatives in terms of their speed of response to conflict situation whenever it occurred in Trans Mara, the study found out that majority of the respondents assigned peace committee representatives fourth as shown by 32.9%, 27.4% assigned it third, 22.6% assigned it second whereas only 17.1% assigned first. This shows that Peace committee representatives come at the far end in times of conflict resolution in the community.

On assigning the position of Council of elders in terms of their speed of response to conflict situation whenever it occurred in Trans Mara, the study found out that majority of the respondents assigned Council of elders third as shown by 31.5%, 28.1% assigned it fourth, 26.7% assigned it second whereas only 13.7% assigned first. This shows that Council of elders also comes among the last options conflict resolution in the community.

On assigning the position of Provincial administration in terms of their speed of response to conflict situation whenever it occurred in Trans Mara, the study found out that majority of the respondents assigned Provincial administration first as shown by 35.6%, 30.8% assigned it second, 19.9% assigned it fourth whereas only 13.7% assigned third. This shows that Provincial administration used to be the first in case of conflict in the region.

The researcher wanted to determine whether there was peace building programs being carried out to promote peaceful coexistence among communities in Trans Mara district, from the study majority of the respondents indicated that there were peace building programs being carried out to promote peaceful coexistence as shown by 65.8%, 21.2% indicated that there no such initiative whereas only 13% of the respondents who indicated that they did not know. This is a clear indication that the individuals in the region have realized the importance of peace initiatives programmes and have also realized that no peaceful coexistence could be achieved until all parties are brought to the same platform and be made to understand the importance of peace.

On whether the respondents were aware of peace committees in Trans Mara district, the study established that majority of the respondents indicated that indicated that there existed peace committees in the district as shown by 63.7% whereas only 36.3% who indicated that at anytime there existed peace committees in the district.
On how the respondents became aware of the existence of peace committees in Trans Mara district, the study found out that majority of the respondents indicated that they became aware of these committees in public baraza, as shown by 45.2%, 30.1% indicated that they learned of existence through friends, 18.5% indicated that they heard of the committees from other sources and finally 6.2% indicated that they became aware of the peace committees over the radio. This is an indication that provincial administration which should conduct as much as possible barazas in the district so that they can preach peace and let the people know that its only with peaceful coexistence they will be able to exploit the economical resources they have and live a good life.

On the respondents opinion whether the civil society was doing enough to educate the community on the need for peace, the study established that 50% of the respondents indicated yes and 50% indicated no. This is shows that the civil society is there but much impact not been felt in preaching peace and propagating for peaceful coexistence.

Among the reasons which made the respondents feel that the civil society has been doing a good job is because they prepared workshop for youth, women and men. They also encouraged people to live together and they educated people to trade together and live together. The civil societies have even taken these campaigns even in churches. They have continued to mobilize the various stakeholders, provincial administrations, local community leaders towards peace initiatives.

The study also wanted to establish the respondents’ level of agreement on the above statements, from the study majority of the respondents agreed that peace campaigns yield much in peace building as shown by a mean of 1.93, they further agreed that peace committee are effective approach to peace building and conflict management and that women are critical to be involved in decision making levels for peace building and conflict management as shown by a mean of 2.36. It was further established that Peace committee resolutions often result in peaceful co-existence and the government provides adequate support to peace committees in Trans-Mara.

The study also wanted to establish the age groups that participated in most of the ethnic conflict, from the study, it was revealed that majority of the people involved in ethnic conflict were aged between 21 and 30, as shown by 61%, others stated 31 to 40 as shown by 24%, 10.3% indicated 18 to 20 years, 3.4% indicated 51 to 60 and finally 1.4% indicated 41 to 50. This is an indication that the youths who are in their early adult hood are the most prone to participation in ethnic conflict. This has been brought about by poor education system making majority of them drop out of school and recruited in very dangerous gangs that carries out the raids. Low level of employment also plays a role in this. Incase these young adults are fully absorbed into the labour markets there will no one to conduct these inhumane actions.

The study also wanted to establish whether the respondents’ community was still relying on traditional measures of conflict resolution, from the findings majority of the respondents indicated that they were still relying on traditional measures of conflict resolution as shown by 85.6% whereas 14.4% indicated that they did not rely on the rely on traditional measures of conflict resolution.

On the most traditional conflict resolution measure being practiced in Trans Mara, the study established that council of elders was the most used practiced as shown by 63%, 18.5% of the respondents indicated intermarriages, 17.8% of the respondents indicated resource management agreement and finally 0.7% indicated others. This shows that traditional conflict resolution practices are still being practiced in the district.

**Summary of the findings**

This research established that the main cause of conflict in the region was ethnic animosity and this was represented by 61.1%. These findings concurs with the findings of Adan and Pkalya (2006) who observed that in most communities especially pastoralist communities where scarcity of resources was the main cause of conflict, resource management agreement helped to do reduce tensions among the many ethnic communities co-existing together. It was further established that provincial administration played significant role in conflict resolution. This shows that all representatives in the community were involved in resolving conflict but the government played the significant role since it had resources and man power to bring volatile situations back to normalcy.

The reason behind the provincial administration being the first to respond during these calling times is because they lived among the community and they had the logistical capacity required to reach the scene of crimes and assist the individuals affected. This is a clear indication that much more is desired from the government.
The research further established that there were peace building programs being carried out to promote peaceful coexistence. This is a clear indication that the individuals in the region have realized the importance of peace initiatives programmes and have also realized that no peaceful coexistence could be achieved until all parties are brought to the same platform and be made to understand the importance of peace. It was also revealed that that provincial administration should conduct as much as possible barazas in the district so that they can preach peace and let the people know that it’s only with peaceful coexistence that will enable their children go to school and complete their education. This will enable them exploit the economic resources they have and live a good life.

It also came to the researchers attention that peace campaigns yield much in peace building and this was represented by a mean of 1.93. Peace committee are effective approach to peace building and conflict management and that women are critical to be involved in decision making levels for peace building and conflict management and Peace committee resolutions often result in peaceful co-existence and the government provides adequate support to peace committees in Trans-Mara.

The research also established that majority of the people involved in ethnic conflict were aged between 18 and 30. This is an indication that the youths who are in their early adult hood are the most prone to participation in ethnic conflict. This has been brought about by poor education system making majority of them drop out of school and recruited in very dangerous gangs that carries out the raids. Low level of employment also plays a role in this. Incase these young adults are fully absorbed in the labour markets there will no one to conduct these inhumane acts. It also revealed that the community was still relying on traditional measures of conflict resolution and that council of elders was the most practiced.

CONCLUSION
The study concludes that main cause of conflict in the region was ethnic animosity and that provincial administration played significant role in conflict resolution. It further concludes that the reason behind the provincial administration being the first to respond during these calling times is because they lived among the community and they had the logistical capacity required to reach the scene of crimes and assist the individuals affected.

This research also concludes that there were peace building programs being carried out to promote peaceful coexistence. This is a clear indication that the individuals in the region have realized the importance of peace initiatives programmes and have also realized that no peaceful coexistence could be achieved until all parties are brought to the same platform and be made to understand the importance of peace.

The study also concludes that peace campaigns yield much in peace building and peace committee are effective approach to peace building and conflict management and that women are critical to be involved in decision making levels for peace building and conflict management.

The study finally concludes that majority of the people involved in ethnic conflict are aged between 21 and 30. This has been brought about by poor education system making majority of them drop out of school and recruited in very dangerous gangs that carries out the raids. Low level of employment also plays a role in this. Incase these young adults are fully absorbed in the labour markets there will no one to conduct these inhumane actions.

RECOMMENDATIONS
This study therefore recommends that peace resolution initiate such as meeting people in churches, schools and launching peace campaigns should be adopted in the peace preaching process. This would play a significant role in creating awareness of peace initiatives. Organisations should use vehicles such as trailers and even hold public meetings and renew the committee’s mode of doing things. Education and training of youths and women should be prioritised. This would empower them with more knowledge on what bring conflicts among communities and how to resolve it amicably.

REFERENCES
CONTRIBUTION OF THE NEW CONSTITUTION IN PROMOTING KISWAHILI USE IN MASS MEDIA

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ABSTRACT
Media plays a major role in the society; it is the medium of providing information, it creates social integration, and promotes shared values, knowledge and entertainment. Proper use of standard language is essential to achieve these objectives. Media industry in Kenya has grown exponentially from the early 1990s. This growth has been characterized by the deployment of the latest technological innovations, increased number of frequency modulated radios and professional media practitioners. Many of the media houses in Kenya today are using different styles and methods to attract and keep listeners for their own economic survival. This paper investigates the effects of new constitution on the language used in the mass media. It highlights the gains that have been made specifically in promoting Kiswahili language as a national and official language as well as the challenges.

IKISIRI

ya kwanza nchini pamoja na kuendelea kuwa lugha ya taifa. Masuala haya ndiyo yalichochea utafiti huu ili kuchunguza iwapo athari za katiba mpya katika lugha ya Kiswahili kwenye vyombo vya habari ni hasi au chanya hasa katika upande wa matumizi ya lugha sanifu.

Makala hii ililenga kuchunguza athari ya katiba mpya kwa lugha ya Kiswahili na jinsi Kiswahili kinaivyotumika katika vyombo vya habari. Hoja muhimu iliyoendeleza huga ni kuwa katiba mpya imechanga kukuza na kupanua lugha ya Kiswahili katika vyombo vya habari. Kwa upande wa pili, hali hii imeleta changamoto kwa kuathiri mbeko za uzingatifu wa Kiswahili sanifu huku vyombo vya habari vina vingatiriza na kikatiba vikua sahihi na wakati wa mkono wa tathmini pamoja na kuendelea kuwa lugha ya taifa. Masuala haya ndiyo yalichochea utafiti huu ili kuchunguza iwapo athari za katiba mpya katika lugha ya taifa. 

Makala hii ililenga kuchunguza athari ya katiba mpya kwa lugha ya Kiswahili na jinsi Kiswahili kinaivyotumika katika vyombo vya habari. Hoja muhimu iliyoendeleza huga ni kuwa katiba mpya imechanga kukuza na kupanua lugha ya Kiswahili katika vyombo vya habari. Kwa upande wa pili, hali hii imeleta changamoto kwa kuathiri mbeko za uzingatifu wa Kiswahili sanifu huku vyombo vya habari vina vingatiriza na kikatiba vikua sahihi na wakati wa mkono wa tathmini pamoja na kuendelea kuwa lugha ya taifa. Masuala haya ndiyo yalichochea utafiti huu ili kuchunguza iwapo athari za katiba mpya katika lugha ya taifa. 

Makala hii ililenga kuchunguza athari ya katiba mpya kwa lugha ya Kiswahili na jinsi Kiswahili kinaivyotumika katika vyombo vya habari. Hoja muhimu iliyoendeleza huga ni kuwa katiba mpya imechanga kukuza na kupanua lugha ya Kiswahili katika vyombo vya habari. Kwa upande wa pili, hali hii imeleta changamoto kwa kuathiri mbeko za uzingatifu wa Kiswahili sanifu huku vyombo vya habari vina vingatiriza na kikatiba vikua sahihi na wakati wa mkono wa tathmini pamoja na kuendelea kuwa lugha ya taifa. Masuala haya ndiyo yalichochea utafiti huu ili kuchunguza iwapo athari za katiba mpya katika lugha ya taifa. 

Tunguzili

Suala la Utafiti
Uzinduzi wa katiba mpya nchini Kenya mnamo mwezi wa Agosti, mwaka wa 2010 ulikuwa hatua muhimu katika
kubadilisha mfumo wa uongozi, jamii na hata siasa. Wananchi wa Kenya kupitia kura ya maamuzi walipitisha katiba
mpya kuambatana na maono yao kama wananchi wa taifa huru. Mengi yaliweza kubadilika serikalini kutokana na
azimio hili kama vile ugatuzi wa serikali, asasi ya mahakama, uwakilishi wa ubunge na utawala. Lugha ya Kiswahili
ilipewa hadhi mpya kupitia katiba hii mpya ambapo sasa ni mojawapo wa lugha rasmi. Awali Kiswahili kilikuwa
lugha taifa pekee. Kuteuliwa kwa Kiswahili kama lugha rasmi kuna maana kuwa matumizi yake inafaa kuwa sahihi na
sanifu. Kutokana na matumizi mapana ya Kiswahili hasa katika vyombo vya habari, palikuwa na haja ya kuchunguza
iwapo matumizi sahihi na sanifu yanazingatiwa kuambatana na vipengele vya katiba mpya la sivyo kujua makosa
yanayotokea na namna ya kuyarekebisha, suala lililopelekea uchunguzi huu.
Malengo ya Utafiti
1. Kuchunguza athari za katiba mpya kwa lugha ya Kiswahili
2. Kuchanganua makosa ya Kiswahili yanayofanywa katika vyombo vya habari
3. Kupendekeza namna ya kurekebisha makosa hasa katika vyombo vya habari.
Maswali ya Utafiti
1. Katiba mpya ya Kenya imeathiri vipi matumizi ya Kiswahili katika vyombo vya habari?
2. Kuna aina gani ya makosa inayofanywa katika vyombo vya habari?
3. Je, pana njia zozote mwafaka za kurekebisha makosa katika vyombo vya habari?
MBINU ZA UTAFITI
Utafiti huu ulitumia uchanganuzi wa kithamano kwa mujibu wa Kasomo (2007). Utafiti wa kithamano hufafanua
hali halisi ya masuala yanayotafitiwa, maelezo yaliyopo kuhusiana na dhana, uchanganuzi, uainishaji, pamoja na
ukadiriaji wa data. Robson (1993) anasema kuwa uchanganuzi wa kithamano hutoa mwongozo rahisi na sahili katika
utafiti wa dhana, mielekeo na imani. Pia mpango wa aina hii wa utafiti huweza kutumiwa kuchunguza data inayoweza
kuwakilisha idadi kuu ya watafitiwa. Lengo la utafiti huu lilikuwa kuchunguza makosa yaliyokuwa tayari yametokea
kwenye vyombo vya habari zinazosomwa kwenye redio na athari zake kwa lugha sanifu ya Kiswahili. Idhaa za redio
citizen na idhaa ya taifa (KBC) ziliteuliwa kwa vile zote hutumia Kiswahili kwa saa 24 na kwamba hupokelewa kote
nchini. Utafiti huu uliongozwa na nadharia ya uchanganuzi makosa kwa mujibu wa Corder (1967) ambayo inaainisha
makosa, kuyaweka kwenye makundi na kutambua vyanzo vyake. Mambo haya yalihitaji kuchunguzwa jinsi yalivyo
huku athari zake zikifafanuliwa na kuchanganuliwa ili kueleweka bayana. Vifaa vilivyotumika kuafikia azimio hili ni
pamoja na jedwali la tathmini na hojaji.
Jedwali la Tathmini
Uchanganuzi wa makosa kwenye taarifa za habari ulifanywa kwa kutumia jedwali la tathmini, ili kuhakikisha kwamba
makosa yote katika nakala za taarifa za habari yalinukuliwa. Mtafiti alinasa taarifa za habari zilizolengwa kwa muda
wa miezi mitatu za saa saba mchana na saa moja jioni kwenye kanda huku akitumia kinasa sauti. Kisha alitumia
kalamu na daftari ili kunukuu taarifa za habari na baadaye kuzipiga chapa kwenye taraklishi na kutoa nakala. Mtafiti
alipitia kila nakala ya taarifa na kutambulisha makosa yaliyokuwepo, kuyaainisha na kuyachanganua. Kifaa hiki ni
muhimu katika shughuli hii ili kuhakikisha kuwa majopo yote ya makosa yalishughulikiwa ipasavyo. Makosa haya
yaliwekwa kwenye majopo maalum kama vile kuchanganya ndimi, kutumia sheng’ na kutumia upatanisho usiofaa
wa kisarufi. Uchunguzi huu ulisaidia kuainisha makosa mbalimbali na kuyaweka kwenye sehemu zilizofaa. Kathuri
na Pals (1993) wanasema kuwa jedwali la tathmini huwa na dhana ambazo watafitiwa huelewa kwa haraka na kutoa
maoni yao kwa wepesi kuliko hojaji wazi.
Hojaji
Hojaji maalum iliyowalenga watangazaji wa habari kwenye mashirika mawili ya habari yaani; Shirika la Utangazaji la
Kenya (KBC) na Idhaa ya Redio Citizen ilitumiwa. Hojaji hii iliongozwa na malengo ya utafiti na ilikuwa na sehemu
tatu maalum. Sehemu ya kwanza ilikuwa na maswali ya jumla kuhusu mtafitiwa, sehemu ya pili ilijumuisha maswali
ya kuainisha makosa kwenye taarifa za habari na sehemu ya tatu ilihusu makosa yanayoweza kuathiri mawasiliano.
Hojaji hii ilikuwa na umuhimu wa kuchunguza chanzo za makosa kwa mujibu wa nadharia ya uchanganuzi makosa.
MATOKEO YA UTAFITI
Athari ya Katiba Mpya kwa Lugha ya Kiswahili
Katiba mpya ya Kenya ilizinduliwa katika mwezi wa Agosti, mwaka wa 2010 baada ya kura ya maamuzi iliyofanyika
nchini. Umuhimu wa katiba hii hauwezi kutiliwa shaka. Sababu ni kuwa katiba hii imesababisha mabadiliko makubwa
Proceedings of the First Intenational Research Conference, 29th to 31st October, 2014

177


haya yameanza haja ya ukuaji wa lugha ili kuiwezesha kuwasilisha dhana mpya katika maisha ya kila siku kama anavyosema King’ei (2000).

**Athari ya Katiba Mpya kwa Vyombo vya Habari na Jinsi Itakavyoathiriki Kiswahili.**

Uzinduzi wa katiba mpya umeleta mabadiliko mengi katika vyombo vya habari kama unavyoathiri asasi zingine za kijamii. Sura ya nne ya katiba mpya itatoa haki za kimwili, haki za kimsingi za binadamu ambazo zinazopata kutolewa kwa kila mwananchi bila mahitaji kwa kila mtu na kwamba hazifai kupokonywa mwananchi yeyote wana kufanya kazi.

Sehemu hii ni unawezesha kiwango vya kufanya uchumi na kutolewa kila mwezi kama hukumishia katika 16 (2) ya Katiba Mpya kwa Vyombo vya Habari na Jinsi Itakavyoathiriki Kiswahili. Katiba hii umaleta mabadiliko mengi katika vyombo vya habari kama ulivyoathiri asasi zingine za kijamii. Sura ya nne ya katiba mpya itatoa haki za kimsingi za binadamu ambazo zinazopata kutolewa kwa kila mwananchi bila mahitaji kwa kila mtu na kwamba hazifai kupokonywa mwananchi yeyote wana kufanya kazi.

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Sehemu hii inatafuta katiba kwa lugia ilembula ili kufanya uchumi na kutolewa kila mwezi kama hukumishia katika 16 (2) ya Katiba Mpya kwa Vyombo vya Habari na Jinsi Itakavyoathiriki Kiswahili. Katiba hii umaleta mabadiliko mengi katika vyombo vya habari kama ulivyoathiri asasi zingine za kijamii. Sura ya nne ya katiba mpya itatoa haki za kimsingi za binadamu ambazo zinazopata kutolewa kwa kila mwananchi bila mahitaji kwa kila mtu na kwamba hazifai kupokonywa mwananchi yeyote wana kufanya kazi.

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Sehemu hii ni unawezesha kiwango vya kufanya uchumi na kutolewa kila mwezi kama hukumishia katika 16 (2) ya Katiba Mpya kwa Vyombo vya Habari na Jinsi Itakavyoathiriki Kiswahili. Katiba hii umaleta mabadiliko mengi katika vyombo vya habari kama ulivyoathiri asasi zingine za kijamii. Sura ya nne ya katiba mpya itatoa haki za kimsingi za binadamu ambazo zinazopata kutolewa kwa kila mwananchi bila mahitaji kwa kila mtu na kwamba hazifai kupokonywa mwananchi yeyote wana kufanya kazi.
lugha na unapotokea katika muktadha rasmi unakuwa ni makosa. Makosa ya aina hii yalidhihirika katika baadhi ya taarifa za habari zilizotafitiwa kama inavyodhirihiha katika mifano ifuatayo:
1a...gari hilo aina ya pick up... redio citizen 3/4/14
2a...ikifuatiwa na rift valley... redio citizen 3/4/14
3a...watu wanne walithibishwa kufa miongoni mwao turnboy wa trela... redio citizen 14/12/14
4a...jaji mkuu dr. Willy Mutunga... redio citizen 12/12/13
5a...wafanyikazi wa maduka ya supermarket ya Tusks...20/12/13

Sentensi sahihi
1b...gari hilo la kubebea mizigo
2b...ikifuatiwa na eneo la bonde la ufa
3b...watu wanne walithibitishwa kufa miongoni mwao utingo wa trela
4b...Jaji mkuu dkt. Willy Mutunga
5b...wafanyikazi wa maduka ya jumla ya Tusks

B. Matumizi Yasiyofaa ya Akronimu za Kiingereza
Akronimu ni vivupisho vya maneno yanayotumiwa kuwakilisha neno kamili. Huwa mbinu maalum katika uundaji wa istilahi katika lugha. Kila lugha huwa na akronimu zake. Hata hivyo, wakati akronimu za Kiingereza zinapotumika katika muktadha wa mawasiliano ya Kiswahili yanakuwa makosa kwa vile wasomaji wanaweza kupata tafsiri isiyofaa. Baadhi ya makosa ya aina hii ni kama yafuatavyo:
6a…OCPD wa Embu... redio citizen 28/12/13
7a...shirika la IGAD lachukua msimamo mkali dhidi ya Sudan … redio taifa 27/12/13
8a...amekiri kwamba wanajeshi wa KDF hawataondoka nchini Somalia… redio citizen 4/4/14
9a...idara ya CID… redio citizen 27/11/13
10a...majaji wa ICC wameipa serikali ya Kenya muda… redio citizen 10/12/13
11a...tume ya IEBC…redio taifa 19/12/13
12a... halmashauri ya NACADA…redio taifa 28/12/13

Makosa haya yangekosolewa kama ifuatavyo:
6b mkwu wa polisi katika eneo la Embu
7b...shirika la kiserikali la maendeleo katika eneo hili (IGAD) lachukua msimamo mkali kuhusu Sudan
8b...amekiri kwamba wanajeshi wa ulinzi wa Kenya (KDF) hawataondoka nchini Somalia
9b...idara ya polisi inayopendeza vitendo vya jinai (CID)
10b...majaji wa makama ya kimataifa kuhusu uhalifu na vitendo vya jinai (ICC)
11b...tume huru ya uratibu wa mipaka na uchaguzi (IEBC)
12b...halmashauri ya kitaifa inayopambana na pombe na dawa za kulevya (NACADA)

C. Matumizi Yasiyofaa ya Vivumishi vya Pekee

13a...huku Omar akijifunga mwenyewe...redio taifa 5/4/14
14a...mtu mwenyewe ameaga dunia usiku wa kuamkia leo... redio citizen4/4/14
15a...serikali yasambaza mbloea kwenye vituo vyote ya halmashauri...redio taifa 21/12/13
16a...washambulaji hao waawamerekana kuifyaatu risasi kadhaa A nyumba ya waathiriwa redio taifa.11/12/13

Sentensi hizi zingesahihishwa kwa njia ifuatayo:
13b...huku Omar mwenyewe akijifunga bao kwenyen langs ngao
14b...mtu aliyea dunia usiku wa kuamkia leo
15b...serikali yasambaza mbloea kwenyen vituo vyote vya halmsahauri
16b...washambulaji hao waawamerekana kuifyaatu risasi kadhaa kwenyen nyumba ya waathiriwa.
D. Ukosefu wa Upatanisho wa Kisarufi


17a….huku ikisema matakwa ya wahudumu za sekt…redio taifa 18/12/13
18a….Bomu la kugwaga kwenye gari kwa mkahawa mmoja katikati mwa Iraq umewaau takriban watu wanne…redio taifa 9/12/13
19a….baada ya kuishinda Nairobi City Stars mbao mawili kwa bila…..26/12/13
20a….kocha wa kilabu hiyo…..redio taifa 4/1/14
21a….bandari kuwa wa Mombasa…2/1/14
22a maafa wa utawala….redio citizen 23/11/13
23a….waya wa stima….redio citizen 26/11/13

Mifano iliyojatia inafaa kusahihishwa kama ifuatavyo:

18b  huku ikisema wahudumu wa sekt….
19b….bomu la kugwaga kwenye gari kwa mkahawa mmoja katikati mwa Iraq limewaua…watu wanne
20b….baada ya kuishinda Nairobi City Stars mabao mawili kwa bila…..
21b….kocha wa kilabu bicho…..
22b…..bandari kuwa wa Mombasa
23b….maafa wa utawala
24b….waya wa stima….

E. Matumizi ya Sheng’


25a…Lipua mamiliioni
26a…Kwachua mamiliioni
27a…Bambika na tusker
28a…Pesa pap
29a…Blue band ya kadogo

Kauli hizi iwapo zingeandikwa kwa lugha sanifu zingefaa kuandikwa kama ifuatavyo:

25b…jishindie mamiliioni ya pesa
26b…pata mamiliioni
27a…burudika na pombe ya tusker
28a…pata pesa mara moja
29a.. siagi ile ndogo

Mahitimisho


Mapendekezo


MAREJELEO


ROLE OF LANGUAGE IN PEACE BUILDING: A CASE OF KENYA'S 2008 COALITION GOVERNMENT

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ABSTRACT

A study on conflicts around the world found that many countries were at high risk of instability and of these, most were
in Africa. Although the African continent continues to glamour for the dire need of peace, it has continued to witness political conflicts arising out of disputed elections. This has often resulted in the formation of coalition governments as a mechanism to securing peace and stability. In doing so, various conflict mechanisms such as mediation, arbitration, negotiation and peacekeeping have been employed by different bodies and/or agencies to restore peace in conflicting states of Africa. However, little attention has been paid to the use of language by the coalition leaders as a mechanism to conflict resolution and peace building. This is informed by the fact that language is the primary means to negotiate power and therefore cannot be ignored. This paper examines lexicalisation in the discourse of the two principals in the Kenyan 2008 Coalition Government negotiation for Portfolio Balance. Four written texts were purposively sampled and accessed from the official website of the former President and former Prime Minister. The study applies Fairclough’s approach of Language and Power and Social Theory anchored in Critical Discourse Analysis to tease out the lexical choices. The findings revealed that the two principals employed language that was mitigated, personalized and highly restrained in relation to hate speech. The language of political persuasion which guided citizens’ orientation and behaviour encoded respect, tolerance, optimism and reassurance for continued political support notwithstanding the underlying power struggles. Policymakers should incorporate the aspect of language in national laws and policies as a guiding principle in conflict resolution and peace building.

**Key words:** Lexicalisation, Kenya, Negotiation Discourse, Portfolio Balance, Critical Discourse Analysis

### INTRODUCTION

#### Background to the Study

There are numerous challenges facing the African continent today. Most of these challenges arise from conflicts confronting these African countries such as political conflicts. The begging question has always been the means of conflict resolution adopted to address such destabilizing conflicts in Africa. In the words of Ikejiaku, there is no doubt that conflict pervades many countries in the African continent. The African continent over the past three decades, particularly in the 1980s and 1990s, has faced greater challenges to stability and progress in all ramifications than ever before. In particular, threats to peace have been much more pronounced and indeed have increased in scale and intensity. It is important to note that most of these political conflicts are attributed to disputed elections which often result in the formation of coalition governments as a measure to securing peace and bringing stability in otherwise collapsing states. This has been the case with Zimbabwe, Kenya and recently, the Southern Sudan. A study on conflicts around the world conducted by the University of Maryland’s Centre for International Development and Conflict Management found that 33 countries were at high risk of instability and of these, 20 were in Africa (Dare, 2001) cited in Ikejiaku 2011: 62).

In the recent past, most elections held in most African countries have been disputed by the political candidates. In our view, this has become a common current trend especially in the African Continent. This discontentment over Presidential elections more often than not foment violence and chaos in the countries involved. However, it can be contended that for most leaders, the coalition governments have proved elusive to manage up to the end of the term and as a result, most have collapsed resulting into fresh violence or call for fresh elections. This political crisis has and is bedeviling most African countries. Constant and perennial infighting and subsequent collapse of coalition governments slow down development. In view of the foregoing precedence, it is important to find amicable ways of managing and resolving such conflicts. This paper brings to our understanding of how language can be used as a negotiator to manage and resolve otherwise contentious issues of national concern in coalition governments, therefore, averting unprecedented political conflict. Consequently, this would sustain the signed Agreements, secure the earned peace therefore bringing coalition governments to the end of their term.

It is important to note that in 2008, the first Grand Coalition government was formed in Kenya. Long-term electoral change in the whole of Africa indicates this may not be a one-off situation, that in future coalitions may become more common in the region. Despite the fact that most African countries are opting for coalition governments as a way of resolving political conflicts, available literature has revealed that most of such governments have failed within the shortest time possible due to the dangers inherent in such governments. We opine that the manner in which coalition partners negotiate divisive issues of national concern is crucial to the success of such governments. In addition, such negotiations cannot materialize without the use of language. As a result, in Wodak’s and Meyer’s words, language becomes a medium of domination and social force, and for this reason, the linguistic choices are ideologically driven. This study sought to demonstrate that language is a powerful tool that people in leadership positions and those seeking power, particularly, politicians can use not only to communicate their policies and ideological positions, but also manage, resolve conflicts and in addition gain political mileage. Our argument in this study is that notwithstanding the
historical social struggle and the unforeseen loopholes in the National Accord, the former President, Mwai Kibaki and the former Prime Minister, Raila Odinga, must have employed discursive strategies which necessitated the amicable resolution of the Portfolio Balance stalemate. This was an indicator that any arising future contentious issues of national concern would be resolved in the same grain. Consequently, this approach would enable them to steer the country together as coalition partners up to the end of their term. We would like to point out on the onset that the type of coalition government referred to in this study is one of power-sharing arrangement which was formed in response to the 2007 disputed elections in Kenya. Therefore, in this case, inclusive mandate resemble risk-averse politics where efforts to prevent conflict trump political competition.

Consequently, the Kenya, the National Accord and Reconciliation Act (2008) sanctioned the existence of the 2008 Grand Coalition government which was anchored in the Portfolio Balance. The principle of the Portfolio Balance was on the basis of power-sharing between the main parties viz: the Party of National Unity (PNU) headed by Mwai Kibaki and the Orange Democratic Movement (ODM) headed by Raila Odinga. There have been several Agreements established in some African countries to secure peace and stability in failing states, Kenya being one of them. Few agreements succeeded while most failed. Therefore, it should be mentioned that in relation to the Kenyan case, the success of the power-sharing agreement in large part hinges on the political will of the two sides notwithstanding the unforeseen loopholes in the Agreement.

Kenya’s coalition Agreement lacks most of the elements that have been found to sustain such arrangements elsewhere. Instead, the Kenyan deal outlines only broad principles for power-sharing and includes minimal guarantees of inclusion. Thus, given the limited scope of the Agreement, its durability depended on how it was implemented over time by the signatories. This brings us to the main objective of this study which is an attempt to investigate how the two principals employed language to negotiate contentious issues of national concern and specifically, the Portfolio Balance and in one way or another sustaining the unforeseen loopholes in the Agreement.

Statement of the Problem
Initial investigations of the discursive relationship between the two Coalition partners in the Kenyan government reveals considerable intellectual interest in the linguistic strategies the principals used in their attempts to negotiate the contentious issues in the Portfolio Balance. However, this interest is confined primarily to their political ideological backgrounds and objectives. Yet without a good understanding of the discursive factors that inform the processes of negotiations involved, it is difficult to fully appreciate the critical positions that the principals occupied in Kenyan life and the impact that their decisions had on the direction of the nation as a whole. This study therefore seeks to investigate the lexicalisation strategies in the discursive resources employed by the Principals in the negotiation for Portfolio Balance in the then Kenyan coalition government.

Research Question
What type of lexicalisation do the two principals employ in the 2007 post-election consultation negotiation discourse on Portfolio Balance and what are the underlying implications?

LITERATURE REVIEW
Conflict and Peace Building in Africa
Conflict has destabilized most African countries. Wayande (1997) cited in Ikejiaku (2011:62) discloses that the cost of conflicts in Africa in loss of human life and property, and the destruction of social infrastructure is enormous. Hundreds of thousands of people have been killed in many of the countries in which the conflicts occur. Many others have also suffered and continue to suffer untold psychological trauma associated with conflicts […] once conflicts occur, scarce resources are inevitably diverted to the purchase of military equipment at the expense of socio-economic development.

Ikejiaku (2011) avers that given these trends, it may seem odd to talk of optimism in most African countries where conflicts have become common, as the table below illustrates. The table above indicates that conflict bedevils most African countries to the recent time and therefore the need for conflict resolution and peace building if Africa is to develop. Conflict resolution refers to all those activities that are concerned with transforming destructive and armed conflict along constructive and nonviolent channels (Haus, 2001). Various conflict resolution mechanisms such as arbitration, mediation, negotiation and peacekeeping have been employed by different bodies or agencies, such as local communities, the governments of conflicting states, the Economic Commission for Africa (ECOWAS), the African
Union (AU), and even the International Community, such as the United Nations (UN), in order to bring peace and stability in conflicting states of Africa.

Table 1: Country and Nature of Conflict

<table>
<thead>
<tr>
<th>Country</th>
<th>Period</th>
<th>Nature of conflict</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern Sudan</td>
<td>2014</td>
<td>Community clashes</td>
</tr>
<tr>
<td></td>
<td>2003,2007</td>
<td></td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>2004 (ongoing)</td>
<td>Riots, violent demonstration and communal clashes</td>
</tr>
<tr>
<td>Sudan</td>
<td>1983-2003</td>
<td>Civil war</td>
</tr>
<tr>
<td>Uppsala</td>
<td>2003</td>
<td>Civil war</td>
</tr>
<tr>
<td>Liberia</td>
<td>1989-2003</td>
<td>Civil and regional wars</td>
</tr>
<tr>
<td>Angola</td>
<td>1975-2002</td>
<td>Civil and regional wars</td>
</tr>
<tr>
<td>Somalia</td>
<td>1981-2002</td>
<td>Civil war</td>
</tr>
<tr>
<td>DRC</td>
<td>1996-2001</td>
<td>Civil war</td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>1991-2000</td>
<td>Civil and regional wars</td>
</tr>
<tr>
<td>Burundi</td>
<td>1991</td>
<td>Ongoing civil and regional wars</td>
</tr>
<tr>
<td>Rwanda</td>
<td>1990</td>
<td>Ongoing civil and regional wars</td>
</tr>
</tbody>
</table>

Source: Content adopted from Ikejiaku (2011:62) and modified in a table by the researchers

Based on this background and given the fact that in coalition governments, the peace Agreements are solely signed by the Party leaders, it is opined that it is the prerogative of such leaders to make important negotiations resulting into decisions that benefit the whole country. Therefore, the importance or the role that language plays in these negotiations cannot be ignored. We contend that it could be the missing link towards fruitful governance.

The Nature of Coalition Governments in Africa

The practice of coalition formation has become quite common in recent years especially among the newly emerging democracies in Europe, Latin America and lately Africa (Oyugi, 2006). While coalition formation has become increasingly common, opinion is still divided about the efficacy of coalition governments whenever the system is in operation (Oyugi, 2006). Similar views are held by Kaverenge (2007) and Sullivan (2005). They argue that coalition governments do have inherent dangers which usually threaten the very existence of that coalition. Nonetheless, Oyugi (2006) states that the actual behaviour of the coalition partners will ultimately be influenced by the socio-political dynamics at play. Kaverenge (2007) also supports Oyugi’s argument in relation to the African experience. In our view, the way coalition partners negotiate divisive issues that pose a threat to the existence of the coalition government could be resolved amicably through language use.

Further, Oyugi (2006) observes that most of the coalitions that have been formed, especially in Kenya, Mauritius and Malawi have been characterized by opportunism because of the weakness of the party system in many African countries. This assertion is also supported by Masime and Oesterdiokoff (2012) who observed that once formed, there is usually no loyalty to the coalition as such. Factions soon emerge which jostle for power and privilege. In Masime and Oesterdiekhoff’s words, coalition governments require that parties with divergent policy opinions or preferences should enter a bargaining process to arrive at a compromise. Similarly, Sullivan (2005) contends that incomplete implementations of Coalition Agreements are attributes of failures of inclusive governments in Africa. The way in which the parties negotiate their political differences on divisive issues would determine the success (the word successful is used in this study to mean that the coalition runs its term) of the coalition. In the Kenyan context, this was because the success and stability of the coalition government largely depended on the actions of the two principals whether verbal or non-verbal. Furthermore, the National Cohesion and Integration Commission (hereafter, NCIC) observed that sustaining peace and calm that was secured depended on how political leaders reconciled their political
differences as the country moved towards the general election on 4th March, 2013. Thus, the NCIC argued that use of “hate speech” among the main participants would lead to incitement hence regeneration into violence.

The survey of the literature on coalition formation recognizes that the nature and form which coalition formation takes is a function of the unique circumstances prevailing in a given country. The literature further demonstrates that the experience of coalition formation has been characterized by highs and lows. Only a few countries, notably in Europe, have had experience with stable coalitions. Elsewhere, coalition governments have been characterized by instability and frequent break-ups. This has been the case especially in the Caribbean and Africa (Oyugi, 2006). With regard to successful coalition governments, Lijphart (1999) observes that only 3 inclusive governments in Africa had been successful out of a total of 16. Kenya being one of the newest successful coalition government raises the question of how the two principals were able to manage a post-conflict country to the end of the coalition term given that the coalition government was made up of over 135 political parties then. It is our view that since language is the means through which negotiations are made, the initial investigation into the linguistic and discursive strategies of the principals reveal that the two principals faced the challenge of collective bargaining in the course of their governance of which they had to negotiate contentious issues of national concern.

**Language as a Means to Conflict Resolution and Peace Building**

Habermann (2003) attributes the success of coalition formation to four conditions: firstly, the political leaders must be able and willing to work together in the spirit of trust: they must be able to rely on each other and show mutual respect—both in their personal contacts and in public pronouncements about each other. Every coalition needs a personal basis of trust among the key political leaders. Their personal closest aides must help create this atmosphere. Secondly, agreements on government programmes must be pursued as part of a coalition government. Thirdly, the coalition should be as concise as possible and as detailed as necessary and when parties form a coalition for the first time, they should lay down comprehensive and detailed policies for all spheres. Lastly, every coalition agreement should contain a provision stating that the coalition parties will form a coalition committee whose duty is to deliberate on important issues needing coalition consensus.

In view of attribute one and two above, our argument is that more often than not, mutual respect is evidenced in language use same to drafting of clear agreements/policies. Furthermore, with regard to the fourth condition, deliberation of divisive issues require appropriate use of language, since language is the primary means to appropriate and negotiate power (Fairclough, 1989). All policies and any issues that require coalition consensus rely on appropriate language use. The fundamental issue is how to achieve stable coalition governments, with a focus on language use, as a major factor, which no coalition government can wish away without the coalition being forced to face internal wrangles which may lead to break-ups of the agreement resulting in conflict.

Therefore, our argument is that ignoring language in any political engagements can be counter-productive. Rather it is a challenge in two directions (Habermann, 2003). First, we all need to realize that language is dynamic and allows for continuous change, whether positive or negative. Secondly, to recognize that language is the means through which power is appropriated, distributed and negotiated (Fairclough, 1989). This is based on the observation that communications, especially in situations of ethnic, political, class and gender diversity, are complex and fluid endeavours (Fairclough, 1989; Habermann, 2003).

Preliminary literature review indicate that no scholar has undertaken a comprehensive evaluation of the role that language has played in informing the decisions that the two principals have made within the context of the Kenyan Coalition Government since its constitution to the end of the term. In order for the value of the problem of power negotiation within the Kenyan coalition government to be appropriately understood, this study sought to find out the role of language as the primary medium through in peace building especially with regard to coalition governments. In addition, some of the available information that touches on the issues of governance in Kenya consists of a number of reports that were sponsored either by the government or Non-Governmental Organizations (NGOs) that sought to investigate the ramifications of the post-election violence of 2007-2008. While the reports are considerably informative, their general focus is on the consequences of inflammatory discourse rather than on the intermediary role that language plays in negotiations for power within coalition contexts. Among the reports are the National Council of Churches in Kenya (NCCK) Task Force Report of 1992, the Kiliku Parliamentary Report of 1992, the Human Rights Watch Report of 1993, the Murungi Report of 1992, the Nyukuri Report of 1995 and the Waki Report (2008).
Furthermore, the numerous reports by national and international organizations that document the threatening atmosphere and violence before, during and after the general election in 2007 in Kenya, all mention the role of hate speech as a feature of the conflict (Bayne, 2008; EU, 2008; IREC, 2008; Kiai, 2008; KNHCR, 2007, 2008). These reports state that the rhetoric of politicians and political operatives prior to the election made it clear that voters should organize along ethnic lines and defend ethnic interests, a tactic also used in the 2002 election. Further, available literature review confirm that when leaders produce this kind of speech, and thereby make it acceptable for public discourse, their actions can be highly detrimental. Therefore, there is need to investigate the role that language plays in conflict resolution and peace building.

The review of the relevant literature also established that several scholars have underscored the link between the concepts of language, power and knowledge to “nationhood.” Studies in CDA have been undertaken by various scholars to analyse the language used by Heads of State during their tenure. The studies revealed that such leaders had employed a variety of lexicalisation strategies to sustain party ideologies, persuade the citizens to vote for them, push for a change in the mode of governance, preach peace, inter alia. The urgency of this study was informed by the dangers that are inherent in coalition governments, for example, frequent break-ups leading to violence or fresh elections such as what happened in Rwanda (Sullivan, 2005). This research addressed itself to one major instance namely: the negotiation for Portfolio Balance, where former President Mwai Kibaki whose key political party was the Party of National Unity (PNU) and the former Prime Minister Raila Odinga (Orange Democratic Movement (ODM) party, were supposed to negotiate on this issue of national concern.

It is important to point out that there were other negotiations made by the two principals on such matters of public interest but this study only focused on that of Portfolio Balance. This is because it was the first political litmus test for the implementation of the National Accord Act (2008). Further, it was necessary to study the discursive strategies of the two principals on this one occasion because it was bound to unearth important knowledge regarding their relationship, mode of governance and the important role the two principals play in the stability of coalition governments in general and the Kenyan nation in particular.

Lexicalisation
Lexical patterning relates to word choice and word creation devices deployed by the writer for some purposes. Consequently, the social actor’s choice of words says and means a lot. In addition, lexicalization involves ideology (“ideology is essentially linked to the process of sustaining asymmetrical relations of power to maintaining domination by disguising, legitimating or distorting those relations,” Thompson, 1984:4). This means that ideology is always the tool or property of dominant social groups. Stated otherwise, lexicalisation is the study of meaning of words, the structures of propositions, coherence and other relations between propositions (Wodak and Meyer, 2001:103). According to Wodak and Meyer (ibid: 103) these meanings may have social consequences. Janks (2009) defines the term lexicalisation as the choice/selection of wordings. In her view, different words construct the same idea differently. For the purposes of this study, both definitions were adapted in the linguistic analysis of data because they both address similar view of lexicalisation being concerned with the meaning of words. In addition, lexical cohesion (created by synonymy, antonymy, repetition or collocation) was also analysed (Janks, 2009).

MATERIALS AND METHODS
The data gathered for the purposes of this study were extracted from the former President’s and former Prime Minister’s website and the Public Communications Office of the Government Spokesperson. The discourses in texts focused on the instance of the Formation of the Grand Coalition Government in Kenya in 2008, specifically the Portfolio Balance. Permission to use these texts for this research was sought and granted by the National Council for Science Technology and Innovation. In total, four texts were purposively sampled for a Critical Discourse Analysis.

The data was modified by numbering the sentences for easier reference during analysis. Thereafter, lexicalisation strategies were analysed based on Fairclough’s (1989; 2003) theories of Language and Power and Social Theory. Critical Discourse Analysis is premised on the assumption that language is not only a product of society but also an important force in (re)shaping social practices, both positively and negatively (Wodak and Chilton, 2005; Fairclough 2010, 2003). CDA is characterized by concepts: critique, power, history and ideology. With such foci, CDA naturally lends itself to the investigation of the ways domination and discrimination are embedded in and mediated through language use (Ietcu, 2006). In studying the relationships of power in modern society, language cannot be ignored. Language in society has a decisive social function. This is because in carrying out a critical discourse study, it aims
to show up connections which may be hidden from people. Critical language study analyses social interactions by focusing upon their linguistic elements, which sets out their generally hidden determinants in the system of social relationships as well as hidden effects they may have upon that system (Fairclough, 1989).

In this study, CDA was used because it brings out the social issues that are a characteristic of the country’s political conflicts. It also reveals the discursive sources of power and shows how these sources of power are initiated and maintained within the Coalition Government. In this study, a critical discourse analysis was fundamentally concerned with exploring the relationship between discursive practices, texts and social structures in the speeches of the two principals in the post-consultation negotiation discourse for Portfolio Balance. Analysing opaque as well as transparent structural relationships of power and control and the implications of the linguistic strategies employed in the texts were focused on.

Critical Discourse Analysis endeavours to make explicit power relationships which are frequently hidden, and thereby to derive results which are of practical relevance. Fairclough and Wodak (1997:271-280) sum up the basic assumptions of CDA as follows: all discourses are historical and can therefore, be understood with reference to their context; language is a social phenomenon; texts are relevant units of language in communication; readers/hearers are not passive recipients in their relationships to texts.

In view of the above tenets, this study adopted all of them. Texts in the post-consultation negotiation discourse were first described to establish the specific contents; interpreted to reveal the discourse strategies employed and then the linguistic means identified; and finally an explanation given. CDA deals with discourse as the instrument of power and control as well as the instrument of social construction of reality. For CDA, language is not powerful on its own; it gains power through the use of powerful people who make use of it. In texts, discursive differences are negotiated and governed by differences in power which are themselves in part encoded in and determined by discourse and genre. Therefore, texts too are often sites of struggle in that they show traces of differing discourses and ideologies contending and struggling for dominance.

RESULTS AND DISCUSSION

In this final section, analysis and findings were compared and contrasted in order to reveal how lexical choices are used to convey information about the two principals in terms of their relationship and representation. This in turn help the writer/speaker to negotiate positioning of the reader’s beliefs and ideologies. The differences indicate that the two main principals in the then Grand Coalition Government in Kenya evidence social struggle and control as a political milestone. The following is an analysis of the lexicalisation strategies and ideological implications in the discursive resources of Mwai Kibaki and Raila Odinga during the negotiation for Portfolio Balance.

Lexicalisation in the Post-election Consultation Negotiations Texts

As mentioned earlier, the choice of words by the speakers in the context of the Post-election consultation negotiation suggest their voice on the issue of Portfolio Balance (Horvath, 2000). In order to have an in-depth understanding of lexicalisation, a keyphrase analysis of both frequently used words and connotations and phrases was undertaken. This type of analysis was informed by other researchers using CDA to analyse political discourse such as (Horvath, 2000; Hunter, 1991; Morris, 2004). We point out that in this study, the keywords were selected in tandem with the divergent issues raised in the Portfolio Balance. This exemplified in the Table 4.1 as follows.

The above key phrase analyses indicate that the phrases, Portfolio Balance” and “Grand Coalition Government” have the highest frequency count of 8 and 7 respectively in Raila’s initiator text and reiterated by Mwai Kibaki in his frequent use Coalition cabinet(7repeats). Raila foregrounds the contentious issues Viz: dissolution of current cabinet (1 frequency count); equal partnership (3 frequency count), allocation of ministries (4 frequency count), formation of coalition cabinet (5 frequency count), and sharing of executive powers (1 frequency count. Kibaki’s response is evidenced in textual silences.

The expression “Grand Coalition Government” is among the leading phrases with 7 frequency count and appears to have a semantic link to other use of key phrases such as “equal partners” (3 frequency count), “sharing executive power” (4 frequency count), “formation of government” (4 frequency count ), and “Portfolio Balance and its collocations” (8 frequency count by Raila Odinga and (10 by Mwai Kibaki respectively, which might be interpreted to attest to the divergent decisions on the issue of power. Further, the use of this expression is in agreement with the use of the key word “cabinet” and “consultations.”
Table 4.1 Frequency Count of Lexicalisation in the Texts

<table>
<thead>
<tr>
<th>Key phrase and collocations vs Portfolio Balance</th>
<th>PB 4.1</th>
<th>PB 4.2</th>
<th>PB 4.3</th>
<th>PB 4.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portfolio balance (stalemate)/this matter</td>
<td>08</td>
<td>10</td>
<td>02</td>
<td>00</td>
</tr>
<tr>
<td>Dissolution of half cabinet</td>
<td>01</td>
<td>00</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>Allocation /cede of Ministries</td>
<td>04</td>
<td>00</td>
<td>04</td>
<td>00</td>
</tr>
<tr>
<td>National Accord and Reconciliation Act</td>
<td>04</td>
<td>02</td>
<td>05</td>
<td>07</td>
</tr>
<tr>
<td>Equal partners/spirit of partnership</td>
<td>03</td>
<td>00</td>
<td>00</td>
<td>03</td>
</tr>
<tr>
<td>Grand Coalition government</td>
<td>07</td>
<td>00</td>
<td>03</td>
<td>00</td>
</tr>
<tr>
<td>Constitution/amendment/law</td>
<td>01</td>
<td>00</td>
<td>02</td>
<td>03</td>
</tr>
<tr>
<td>Coalition cabinet(formation)</td>
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<td>07</td>
<td>05</td>
<td>03</td>
</tr>
<tr>
<td>Expanded/enlarged /bloated cabinet</td>
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<td>01</td>
<td>01</td>
<td>01</td>
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<tr>
<td>New preconditions and ultimatums</td>
<td>00</td>
<td>01</td>
<td>00</td>
<td>01</td>
</tr>
<tr>
<td>Sharing (monopolize)executive power</td>
<td>01</td>
<td>00</td>
<td>02</td>
<td>04</td>
</tr>
<tr>
<td>Transfer of power</td>
<td>00</td>
<td>00</td>
<td>00</td>
<td>01</td>
</tr>
<tr>
<td>Consultation(s)/ meeting(s)</td>
<td>02</td>
<td>03</td>
<td>00</td>
<td>01</td>
</tr>
<tr>
<td>Joint team of four members</td>
<td>01</td>
<td>00</td>
<td>01</td>
<td>00</td>
</tr>
<tr>
<td>Concrete Agreements</td>
<td>01</td>
<td>00</td>
<td>04</td>
<td>00</td>
</tr>
<tr>
<td>Retraction/renege agreements</td>
<td>00</td>
<td>00</td>
<td>02</td>
<td>00</td>
</tr>
<tr>
<td>Unilateral appointments</td>
<td>00</td>
<td>00</td>
<td>01</td>
<td>00</td>
</tr>
<tr>
<td>Government coalition</td>
<td>00</td>
<td>00</td>
<td>00</td>
<td>08</td>
</tr>
</tbody>
</table>

Source: Author’s Analysis (2014)

LEXICALISATION IN RAILA ODINGA’S TEXTS

Lexicalisation portrays the principals’ attitude and decision towards the resolution of contentious issues in the Portfolio Balance. The meeting adjourned...after you declined further discussions... and insisted on your proposed allocation of Ministries (Line 2 PB 4.1).

This opinion is also evidenced in the use of key words like “decline”, and “insisted“ which implies despotic behaviour, accusatory tone and a non-compromisable attitude on the part Kibaki as concerns the contentious issues.

- ... our party now maintains that the Grand Coalition cabinet should not exceed 34 ministries. (11 PB 4.1)
- It is important I reiterate that the above represents and remains our party’s irreducible minimum position (13 PB 4.1). The bolded words indicate a hard liner negotiation and presupposing assertion of power by Raila. The words reveal threats, distrust, adversarial conception which all point out to brinkmanship and applying pressure to negotiate.

- Our party is deeply concerned ...is increasing uncertainty and anxiety in the country. It is escalating mistrust that we as leaders were expected to eliminate by establishment of the Grand Coalition (3 PB 4.1)

The choice of the bolded words above by Raila construct Raila as a hard liner who applies pressure through threats to negotiate. This further reveals underlying power issues.

- The National Accord and Reconciliation Act is already in force. It must be understood that ODM and PNU are equal partners in the Grand Coalition (4 PB 4.1)

The use of “must” and “equal partners” also presuppose the threat and a warning/reminder about the issue of having equal powers as the former President.

- With cries of jubilation and Happy New Years, (sic) Kenyans on 28th February began to breathe freely again as the National Accord brokered by Mr. Kofi Annan was signed by President Kibaki and myself. The terror and fear they had been living under the hands of mobs, militias and government forces was finally over... (1PB 4.3)
- But since then Kenyans have observed with growing dismay and anxiety that not a single concrete agreement has been achieved on any aspect of the new coalition government. Our nation is a drift and without direction, and with each passing day, our problems are mounting. (2 PB 4.3). To overcome this terrible impasse and another looming crisis... (3PB 4.3).

The choice of the words depict lawlessness especially before the signing of the Accord. They invoke paranoia and paints a country on the verge of collapse. His lexicalisation thus evidence the art of brinkmanship and consequently
a call which creates fear into the citizens to side with him in his front for the formation of the Coalition Government.

- On Saturday, I received from Ambassador Muthaura a letter unilaterally indicating that the cabinet to be announced would be formed on the basis of an enclosed list of ministries and their allocations that we had rejected on 2nd April! The agreements we reached in our 3rd April meeting were nowhere to be seen. (8 PB 4.3)

The bolded words advance the argument that Kibaki is a soft bargainer because he yields to others’ demands which reveal different centres of power apart from the two Principals. It also reveals single party dominance and power hoarding by the PNU side.

- This latest crisis in Portfolio balance captures the astonishing lengths PNU is willing to go to ensure that it continues to monopolize power (5 PB 4.3).
- In PNU’s interpretation, the Constitution grants the President exclusive executive power to run this country on his own, and that these powers supersede all the provisions of the Accord.

REJOINDER FROM MWAI KIBAKI

- The meeting yesterday was a culmination of several consultation meetings between myself and Honourable Raila Odinga, in accordance with the National and Reconciliation Act, 2008.(2PB 4.2)
- I have accorded this matter my personal attention and highest priority throughout.(3 PB 4.2)
- I realize the importance of this matter to all Kenyans and the anxiety it is causing and it was my personal desire to have this matter concluded today.(4PB 4.2)

The highlighted words serve as legitimation against the FTA levelled against him by Raila. The words portray Kibaki as a principled negotiator –reference to the Accord. However, they also construct him as a soft bargainer – views the negotiation as being close to competition thus chooses a gentle style of bargaining which is also evidenced by textual silences elsewhere in the texts.

- I, on my part, have been ready since last week and was expecting to announce an expanded cabinet yesterday and have been ready to do so today.(10 PB 4.2)
- I remain ready and willing to conclude the formation of the Coalition Cabinet at the earliest possible opportunity.(11PB 4.2)

Mwai Kibaki’s lexicalisation shows his optimism in resolving the Portfolio which is evidenced in the repetition of the words; …been ready; [1]I remain ready and willing to conclude the … Cabinet. The repetition of the word ‘ready’ stresses his political commitment to end the crisis as well as expediting the negotiation process.

- Government Coalition has been surprised by the statement made by ODM in regard to the implementation of the National Accord Act and the related Constitutional Amendment. The ODM in their statement allege that the Government Coalition is dragging its feet in the formation of the Cabinet. This is untrue and contrary to the reality. In actual fact, the Government Coalition is the one that has been prodding ODM to respond to the urgency of formation of Cabinet and the ball has been in their court for the last two weeks. (1 PB 4.4)

Note the repetition of the phrase “Government Coalition.” In fact it is repeated 7 times in the whole text. It is used as a unification strategy and as a collectivism. The implication being that when confronted with weighty issues of national concern, the leader seek for strength and support from their in-group. This may imply that they use their group to rubber-stamp their decisions. Further the use of the idioms signal a legitimating strategy against the FTAs and rationalizing their actions.

- Bearing all these activities it is, therefore, dishonest on the part of the ODM to claim nothing has happened since the signing of the Accord on February 28, 2008 (3PB 4.4)
- Greater progress will be made through working together as coalition partners and not through confrontational public shows. ODM should now move from confrontational and activist politics of the opposition into responsible politics of governance (4PB 4.4).

The highlighted words reveal a deprecatory tone which act as a warning to the ODM side to cease from using intensifying discourse which could polarize the nation. The warning also is an indicator of power.
• The sharing of power, as clearly spelled out in the Accord is within the framework of the Constitution with all the checks and balances therein. In this regard, sharing of power in the Accord does not mean TRANSFER of power. What we have is indeed sharing and apportionment of responsibilities (5PB 4.4).

• The ODM should understand clearly with no uncertain terms that the Executive Authority of the state is vested in the President. The assumption that these powers are irrelevant as a result of the National Accord and Reconciliation Act is irresponsible, reckless and distortion of the facts and the law (6PB 4.4).

Through reference to the Constitution, Kibaki presents himself as a principled bargainer but the fact that he disregards the Accord on the issue of the powers of the PM, portrays him as a hard bargainer whose ultimate goal is to assert his power and single party dominance by relying on the Constitution only. The choice of the words, “dishonest, irresponsible, reckless, distortion of facts…” reinforce his argument that the PM does not have executive powers. This implies that he was the one holding the veto power therefore the underlying social struggle between the former PM and the former President.

CONCLUSION

Both Mwai Kibaki and Raila Odinga chose their words carefully to exonerate themselves from the face threatening acts presented by either side. Conclusively, both principals adopted a register that was personalizing. Their lexicalisation signals their power, political position as well as practical reasoning strategies in influencing each other. At the interaction level, politeness is signaled by the formal modes of address like your Excellency,” Prime Minister, throughout exchanges, both principals presents their message in a defensive tone following the counter-accusations made by the other side, respectively. Furthermore, the use of the words like “invite”, ‘appeal’, and ‘willing’ presents them as being ready to continue with the discussions on the Portfolio Balance list.

From the foregoing discussion and findings, we can observe that the former Premier uses slightly intensifying words while the former President tries to smooth over divides, which might point to the alleged “stolen victory” convictions on the part of the former. The former PM was known for his strong connection to the ideology of “Restoration of Democracy” in Kenya since the 1980’s. As mentioned earlier, the former President is more restrained in his choice of words and appears to be more “passive” to the tense political connotations expressed by the former PM in his discourse. However, he does not divert from the same view. It can be argued that the direction of criticism in the discourses is one significant difference between the two Principals.

The role of language as the medium through which power is appropriated, negotiated, deployed and distributed cannot be overemphasized. This study established that language played a great role in informing the actions and decisions of the two principals in the Kenyan Grand Coalition post-consultation negotiation discourse, whenever an inappropriate or otherwise demeaning or inciting language was adopted by one party, the other was quick to amicably point it out and request for moderate use of language. This provided checks and balances against any inflammatory discourse therefore the sustained peace and calm amidst an otherwise explosive situation.

Last but not least, the principals used language that was mindful of the other, it revealed rational arguments that could be justified using the legal documents, particularly, the National Accord and the Constitution of Kenya (2010), persuasive language encoding tolerance and optimism and also reassurance for continued political support notwithstanding the competition for power. A conclusion can therefore be made that despite a contested, competitive and precarious relationship between the coalition partners, notwithstanding the loopholes in the Agreement, a respectful, reasonable, mindful, mitigated use of language during negotiations on contentious issues of concern served resolve the Portfolio Balance issue and as a result averted conflict leading to successful negotiations. This positive use of language by the coalition partners to negotiate their political differences is important for the success of any coalition government.

REFERENCES

RECONSTRUCTIONIST ANALYSIS ON THE RELEVANCE OF SECONDARY SCHOOL CURRICULUM CONTENT IN PROMOTING NATIONAL COHESION AMONG STUDENTS IN MACHAKOS TOWN SUB-COUNTY, KENYA

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ABSTRACT
Education is the primary means of promoting national cohesion, international cooperation as well as socio-economic development. Through school curricula, education enables a country to achieve its needs and aspirations. The National Cohesion and Integration Commission has emphasized the importance of education in promoting cohesion and integration among Kenyan communities. However, the country is faced with ethnic divisions, religious intolerance and violence and this raises concerns on relevance of the school curricula content in promoting national cohesion. This study investigated the relevance of secondary school curricula content in promoting national cohesion. The study was based on the ideals and principles of a school curriculum as advocated by re-constructionism philosophy. Descriptive survey research design was adopted. A sample size of 409 respondents comprising of 360 student leaders, 48 teachers and Sub-County Quality Assurance and Standards Officer was used. Purposive sampling was adopted to select the
respondents. Questionnaires and interview schedule were used in data collection. Validity of research instrument was ascertained by experts in Faculty of Education and Resources Development. Reliability of instruments was estimated using Cronbach coefficient alpha method and the coefficients obtained were 0.78 and 0.81 for teachers and student leaders’ questionnaire, respectively. Descriptive statistics were used to analyze data. Secondary school curricula content gave the students little opportunity to reflect critically on issues affecting national cohesion which is attributed to lack of practical skills on issues related to national cohesion. The study recommends a review of secondary school curricula content to reflect on emerging issues on national cohesion and integration. This study provides critical information to educational stakeholders on the relevance of secondary school curricula content in promoting national cohesion.

Key words: Cohesion, Curriculum design, Re-constructionism philosophy,

INTRODUCTION

Education is a vital tool in the developmental process of any given nation (Ojiambo, 2009). Education facilitates development and stability of a nation through schools supporting the existing political and economic system in the nation. Bowers (1997) posits that schools through the prescribed curriculum content develop national unity while promoting economic development. Further, education fosters transmission of values, norms and expectations related to national cohesion. National cohesion is a process and an outcome of instilling and enabling all citizens to have a sense and a feeling that they are members of the same nation engaged in a common enterprise, facing shared challenges and opportunities (Republic of Kenya, 2007). Thus, national cohesion presupposes national development in a country.

Since Kenyan independence, the government has recognized the need to promote national unity and appreciation of diversity. The initiatives put in place towards achieving this endeavour focused on the national goals of education which emphasize national unity, moral and religious values, social equality and responsible citizenship as the key in enhancing harmonious co-existence among citizens (MOE, 2010). Education is seen as the primary means of social mobility, national cohesion and socio-economic development. The Ominde Commission Report identified education as a critical pillar in promoting national cohesion in Kenya (Republic of Kenya, 1964). Education is a central component of the nation’s developmental process. The Kenya Vision 2030, which is the blue print of development in Kenya aims at making Kenya a globally competitive and prosperous nation with high quality of life by the year 2030 (ROK, 2007). Kenya recognizes that education and training of all individuals is fundamental to the success of Vision 2030.

Reconstructionism is a philosophy that centers on the idea of constant change and emphasizes on addressing of social questions to create a better society and worldwide democracy through education (Brameld, 1956). Reconstructionism philosophy advocates for a school curriculum content that emphasizes social reform as the aim of education. Brameld (1965) notes that the school curriculum content should focus on student experience by taking social action on real problems, such as violence, hunger, ethnicity, international terrorism, religious intolerance and inequality. Counts (1971) stresses that curriculum content should include units on such issues as religious intolerance, ethnic tension, world poverty, gender differences, and socio economic domination. This is because reconstructionist educators focus on a content of learning that highlights social reform as the aim of education. The curriculum content for the reconstructionism philosophy involves the students being active in the community (Brameld, 1971). Students benefit from interaction in society on specific matters. Social sciences such as anthropology, economics, sociology, political science, and psychology are useful in providing the background and methods for planned social change. This will make the curriculum content to be relevant in promoting national cohesion. This is to enable individuals to become useful citizens in the society.

The objective of secondary school education in Kenya is to prepare students to make a positive contribution to the development of society and to acquire attributes of national patriotism, self-respect, self-reliance, cooperation, adaptability, a sense of purpose and self-discipline (Sifuna, 1990). Rafique (2009) observed that a national curriculum content of a country is the backbone of educational system and should remain the government’s subject for promoting national cohesion. The curriculum content of the school reflects layered cultural understandings of what is considered necessary for young people to know or experience if they are to take their place in the social and cultural order. Counts (1971) points out that the scope and nature of the curriculum content are viewed as critically important for teachers, students and other educational stakeholders. The curriculum content should examine world problems and seek to resolve them so that people can improve the quality of life in the nation as a whole (Dewey, 1944). A core curriculum is a course of study which is deemed central and usually made mandatory for all students in the school system. Curriculum content should thus relate to relevant contemporary issues of a country.

According to Oluoch (2002) secondary education in Kenya covers six major areas of curricula activities: communication,
mathematics, science, humanities, applied education and physical education. This is geared towards meeting the needs of both the students who terminate their education after secondary school and those who proceed to higher education. Education equips citizens with understanding and knowledge that enable them to make informed choices about their lives and those facing Kenyan society. However, a critical examination of Kenya’s Vision 2030 indicate that there is minimal emphasis on the role of education and especially the curriculum content in enabling Kenya become a one nation by the year 2030 (Ojiambo, 2009). Thus the role of education in the process requires redefinition and more so with emphasis on secondary school curriculum content.

Despite the goal of Kenyan education system of fostering nationalism, patriotism as well as national unity; national harmony has not been achieved (Ojiambo, 2009). A research done by Kenya Institute of Curriculum Development (KICD) on secondary school curriculum in Kenya showed that the current curriculum had not played its role effectively in promoting national cohesion especially in view of the post-election violence that the country experienced in 2008 (KICD, 2013). A summative evaluation of the secondary school curriculum carried out by KICD revealed that the negative practices that learners encounter do not enable them to internalize the values of nationalism, patriotism, national unity and cohesion as spelt out in the national goals of education and the National Cohesion and Integration Act. On the contrary, when children watch opinion leaders in society talk ill of some ethnic groups, defy court orders and get away with it, the children start to internalize values that create national disharmony such as ethnicity, religious intolerance, socio-economic domination and gender differences.

The nation’s cohesion and security has continued to disintegrate under the political system founded around ethnic differentiation and segmentation together with reintroduction of multi-party politics in Kenya (Kenya National Youth charter, 2013). MOE (2010) points out that there is a mismatch between what is taught and what is expected as education products of the society. Indeed there is need to investigate the relevance of secondary school curriculum content in promoting national cohesion as a social and national issue. Machakos Town Sub-County was chosen because it is a cosmopolitan region occupied by people from diverse communities whose children interact together and especially in schools. This study investigated the relevance of secondary school curriculum in promoting national cohesion in Machakos Town Sub-County. The analysis was based on the ideals of a curriculum as advocated by reconstructionism philosophy.

Statement of the Problem

The Kenyan goals of education underline the importance of education in promoting national cohesion and peaceful coexistence, a prerequisite component for national development. Through the school curriculum content, education enables a country to achieve its needs and aspirations. National Cohesion and Integration Commission (NCIC) has emphasized the importance of education in the achievement of long term cohesion and integration among Kenyan communities. Despite the emphasis however, ethnic divisions, clashes, religious intolerance and other social ills have been witnessed over the years and worsening with the advent of multi-partism in Kenya; a vice that threatens the development of the country. This raises the question on the relevance of the school curriculum content in promoting national cohesion. Thus the study sought to investigate the relevance of secondary school curriculum content in promoting national cohesion among students in Machakos Town Sub-County.

METHODOLOGY

The study used descriptive survey research design. This design was adopted for this research because it involved studying conditions or events that had already occurred. The description of the phenomenon under study was enriched with philosophical techniques of critical analysis and conceptual analysis to ensure that elaborate analysis and description was done. A sample of 409 respondents was used in the study which comprised of 360 student leaders, 48 teachers and the Sub-County QASO. Questionnaires and interview schedule were used for data collection. Descriptive statistics was used to analyze quantitative data obtained using frequency counts and percentages. Qualitative data obtained from open ended questions was organized into themes and reported thematically in line with the objectives of the study.

RESULTS AND DISCUSSION

The objective of the study sought to determine the relevance of secondary school curriculum content in promoting national cohesion. Responses were obtained from student leaders on the extent to which the secondary school curriculum content gave students an opportunity to reflect critically on issues related to national cohesion. The responses from student leaders are as shown in Table 1.
Table 1. Student Leaders’ Responses on Relevance of Curriculum Content in Promoting National Cohesion

<table>
<thead>
<tr>
<th>Issues related to national cohesion</th>
<th>V. great extent</th>
<th>Great extent</th>
<th>No opinion</th>
<th>Small extent</th>
<th>No extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Religious tolerance</td>
<td>15</td>
<td>4.2</td>
<td>44</td>
<td>12.2</td>
<td>28</td>
</tr>
<tr>
<td>Ethnic co-existence</td>
<td>9</td>
<td>2.5</td>
<td>58</td>
<td>16.1</td>
<td>68</td>
</tr>
<tr>
<td>Gender equity</td>
<td>29</td>
<td>8.1</td>
<td>28</td>
<td>7.8</td>
<td>39</td>
</tr>
<tr>
<td>Socio-economic integration</td>
<td>16</td>
<td>4.4</td>
<td>72</td>
<td>20</td>
<td>55</td>
</tr>
<tr>
<td>Racial diversity</td>
<td>36</td>
<td>13.1</td>
<td>47</td>
<td>13.1</td>
<td>88</td>
</tr>
</tbody>
</table>

Majority (43.3%) of the student leaders indicated that school curriculum content did not give them an opportunity to critically reflect on issues related to religious tolerance, 32.5% indicated that curriculum content gave them opportunity to a small extent, 12.2% indicated great extent, 7.8 % held no opinion, while 4.2% indicated that curriculum content gave them an opportunity to a very great extent (Table 1). On ethnic co-existence, 36.9%, indicated that school curriculum content gave them opportunity to a small extent to reflect critically on this issue while 25.6% indicated no extent. Only 16.1% indicated that curriculum content gave them opportunity to reflect on this issue to a great extent while 2.5% indicated a very great extent.

As relates to gender equity, 39.7% indicated that school curriculum content did not give them an opportunity to reflect critically on gender equity, 33.6% indicated a small extent, 10.8% held no opinion, 8.1% and 7.8% of the respondents indicated a great extent and very great extent respectively. On socio-economic integration, 36.7% indicated that curriculum content gave them an opportunity to reflect critically to a small extent, while 23.6% indicated no extent. A total of 20% indicated a great extent, while 4.4% indicated a very great extent. Table 1 further showed that 28.3% indicated that curriculum content gave them an opportunity reflect critically on racial diversity to a small extent, 24.4% held no opinion, 24.2% indicated no extent while 13.1% and 10.0% indicated a great extent and very great extent respectively. A similar item was included in the teachers’ instrument which sought information on the extent to which secondary school curriculum content gave students an opportunity to reflect critically on issues related to national cohesion. The responses from teachers were as shown in Table 2.

Table 2. Teachers’ Responses on Relevance of Curriculum Content in Promoting National Cohesion

<table>
<thead>
<tr>
<th>Issues related to national cohesion</th>
<th>V. great extent</th>
<th>Great extent</th>
<th>No opinion</th>
<th>Small extent</th>
<th>No extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Religious tolerance</td>
<td>2</td>
<td>4.2</td>
<td>5</td>
<td>10.4</td>
<td>7</td>
</tr>
<tr>
<td>Ethnic co-existence</td>
<td>3</td>
<td>6.2</td>
<td>2</td>
<td>4.2</td>
<td>5</td>
</tr>
<tr>
<td>Gender equity</td>
<td>5</td>
<td>10.4</td>
<td>6</td>
<td>12.5</td>
<td>8</td>
</tr>
<tr>
<td>Socio-economic integration</td>
<td>3</td>
<td>6.3</td>
<td>4</td>
<td>8.3</td>
<td>4</td>
</tr>
<tr>
<td>Racial diversity</td>
<td>3</td>
<td>6.3</td>
<td>7</td>
<td>14.6</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 2 shows that 50% of the teachers indicated that school curriculum content did not give students an opportunity to reflect critically on religion tolerance, 20.8% indicated a small extent, 14.6% held no opinion while 10.4% and 4.2% indicated a great extent and a very great extent respectively. On ethnic coexistence, 41.7% indicated that school curriculum content gave students an opportunity to reflect critically on the issue to a small extent, 37.5% indicated no extent, 10.4% held no opinion while 4.2% and 6.2% indicated a great extent and very great extent respectively. On socio-economic integration, 45.8% indicated that school curriculum content gave students an opportunity to reflect critically on the issues to a small extent, 22.9% indicated no extent while 6.3% indicated a very great extent. Table 2 further showed that 45.8% of the teachers indicated that school curriculum content did not give students an opportunity to reflect critically on racial diversity, 16.7% indicated that the curriculum content gave students opportunity to a small extent, 14.6% indicated a great extent while 6.3% indicated a very great extent.

The information in Table 1 and Table 2 shows that in most of the issues the student leaders and teachers responses concur. The findings suggest that the curriculum content gave students little opportunity to reflect critically on issues related to national cohesion, that is, religious tolerance, ethnic co-existence, gender equity, socio economic integration and racial diversity. This means that the curriculum content does not consider the philosophical questions such as what
knowledge is considered most worthwhile and its relevance to the contemporary issues of the country. The content taught should be selected for its relevance and fitness to the emerging needs of students and to the society it is intended to serve. The curriculum content should enable an individual to develop in all aspects through identifying and solving social problems affecting national cohesions. According to Brameld (1966) teachers should develop constructive social change and reform among students by exploring social problems, suggesting alternative perspectives and facilitating students on analysis of these problems through content presentation.

According to reconstructionism philosophy, the curriculum content should involve practical application of skills for the learners to relate what they learn in solving problems in the society. Lack of application of practical skills could have probably led to this observation as majority of respondents noted it as a weakness of curriculum content in promoting national cohesion. Basing on the ideals of curriculum as advocated by reconstructionism philosophy, the study concludes that curriculum content gave the respondents little opportunity to reflect critically on issues related to national cohesion suggesting that there is no relevance of curriculum content in promoting national cohesion.

The study determined from the student leaders the extent to which curriculum content promotes collaborative interactions under different components of national cohesion. The responses of student leaders is shown in Table 3.

Table 3. Student Leaders’ Responses on Collaborative Interactions

<table>
<thead>
<tr>
<th>Components of national cohesion</th>
<th>V. great extent</th>
<th>Great extent</th>
<th>No opinion</th>
<th>Small extent</th>
<th>No extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Religious practices and beliefs</td>
<td>11</td>
<td>47</td>
<td>18</td>
<td>117</td>
<td>167</td>
</tr>
<tr>
<td>Cultural backgrounds</td>
<td>24</td>
<td>28</td>
<td>64</td>
<td>90</td>
<td>154</td>
</tr>
<tr>
<td>Gender differences</td>
<td>44</td>
<td>49</td>
<td>79</td>
<td>101</td>
<td>87</td>
</tr>
<tr>
<td>Socio-economic backgrounds</td>
<td>21</td>
<td>24</td>
<td>85</td>
<td>123</td>
<td>107</td>
</tr>
<tr>
<td>Racial diversity</td>
<td>45</td>
<td>43</td>
<td>53</td>
<td>93</td>
<td>126</td>
</tr>
</tbody>
</table>

The information in Table 3 shows that 46.4% of the student leaders indicated that curriculum content does not promote collaborative interactions as relates to religious practices and beliefs. On cultural backgrounds, 42.8% of the student leaders indicated that curriculum content do not promote collaborative interactions on this issue while 28.1% of the student leaders indicated that curriculum content promotes collaborative interactions under gender differences to a small extent. On socio-economic backgrounds, 34.2% of the student leaders indicated that curriculum content promotes collaborative interactions under socio-economic backgrounds to a small extent 25.8% indicated it does so to a small extent.

The study determined teachers’ responses on the extent to which curriculum content promotes collaborative interactions among students. The responses of teachers are as shown in Table 4. Information in Table 4 shows that, majority (50%) of the teachers indicated that school curriculum content do not promote collaborative interactions under religious practices and beliefs while 37.5% indicated that curriculum content promote collaborative interactions under cultural backgrounds to a small extent. On gender difference, 41.7% of the teachers indicated that curriculum content did not promote collaborative interactions on this issue while 47.9% of the teachers indicated that curriculum content promotes collaborative interactions under socio-economic backgrounds to a small extent.

The findings presented in Table 3 and 4 shows that there is concurrence among the respondents that curriculum content does not promote collaborative interactions under religious practices and beliefs, cultural backgrounds, gender differences, socio-economic backgrounds and racial diversity. This implies that the students are not fully involved in sharing knowledge among themselves. A critical characteristic of collaborative interactions in classrooms is that students are not segregated according to supposed ability, achievement, interests, or any other characteristic. Segregation weakens collaboration and impoverishes the classroom by depriving all students of opportunities to learn from and with each other. Shared knowledge mediates learning, and heterogeneous groups of students are essential characteristics of collaborative interactions which promote national cohesion. This is in line with Woolman (2001) who observed that national stability and collaborative interactions within a country depend on effective integration of curriculum content with a sustainable policy of national cohesion in relation to socio-economic integration, religion tolerance, gender, ethnic background and racial diversity. This study suggests that there is no relevance of school curriculum content in promoting national cohesion under collaborative interactions.
Table 4. Teachers’ Responses on Collaborative interactions

<table>
<thead>
<tr>
<th>Components of national cohesion,</th>
<th>V. great extent</th>
<th>Great extent</th>
<th>No opinion</th>
<th>Small extent</th>
<th>No extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Religious practices and beliefs</td>
<td>F</td>
<td>%</td>
<td>F</td>
<td>%</td>
<td>F</td>
</tr>
<tr>
<td>Cultural backgrounds</td>
<td>1</td>
<td>2.1</td>
<td>4</td>
<td>8.3</td>
<td>8</td>
</tr>
<tr>
<td>Gender differences</td>
<td>3</td>
<td>6.3</td>
<td>4</td>
<td>8.3</td>
<td>8</td>
</tr>
<tr>
<td>Socio-economic backgrounds</td>
<td>2</td>
<td>4.2</td>
<td>5</td>
<td>10.4</td>
<td>12</td>
</tr>
<tr>
<td>Racial diversity</td>
<td>5</td>
<td>10.4</td>
<td>4</td>
<td>8.3</td>
<td>3</td>
</tr>
</tbody>
</table>

CONCLUSION

The researcher explored on the relevance of secondary school curriculum in promoting national cohesion among students in Machakos Town Sub-County. From the findings, the researcher concluded that the curriculum content gave students little opportunity to reflect critically on issues related to national cohesion. This could be attributed to lack of practical skills on issues related to national cohesion. The secondary school curriculum content does not enable the learners to internalize the values of nationalism and patriotism through the curriculum content. The curriculum content did not promote collaborative interactions under issues related to national cohesion.

RECOMMENDATION

There is need to review the secondary curriculum content to enhance flexibility and responsiveness to the needs and interests of all learners towards promoting national cohesion. All subjects taught in secondary schools should include content related to issues of national cohesion. The study also recommends review on secondary school curriculum content to reflect on emerging issues on national cohesion and sensitization on all educational stakeholders on the importance of the role that education and in particular secondary school curriculum content plays in promoting harmonious living in the society.

REFERENCES

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ABSTRACT
The Government of Kenya introduced Performance Contracting (PC) in the public service to improve service delivery. This study investigated the effectiveness of PC in service delivery in the public universities in Kenya. It evaluated the level of involvement of university staff and students in PC, the effectiveness of PC in improving customer satisfaction and accountability, as well as feedback and conflict resolution. It was based on the assumption that respondents were aware of PC policies. It used descriptive survey design and targeted 132,021 subjects, comprising 84,290 students, 15,937 academic staff, 31,789 non-teaching staff and 5 directors of PC in five public universities. A normal sample size of 384 respondents was appropriate, but 500 were used to compensate for attrition. Purposive sampling was used to select directors and simple random sampling to select academic staff, non-academic staff and students. Questionnaires and interview schedules were used in data collection. Piloting was done in three public universities which had similar characteristics with the sampled universities. Reliability was tested using split half technique and Cronbach formula was used to compute reliability, resulting in 0.81, 0.78, 0.73 and 0.79 for academic staff, non-academic staff, directors and students, respectively. Data analysis was done using SPSS. A response rate of 93% was achieved. Majority of the staff were involved in PC and a positive correlation between level of staff involvement in PC and improvement in service delivery (0.699, $\alpha=0.05$) resulted. A positive correlation between: effectiveness of PC and customer satisfaction (0.807), as well as feedback process (0.90) resulted. Public universities should regularly sensitize staff and students on PC and service delivery, reward staff that perform well in PC and involve students in development of service delivery charters. The Government should strengthen public universities in carrying out PC to progressively improve service delivery.

Key words: Effectiveness, Performance Contracting, Service Delivery

INTRODUCTION
Background to the Study
The primary development goal for any country is to achieve broad-based, sustainable improvement in the standards and the quality of life for its citizens (GOK, 2010). This can be achieved by effective and quality delivery of services by the human resource in various public and private institutions (Kobia and Mohammed, 2006). According to Armstrong (2006) human resource refers to a set of individuals who make up the work force of an organization, business or economy. Development of human resource results to increase in productivity, eradication of social and economical backwardness and social and political revolution (Balgon, 2003). Effective human resource management enables employees to contribute effectively to the whole institution and to the accomplishment of the organizational goals and objectives (Balgon, 2003). Human resource management is moving away from traditional personnel administration and transactional roles which are increasingly outsourced. Human resource management is expected to add value to the strategic utilization of employees and employee programmes in measurable ways (Armstrong, 2006). The human resource aspect within an institution contributes to eighty percent of the institutional value and this implies that if people are not managed properly the organization faces a chance of falling apart ((Armstrong, 2006). This shows the critical role that human resource plays in organizations.

When the delivery of services is constrained or becomes ineffective, it affects the quality of life of the people and nations development process (Kobia and Mohammed, 2006). This shows the consequences of service delivery to individual and societies which gives impetus to the current study. According to Balgon, (2003) the civil service inherited at independence had not been designed to grapple with development needs of post-independence Kenya. The gradual erosion of the ethics and accountability has continued to bedevil the public sector reforms that are meant to address these challenges and therefore, have achieved minimal results (Balgon, 2003). This led to the launching of the reform efforts necessitated by need to address the wanting performance of the public service. Performance contract system originated in France in the late 1960’s and has been used in about 30 developing countries in the last fifteen years. The problems that have inhibited the performance of government agencies are largely common and have been identified as excessive controls, multiplicity of principles, frequent political interference, poor management and outright mismanaging. The fundamental principle of performance contracting is the devolved management style where emphasis is management by outcome rather than management by process (RBM Guide, 2005).

Performance contracting is a freely negotiated performance agreement between the government acting as the owner of public agency on one hand and the management of the agency on the other hand (GOK, 2010). The performance contract specifies the mutual performance obligations, intentions and responsibilities of the two parties. It organizes and defines tasks so that management can perform them systematically, purposefully and with reasonable probability of achievement. These also assist in developing points of view, concepts and approaches to determine what should be done and how to go about doing it. The expected outcome of the introduction of the performance contracts includes
improved service delivery, improved efficiency in resource utilization, institutionalizing of a performance oriented culture in institutions of higher learning, measurement and evaluation of performance, linking rewards and sanctions to measurable performance, retention or elimination of public agencies on exchequer funding, instilling accountability for results at all levels and enhancing performance in institutions of higher learning. These government initiatives lack the performance information system, comprehensive evaluation system and performance incentive system (GOK, 2005). It is within this context that the Kenyan Government introduced performance contract as a management tool for measuring performance against negotiated performance targets (GOK, 2003). To ensure that standards of the quality life are achieved, performance contracting use has been acclaimed as an effective and promising means of improving the services in public sector all over the world (GOK, 2010).

There are three types of public institutions that sign Performance Contracts (PCs) in Kenya. The parties to the contracts are as follows: Performance Contracts for Government Departments/ Ministries which is signed between the Cabinet Secretary (Principal) and the relevant Permanent Secretary (Agent). PCs for Local Authorities (Municipalities) which is signed between the Permanent Secretary, Ministry of Local Government (Principal) and the Council of Local Authority (Agent) (GOK, 2003). Performance Contracts for State Corporations which is signed between the Permanent Secretary (Principal) of the administrative ministry in charge of supervising the State Corporation and the Board of Directors (Agent) of the State Corporation. Public universities are factored in this category where the performance contract is signed between the Permanent Secretary and the respective university councils which constitute the management board.

The performance contracting reform is not readily accepted by everybody in the public service, especially those who might feel exposed negatively in terms of poor performance by the outcomes. Several questions are being raised as to whether the system is good enough for public service as any loophole within the system are being investigated with a view of discrediting it (GOK, 2011). The GOK (2011) Report on Evaluation of Performance Contracting notes that cases of resistance on the grading structure especially in state corporations where sentiments have been expressed that it is unfair to grade state corporations operating at different sectors of the economy together. Some state corporations would prefer to be grouped and ranked differently citing their uniqueness emerging from their areas of service delivery, size in terms of turnover, number of employees and even mandate.

Balogun (2003) notes that the general public and even high ranking public servants have embraced the idea of performance contracting and measuring performance as it has developed a culture of professionalism, competitiveness, innovation and target setting. On the negative side, Balogun(2003) notes that despite the signing and evaluations of performance contracts between the respective public agencies with the government of Kenya, the culture of non-performing, poor service delivery, lack of accountability and inefficiency is fighting back to resist the performance contracting reform in many state corporations. No studies have been done to evaluate the effectiveness of performance contracting on service delivery in public universities. It is against this background that the need arises for a research to evaluate the effectiveness of performance contracting on service delivery in public universities in Kenya.

**Statement of the Problem**

The government of Kenya is tasked with the responsibility of providing services to its citizens. This is done through the public service. To achieve quality service delivery, the government has initiated major reforms in the public sector, including state corporations like the public universities. Performance contracting is the current reform measure. Despite the gains anticipated with the introduction of performance contracting, concerns have been raised on its effectiveness in promoting quality service delivery in public universities in Kenya. Concerns have been raised as to whether involving university staff and students in performance contracting significantly improves service delivery in the public universities. This study therefore, will seek to evaluate the effectiveness of performance contracting on service delivery in public universities in Kenya.

**Objectives of the Study**

1. To establish the extent of involvement of the university staff and students in performance contracting activities in public universities in Kenya.
2. To evaluate the extent to which involvement of the staff in performance contracting activities improves service delivery in the public universities in Kenya.

**Hypothesis**

There is no statistically significant relationship between the involvement of the university staff in performance contracting activities and improving service delivery in public universities in Kenya.
METHODOLOGY
This study used descriptive survey research design. Descriptive survey research design is used in preliminary and exploratory studies to allow researchers to gather information, summarize, present, and interpret for the purpose of clarification (Orodho, 2004). The design was based on the fact that the researcher did a status study; collect, analyze and interpret information from the respondents without manipulating the variables involved in the study.

Location of the Study
This study was carried out in the public universities in Kenya. Public universities in Kenya are part of state corporations that sign performance contracts and the choice of the universities for the study was made based on that strength. The public institutions were: University of Nairobi, Moi University, Kenyatta University, Egerton University, Jomo Kenyatta University of Agriculture and Technology.

Population
The population for the study was 132,021 subjects which consisted of 15,937 academic staff, 31,789 non-teaching staff, 84,290 students and 05 directors of performance contracting in the public universities in Kenya (GOK, 2012). According to Kathuri and Pals (1993) for a population of 132,021 a normal sample size of 384 is considered appropriate. The researcher used a sample size of 500 for the study to take care of attrition and to enhance representativeness of the sample to the population. Random sampling was used to select 5 universities from the public universities. Proportionate sampling was used to select 60 teaching staff, 120 non-teaching staff and 320 students who were distributed in the 5 universities.

In the 5 sampled universities, 6 academic departments were randomly selected and the head of sections were purposively selected. One academic staff and one non-teaching staff in these departments were randomly selected to participate in the study making a total of 12 academic and 6 non-academics staff members. Random sampling was used to select 9 non-academic departments from each of the public universities. The head of departments were purposively sampled and 1 staff member randomly sampled making a total of 90 respondents. The 320 students were equally distributed in the 5 universities to give a total of 64 students in each university. Purposive sampling was used to select the 4 student leaders and 60 students randomly distributed in the 6 academic departments. Purposive sampling was used to select the directors of performance contracting for the study.

Instruments
The instruments that were used for data collection were the questionnaires and interview schedule. There were three sets of questionnaires: academic staff questionnaire, non-academic staff questionnaires and student’s questionnaire. Borg and Gall (1996) points out that questionnaires are appropriate for studies since they collect information that is not directly observable as they inquire about feelings, motivation, attitudes and accomplishment as well as experiences of individuals. Questionnaires were chosen for this study on the basis of these strengths.

Reliability and Validity
The research instruments were piloted in 3 of the public universities that have similar characteristics and manage performance contracting like the other public universities in Kenya. Piloting was deemed important in this study in developing and testing the adequacy of questionnaire items. The pre-testing assessed the clarity of the questionnaire items and discarded/modified inadequate or vague items. The Crobanch’s alpha reliability coefficient of the academic staff, non-academic staff, students questionnaires and director performance contracting interview schedule were found to be 0.81, 0.78, 0.79 and 0.73 respectively hence recommended for the study. Validity is the degree to which a test measures what it is supposed to measure (Gay, 1992). Validity of the research instruments was ensured through expert judgment of faculty members and supervisors competent in research techniques and performance contracting process. Borg and Gall (1996) points out the content experts helped determine validity by defining in precise terms the domain of the specific contents that the test is assumed to represent and then determine how well that content universe is sampled by the test item.

Data Collection Procedures
The researcher obtained the research permit from the National Commission for Science and Technology (NACOST). The researcher was assisted by 3 research assistants to administer the instruments to all the respondents. The research assistants were trained on data collection before the actual data collection. The research assistants gave the respondents about four days so as to respond to all the items adequately and the researcher took two months for data collection.
Methods of Data Analysis
Data analysis used the Statistical Package for Social Sciences (SPSS) version 11.5. Descriptive as well as inferential statistics was used. The statistics included frequencies, percentages and Pearson moment correlation coefficient for qualitative and quantitative trends.

RESULTS AND DISCUSSION
Response Rate
The response rate was 91.6% of the academic staff who returned the answered questionnaires, 88.3% of the non academic staff and 95% of the students. All the directors of performance contracting were interviewed. According to CAPAM (2005), the consensus response rate of 70% from the items is acceptable for analysis of data. The consensus response rate for the study was 93% and therefore acceptable for the analysis.

Demographic Characteristics of the Respondents
The demographic profile provides information about the population structure and helps create a mental picture of the characteristics of the subgroups that exist in the overall population (Greiling, 2002). The study sought to find out the gender composition of the respondents. The information obtained is presented in Figure 1.

![Figure 1. Gender of the Respondents](image)

There were more male respondents from the academic staff (61.8%) and more female respondents from the nonacademic staff (53.8%) compared to (38.2%) from the academic staff. This information reveals that gender was fairly distributed across the study population. On the academic achievement of the non academic and academic staff in public universities in Kenya, majority (61.8%) of the academic staff had a masters degree, 23.6% had a bachelors degree, while 14% had doctorate degree. The study further established that the majority (69.4%) of the non academic staff had bachelor’s degree, 22.2% were diploma holders, and 5.6% had a certificate, while only 2.8% had a doctorate degree. Majority of the academic staff (72.2%) interviewed had the working experience between 2-10 years, 15% had a working experience of 0-1 years while 13% with over 10 years working experience. Majority (69.4%) of the non academic staff in the public universities had a working experience of between 2-10 years and 20% had the working experience of over 10 years. This indicated that majority of the staff in the public universities where the study was conducted had less than 10 years working experience. Majority (72.1%) of the students’ respondents were regular students and 51% of the students respondents were male students.

Involvement of University Staff in Performance Contracting Activities
Majority (44.1%) of the staff in the universities said that they were involved in setting performance targets to a great extent. The study further established that the staffs were being involved in ensuring that cascading of performance contracts is done effectively to a great extent, as was indicated by the majority (48.4%) of the respondents. The study further established that 30.4% of the staffs were being involved in ensuring that performance contracts were signed within the first quarter to a great extent and 17.4% to a very great extent. The signing of performance contracts ensures effective implementation of the set target activities. The study further established that the staffs were involved to a great extent in explaining the link between performance contracting and service delivery to other staff members as was revealed by the 34.8% of the respondents.
On the extent of involvement in ensuring that performance appraisals are linked to performance contracting, 34.2% indicated that the staffs were being involved to a great extent and 18.0% to a very great extent. The study further established that the staffs were being involved to a great extent in encouraging teamwork in the universities, as was indicated by the majority (24.8%) of the respondents and 24.2% to a very great extent.

The staffs were being involved in providing resources in a timely manner for implementation of performance contract targets to a great extent, as was revealed by the majority (34.2%) of the respondents and 26.1% of the staff were involved to a very great extent. The study further established that the staffs were being involved in ensuring that the performance contracting process is linked to core mandates of the university to a great extent, as was revealed by the 34.2% of the respondents.

On ensuring that there was feedback on performance contracting process, the staffs were being involved to a great extent, as was revealed by 31.1% of the respondents. The staffs were also being involved in developing the performance evaluation framework, to a great extent, as was indicated by the 27.3% of the respondents. The study further established that the staffs were being involved to a great extent, in ensuring that performance contracts are anchored on the medium term plans and the university performance standards, as was revealed by the 28.0% of the respondents. The study indicates that university staffs are significantly involved in the performance contracting activities in the public universities.

The study revealed that the directors of performance contracting in all the universities were involved in performance contracting activities. Further the study revealed through the directors of performance contracting that the universities ensured that performance contracting effectively improves service delivery despite some of the internal inefficiencies in the public universities.

The Extent of Involvement of Students in Performance Contracting Activities
The information reveals that 27.3% of the students’ respondents indicated that they were involved to a great extent in discussing what performance contracting is with the university management and 8.9% were involved to a very great extent. However, 23.9% of the students respondents were not involved in discussing what performance contracting is with the university management and 10.9% were undecided. Majority (27.3%) of the student’s respondents was not involved in explanations on the link between performance contracting and service delivery by in the universities, 24% were involved to a small extent and 15.1% were undecided. A minority (5.9%) of the students’ respondents were involved to a very great extent in explanations on the link between performance contracting and service delivery in the universities.

Majority (36.2%) of the student’s respondents indicated that they were involved to great extent in team building activities in the universities and 22.7% were involved to a very great extent. However, the students were not involved in developing university service delivery charter, as was indicated by the majority (32.9%) of the respondents and 18.1% were undecided. A minority (6.9%) of the students’ respondents were involved in developing the service delivery charter.

The students were being involved in meeting other student’s needs to a small extent, as was indicated by the 33.9% of the respondents. The study further established that students were involved in gender mainstreaming activities to a small extent, as was indicated by the 21.1% of the respondents and 15.5% were undecided. The students were being involved in creating awareness on HIV/AIDS to university community to a great extent, as was indicated by the majority (29.6%) of the respondents. However, the majority (33.9%) indicated that they did not discuss the issues related to their social life, with the management of the universities. The majority (25.7%) of the respondents indicated that they did discuss the academic issues that affect them with their lecturers.

Extent to Which Involvement of Staff in PC Activities Improves Service Delivery in the Public Universities
The study sought to establish from the academic and non academic staff, the extent to which involvement in performance contracting activities improves service delivery in the public universities. Majority (42.2%) of the staff respondents indicated that involvement of in setting performance targets improves service delivery in the universities. The study further established that involvement of staff in cascading of performance contracts improves service delivery in the universities to a great extent as was indicated by the majority (44.7%) of the respondents.
The study further established that involvement of the staff in ensuring that performance contracts are signed within the first quarter improves service delivery to a great extent, as was revealed by the majority (42.9%) of the respondents. The study also revealed that involvement of the staff in explaining the link between performance contracting and service delivery to other staff members led to an improvement of service delivery to a great extent, as was revealed by the majority (39.8%) of the respondents.

Involvement of staff in ensuring that performance appraisals are linked to performance contracting targets led to improvement of service delivery to a great extent, as was revealed by the majority (42.9%) of the respondents. Linking appraisal with performance contracting is a necessary step towards service delivery as Muthaura (2007) argues that performance contracting forms a very strong base for employees’ employment terms of service since they have to justify their stay in the payroll through performance and reckon that “every employee has to justify why they should be retained in the payroll through performance”.

The involvement of staff in encouraging teamwork in the university improves service delivery to a great extent, as was revealed by the majority (39.1%) of the respondents. The majority (37.9%) of the respondents indicated that involving the staff in providing resources in a timely manner for implementation of performance contract targets improved service delivery to a great extent. The study further established that involvement of staff in ensuring that the performance contracting process is linked to core mandates of the university, led to an improvement in service delivery, to a great extent, as was revealed by the majority (41.0%) of the respondents.

The majority (40.4%) of the respondents indicated that involving the staff in ensuring that there is feedback on performance contracting process, did improve service delivery. The study further established that staff involvement in developing the performance evaluation framework also helped in improving service delivery in the universities to a great extent, as was revealed by the majority (30.4%) of the respondents. The study further established that involvement of the staff in ensuring that performance contracts are anchored on the medium term plans and the university performance standards also improved on service delivery in the universities to a great extent, as was revealed by the majority (34.2%) of the respondents. The study revealed that involvement of university staff in performance contracting activities significantly improves service delivery in the public universities.

Pearson Correlation analysis was run to test whether there was statistically significant relationship in the extent of involvement of the university staff in performance contracting and improving service delivery in public universities in Kenya. Table 1 shows the relationship of the level of involvement of the university staff in performance contracting and improving service delivery. The results in Table 1 indicate a positive correlation coefficient, r-value=0.699 and a highly significant correlation (P<0.05) between the extent of involvement of university staff in performance contracting and improving service delivery. This shows that the degree of association between the extent of involvement of the university staff in performance contracting and improving service delivery is high. This is evidenced by 48.86% (r²=0.699) of the variations in improvement of the service delivery is explained by the staff involvement in performance contracting. The positive correlation between the involvement of the university staff in performance contracting activities and improving service delivery shows that the university staff ensures responsiveness in the involvement of performance contracting activities. This is in line with the government’s objectives that the purpose of performance contracting is to establish the basis for ensuring that efficient and effective services are delivered by ensuring responsiveness by public servants in delivery of services (GOK, 2010).

### Table 1. Correlation Analysis between the Involvement of the University Staff in Performance Contracting activities and Improving Service Delivery

<table>
<thead>
<tr>
<th>Involvement of university staff</th>
<th>Service delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation</td>
<td>.699**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.001</td>
</tr>
<tr>
<td>N</td>
<td>161</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.05 level (2-tailed).

### REFERENCES


LOST OPPORTUNITY: PEACE BUILDING INITIATIVES IN CONFLICT PRONE AREAS

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ABSTRACT

Kenya has had ethnic conflict since the inception of multi-party democracy in 1992. In Molo Division in Nakuru County, a number of governmental and non-governmental reports underscore the social and economic ramifications of the violence. However, serious and sustained peace building efforts have been lacking in an effort to reconcile a society that has been fractured. This paper argues that there have been a number of opportunities that should have seized to reconcile citizens, but such opportunities were lost. The task of peace building has largely been reduced to mere calls for peaceful coexistence, without interrogating the fault lines that open the possibility of fresh ethnic outbreaks and violence. This paper critiques previous and current peace building initiatives in Molo Division. Data collection used focus group discussions, oral interviews, questionnaires and written documents, and analysis used the Coser Lewis conflict theory. The various peace initiatives have failed to address the issues that led to ethnic violence. Memorialization, restitution and restoration of land rights, creation of job opportunities for the youth and profiling of all victims of ethnic violence are critical ingredients for sustainable peace not only in Molo Division, but other parts of the country that have been affected by ethnic violence.

Key words: Peace, Initiative, Conflict, Opportunity, Coexistence

INTRODUCTION

Kenya has been a theatre of periodic ethnic conflict since the inception of multi-party democracy in Kenya in 1992. An excellent case is Molo Division, in Nakuru County, which has experienced three major waves of violence- 1992, 1997-8 and in 2007-8. The extent of the social, political and economic consequences of the violence has been documented in a number of reports such as the National Council of Churches in Kenya (1993) report, the Kiliku Report (1993), the Akiwumi report (1999) and more recently, the Kenya National Human Rights Commission as well as the Commission...
of Inquiry into the Post Election Violence (CIPEV) (2008) popularly known as the Waki Report. The wretchedness that has been imposed upon the victims by the violence in the period 1992-2008 demands that measures be put in place to mitigate the consequences of the conflict. Most importantly, and if past experience is anything to go by, effort must be made to ensure that the area will not relapse to ethnic violence in future.

Statement of the problem
Various peace building actions and approaches to prevent, reduce, transform and help people recover from violence have been initiated. However, evidence shows that to a large extent, the approaches adopted by the various peace agencies in the area have not succeeded in securing enduring peace among the various ethnic groups that reside in the area. There have been a number of opportunities that both the government and non-governmental organizations should have seized to reconcile citizens; yet, such opportunities were lost. Therefore, this paper seeks to analyze the effectiveness of the existing peace building initiatives and suggest strategies that can be adopted to secure enduring peace in the area.

Research questions
This paper will be guided by the following questions;
1. How have the victims of ethnic violence been treated since 1992?
2. Have the victims of ethnic violence received meaningful support to rebuild their lives?
3. What are some of the opportunities that the organizations have had to reconcile citizens
4. Has the government and non-governmental organizations used the opportunities they have had to make the process of re-integration successful?

Research Objectives
1. To analyze the role of both state and community based peace initiatives in ensuring sustainable peace
2. To establish whether the government and non-governmental organizations have used the opportunities they have had to make the process of re-integration successful
3. To suggest strategies that can be adopted to secure enduring peace in the area

METHODOLOGY
The paper uses a qualitative design which gives a narrative description of the state of affairs as it exists. It will use a case study of Molo Division which is very significant in capturing the exact details the role of both state and community based peace initiatives in ensuring sustainable peace in the area and whether the government and non-governmental organizations have used the opportunities they have had to make the process of re-integration successful. Desk top review, Focus group discussions and oral interviews were used in the collection of primary data. To carry out the interviews, a purposive sampling procedure was employed.

The researchers organized four focus group discussions- one in each of the four locations where this study was carried out. Each focus group discussion had 7 respondents. Care was taken to ensure that respondents in Oral interviews were conversant with the undercurrents of ethnic violence in the area since 1992. A total of twenty eight informants were interviewed. Government Reports, books, journals, newspaper articles as well as reports from non-governmental bodies were also used to complete the above mentioned primary sources. Overall, the data was presented descriptively.

Theoretical framework
This research was guided by conflict theory. The theory has a long history, from Ibn Khaldun and Thucydides in the classical world, Karl Marxin the 19th century while Wright Mills, Ralf Darendorf, Irving Louis, Lewis Coser, Herbert Marcuse, Randall Collins and Andre Gunder Frank constitute contemporary conflict theorists. This theory has been found appropriate in the analysis of racial conflicts, class wars, strikes, student power movements, revolutions and peasant uprisings. The underlying assumptions of conflict theory are:

(i) There are seeds of conflict embedded in every social structure
(ii) The social universe and its component elements are in a state of flux
(iii) Every part of society is constantly changing
(iv) Every society experiences at every moment social conflict; social conflict is ubiquitous and
(v) Human beings are sociable but conflict prone.
Study Locale
This study was done in Molo Division, Nakuru County, Kenya. It is mainly inhabited by the Kipsigis, Ogiek, Agikuyu and the Abagusii. The Akiwumi’s Commission noted that this ethnic diversity had been a source of tension and ethnic conflict pitting the Kalenjin (Kipsigis and the Ogiek) on the one hand and the Kikuyu and the Kisii on the other. According to the 2009 census, according to the 1999 population census, the Division has a population of 542,103 people. The Division is part of the larger Nakuru County. The Division has been affected by three waves of ethnic violence: 1992, 1997 and 2008. The Commission of Inquiry on the causes of ethnic clashes led by Justice Akiwumi (1999) noted that in Nakuru County, Molo and Olenguruone Divisions were the most affected by the 1992-1993 clashes. Indeed, Molo Division was among the few areas declared security operation zones under the Preservation of Public Security Act by President Daniel Arap Moi on September 2 1993 (Akiwumi, 1999:133). This study was done in selected locations of the Division namely; Turi, Mukinyai, Kapsita and Sagaitim. According to the Kenya Land Alliance Report (2009), Turi, Kapsita (within Elburgon) and Mukinyai alone received a total of 2231 returnees after the 2007-2008 ethnic violence.

RESULTS and DISCUSSION
Critical Analysis of the Role of State Sponsored Peace Initiatives
The State plays a critical role in the maintenance of domestic peace because it provides most of the institutionalized agencies and processes of social change (Morgenthau, 2012: 532). It is within this logic that after every wave of violence, the government established police posts manned by the Administration Police (AP) in several parts of the Division so as to keep peace in the area. Such a state sponsored peace process had inherent weaknesses. First, victims and residents of the area were categorical that the state was an accomplice in the violence, implying that they could not trust the same state to maintain peace. In the light of evidence obtained from the Akiwumi (1999: 132) and CIPEV (2008: 91) reports, such fears were not misplaced.

Secondly, the state failed to appreciate the fact that violence had engendered conditions that would make the conflict self-reproducing. For instance, the creation of many unemployed youths who moved to Elburgon, Molo and Njoro towns made them easy targets for recruitment into ethnic militias. On the same note, the destitution that followed displacements and dispossession created deep feelings of resentment and bitterness among the locals. Moreover, the fact that no attempt was made by the state to identify and bring perpetrators of the violence to justice has cast doubts on the credibility of any state sponsored peace initiative, Alfred Otoigo, (Oral Interview, 01/12/13).

When the coalition government was formed after the 2007-08 violence, the state through the Office of the President, attempted to take over humanitarian relief and reconstruction from international agencies and the Kenya Red Cross. Consequently, the Ministry of State for Special Programmes was given the responsibility of assisting the Internally Displaced Persons. The ministry launched a poorly conceived, organized, and timed Operation Rudi Nyumbani (Return Home) and the related operations TujengePamoja (Build Together) and UjiraniMwema (Good Neighborliness) using the provincial administration to manage them. The administration police could not properly support the exceptionally challenging resettlement and peace building tasks and at the same time deal with broader security concerns (USIP, 2010: 7). In fact, it can be argued that the presence of camps for the Internally Displaced Persons- camps that were littered across the Rift Valley province was not only an indictment to the political class and an embarrassment to the state. Therefore, the camps had to be dismantled. This might explain the urgency with which Operation Rudi Nyumbani was executed.

The government ordered the provincial administration to dismantle refugee camps without adequately preparing the ground for their proper reception and re-integration with the communities in the areas they had been evicted from. Under such circumstances, both the displaced persons and their former neighbors were not adequately prepared to live together again, MungaiThuo, (Oral Interview, 10/12/13).

To help displaced families re-start their lives, the government gave them ten thousands shillings each through a process that was characterized by corruption. Many victims of the 2007-08 violence in the areas where this study was done did not get the money, even after making a lot of effort, RufaiAbengi, (Oral Interview, 10/12/13). A number of government officials and a people masquerading as IDPs appropriated the money meant for the victims. In a survey done by the Kenya Land Alliance, it was found out that the majority of the 2,746 displaced people interviewed did not receive start-up capital of 10,000 or 25,000 shillings. In one location of Kuresoi, a chief had allocated compensation to his supporters, including young people involved in the violence (Kenya Land Alliance, Land Data Survey Report, 2009:9).
The government has also used the National Cohesion and Integration Commission (NCIC) to reconcile ethnic groups living in the larger Nakuru County. An independent constitutional commission, the NCIC brought together more than one hundred elders mainly drawn from the Kikuyu and Kalenjin communities. The commission engaged elders from the various ethnic groups separately where the elders highlighted injustices meted on their respective communities since the colonial period. After a year of such meetings, a joint eight-point peace plan was developed and a peace accord signed on 13 May 2012.

Among the resolutions made by the elders, on behalf of their communities, was a promise to respect each other’s culture, traditions and freedoms enshrined in the constitution. They also pledged to develop and support a dispute resolution mechanism, avoid derogatory statements, condemn violence and put to task politicians who preach hatred (The Sunday Nation, 29 April 2012). Evidently, the failure to include youths and elders from the village level may hamper the success of the commission’s efforts. Yet, it is the youths who do the actual fighting while the elders are known to ‘bless’ them before they go to war against other ethnic groups (USIP, 2009: 11). With such challenges, government sponsored resettlement and peace initiatives have ended in failure.

Community Based Peace Strategies.
While the state is indispensable in the maintenance of domestic peace, it is not in itself sufficient (Morgenthau, 2012: 531). Other players such as religious organizations, non-governmental organizations, community workers are also involved in re-membering post-conflict societies. At the community level, apart from the government initiative discussed above, no efforts have been made to ensure inter-ethnic harmony in the four locations where this study was done. However, in other parts of the larger Molo such as Kuresoi and Likia, the National Council of Churches of Kenya (NCCCK), the Catholic Diocese of Nakuru and the provincial administration police involved the residents in electing elders and youth from every ethnic group in the area to oversee peace meetings and reconciliation, Douglas Mutiga, (Oral Interview, 10/12/13). The committees have achieved some significant results especially in the Likia zone, near Njoro. A collaborative effort by Muslim, Christian and Hindu leaders, the Likia and Beyond Peace and Conflict Re.solution Council has been active in peacebuilding activities (USIP, 2009:9).

Notable among community based peace initiatives was the campaign by Carol Teachers Training College choir. The choir was established after the 2007-08 violence. At the height of the violence in 2008, some youths attempted to burn down the college, which is located at Rongai, East of Molo Division. After the situation returned to normalcy, the choir began outreach programs to create an awareness on the importance of ethnic harmony.

As a way of engaging the youth in meaningful activities, the college started elementary computer lessons for youths in the area. The choir organized periodic peace caravans in Molo, Kuresoi, Njoro, Kericho and other areas to preach ethnic harmony. The group goes to churches, market places, schools and other public places to perform skits, poems, songs and dances that emphasize on peace (The Daily Nation, January 30, 2012). The choir and the college at large is no longer involved in peace building activities, perhaps, due to the illusion of peace that now prevails in the area. Yet, conflict theorists remind us that conflicts can be latent until that moment when a combination of circumstances brings them to the surface (Abraham, 1981: 112). While the efforts done by the various agencies discussed above cannot be ignored, the general situation in Molo Division reveals that more effort needs to be made to secure enduring peace in the area. The fact that some of the displaced still live in refugee camps attests to the failure of the peace processes. The following section discusses some approaches that can be used to achieve this end.

Strategies that can be adapted to Secure Enduring Peace in the Area

Memorialization

Memorialization refers to the process of creating a memorial for purposes of perpetuating the memory of a person, group of persons, incident, event or era. Given that memory is significant to the writing of history, lineage and group identity, memory is often contested and can be itself a source of conflict. However, memory, as perpetuated through processes such as memorialization seen in national monuments and commemorative celebrations can assist survivors of human rights violations, through symbolic reparations, to begin the process of healing; and assist the previous divided society in processes of reconciliation.

The purposes of memorialization initiatives include truth-telling; seeking justice; building a culture of democracy; commemorating previously marginalized histories and heritage; and recognizing victims and survivors of human rights violations. Memorialization can take a variety of forms, for instance, renaming of public facilities, plaques, exhibitions, museums and monuments. It is sometimes categorized within the transitional justice discourse as forming a subcomponent within the area of reparations (i.e. symbolic reparations).
Memorialization has been applied in Chile, South Africa and Rwanda (Kenya Human Rights Commission, Transitional Justice in Kenya: A Tool Kit for Training and Engagement, 2009:58). Besides state-level support for memorialization, survivor groups initiated and participated in various memory projects which included designing and sustaining memorials and sites of memory, including former torture centres, recording names and details of those who died or were victimized during a conflict, and organized events on key historical dates. The fact that survivors, states and truth commissions recognize the significance of memorialization further highlights the positive potential of memorialization within post-conflict societies. After three waves of violence, it may not be practically possible to bring perpetrators to retributive justice. Perhaps, time has come for residents in Molo Division as well as policy makers to give the concept of memorialization a chance. Admittedly, there are several obstacles to the successful implementation of memorialization initiatives. They include: inadequate information, the lack of empirical information on and around memorialization as a process within transitional justice may result in ad-hoc, uncoordinated and unmonitored memorialization efforts that may serve only the needs of specific groups.

For any memorialization initiative to achieve its objective as a peace-building mechanism there needs to be some level of consultation by the initiators or sponsors of the project with the community that they seek to empower through the project. In this regard, a top-down approach to memorialization should be avoided. The ethnic groups that have been in conflict need to own the initiative for peace-building in the area to succeed. Perhaps, residents, government and others who are interested in peace in the area can borrow a leaf from members of the Kikuyu, Kalenjin, Luhya, Luo, Kisii and the Turkana ethnic groups who came together to reconstruct the Kenya Assemblies of God (KAG) church at Kiambaa in Eldoret that was set on fire on 1st January 2008, during the post-election violence. Seventeen people were burnt to death, eleven died on the way to the Moi Teaching and Referral Hospital in Eldoret while fifty four were treated and discharged (CIPEV, 2008: 48). Previously a predominantly Kikuyu congregation, the church has been renamed Kiambaa Unity and Reconciliation Church so as to reflect the need for inter-ethnic cooperation and harmony in the post-conflict period. The church has been instrumental in peace initiatives in the greater UasinGishu County (The Daily Nation, 24 October 2012).

Politicization of memorialization is another potential challenge, it is important to note that many memorialization initiatives are government funded and often become tools to further political agendas and consolidate the power of the ruling faction. The effect is usually a memorial that is distasteful or offensive.

Finally, given that most initiatives are built with an aim of ensuring permanence and spanning generations, memorialization often run the risk of becoming irrelevant to future generations which may not understand or appreciate its context and value. This is especially the case where there are no educational programs aimed at reinforcing the significance of the memorials to future generations.

A good example of an event that can be memorialized to foster inter-ethnic harmony is the Sachangw’an Accident. On the evening of January 31, 2009 an oil tanker overturned and burst into flames and burnt to death more than 130 villagers who had rushed to siphon the oil at Sachang’wan town centre, 60 kilometers from Nakuru town on the Nakuru-Eldoret highway. Torn apart by inter-ethnic violence since 1992, the incident temporarily provided an opportunity for inter-ethnic co-operation. According to an informant, this tragedy helped to forge inter-ethnic harmony in the following way:

During the 2007-2008 Post-Election Violence, every ethnic group buried its own people. But in this tragedy, many families in the Mukinyai- Kibunja-Sachang’wan area lost a member while others lost several members. Since it was practically impossible for many families to handle the pain and the logistics of interring their dead, the elders and church leaders came together and agreed that we should bury our dead in an organized manner. We could bury a Kisii today, a Kikuyu tomorrow and a Kalenjin the following day. For the first time in many months, we were free to walk into our neighbor’s homesteads and they could also come to our homes. We mourned together, we wept together. . . the speeches made during the funerals were very solemn, all of us regretted our past animosity, for the first time since 1992, my bitterness was gone, we had been combatants for a long time, we now shared in the same fate, we were united in grief (Wakaba, Oral Interview, 10/12/2013).

With the support of the government, such a date, marked every year, would prove critical in enhancing inter-ethnic harmony in the area. It is worth appreciating that a plaque bearing the names of those who were burnt beyond recognition and were consequently buried in a mass grave was constructed at the site of the accident. The event
provided an opportunity to construct a collective memory and a shared narrative of ethnic violence. Such a narrative, reinforced with a commemoration every year, would eventually replace the selective ethnic narratives and memories that make violence in the area self-perpetuating. Both the state and non-state actors ought to have gone beyond the mere construction of a plaque and turn it into a powerful symbol that cuts across ethnic groups that live in the area (Tabutany Chumo, Oral Interview, 04/12/13).

Another way in which the tragedy united the various communities was the fact that since many of the victims of the fire tragedy had been burnt beyond recognition, families whose members were missing accepted the government’s proposal to bury the remains in a mass grave at the scene of the accident. A plaque bearing the names of the deceased was erected at the scene after the highly publicized ceremony attended by high ranking government officials who included the president, the prime minister and the vice-president. The importance of commemorating the incident has continued to decrease with every passing year. While residents in the area have continued to remember the accident in the subsequent years; the state has not taken a leading role in these annual memorials (The Standard, February 1, 2012). Yet, it has been observed that the proper creation and promotion of memorials is a pivotal component of reconciliation as this is the terrain in which divisive identities and myths are created, contested and destroyed.

Reconciliation

Reconciliation can also be used to bring inter-ethnic harmony. Truth telling, that means, a full accounting of the past, including the identities of both victims and perpetrators is necessary for reconciliation. To build reconciliation, individuals and institutions need to acknowledge their own role in the conflicts of the past, accepting and learning from it in a constructive way so as to guarantee non-repetition. Religious leaders can be useful agents of reconciliation. It has been noted that churches and mosques can emphasize the re-discovering of a new conscience in individuals and society through moral reflection, repentance, confession and rebirth. For reconciliation to succeed, the residents of Molo Division must actively initiate the process. The Kiambaa experience mentioned above provides some insights:

Those interviewed (by the Daily Nation journalist) say that whereas they recognized the chief mediator Koffi Annan’s role in midwifing the peace process, (at the national level) the peaceful coexistence realized at the grassroots has largely been due to the residents’ efforts. One, they argue, must own the reconciliation drive for the initiative to be meaningful (The Daily Nation, 24 October 2012).

Restitution and restoration of land rights

Many victims lost their lands and also their documents such as title deeds which were either burnt or misplaced. It is imperative for the government to facilitate their replacement so that the victims who lost land can recover their land rights. In situations where it is impossible for victims to go back to their former lands, the state can compensate the victims in accordance with the current market rates for land. This will enable the affected to reconstruct their lives. Besides loss of land and land rights, in areas like Mukinyai and Kapsita, victims of violence have been embittered by the fact that they could identify iron sheets, bicycles, television sets and cattle stolen from them in the course of the violence. Voluntary surrender of such property to their owners would go a long way in restoring raptured ethnic and personal relationships. The success of restitution would be determined by the effectiveness of reconciliation. Bearing in mind that the expectation of restorative justice is a key component in building sustainable peace (Morgenthau, 2012: 526).

Significant cultural and attitudinal change

To overcome negative ethnicity, there is need for residents in Molo to change how they relate to, and direct their attitudes towards one another. The culture of suspicion, fear, mistrust and violence need to be broken down and opportunities and space opened up in which people can hear and be heard. Similarly, the cultural basis of violence ought to be dealt with. It was in the appreciation of this fact that the National Council of Churches in Kenya (NCCCK), Gender Equity Network and Genesis Art Creation organized a joint initiation ceremony comprising of the Kalenjin, Kikuyu and the Abagusii in Molo and Kuresoi in December 2012. The initiates were first trained on peace building (http://m.news24.com/kenya, March 3 2012). If sustained, such an approach will in the long run prove vital. Circumcision ceremonies are important avenues for confronting violence; a young man had confided that:

It is during the circumcision ceremony that youths are trained on how they can develop to be real warriors and how they can exterminate other communities (their enemies). During this rite of passage from childhood to adulthood they are taught that if they can kill there would be no either spiritual or emotional impact has they would be purified later after killing (USIP, 2009:11).
The Agikuyu and the Kalenjin, who have been the main protagonists in the conflict, are both inclined to the Warrior Tradition, discussed in detail by Ali Mazrui and Michael Tidy (1977). In both ethnic groups, the circumcision of young men and their subsequent seclusion from the society is laden with military meaning. Upon initiation, young men enhance the military capital of their respective communities, Oral Interview (Kiboss Letio, James Mungai, Oral Interview, 10/12/2013). This implies that for any peace-building efforts to bear fruits in the long run, it must address the cultural dimension of the conflict. Dahrendorf, posits that conflicts emanate from the very nature of social structure and that there are seeds of conflict embedded in every social structure (Dahrendorf, 1973: 102).

Creation of job opportunities for the youth
Although unemployment is not unique to Molo Division alone, two decades of intermittent ethnic conflicts in the area has compounded the challenges faced by youth in Molo. Many of them were unable to pursue education to higher levels, making them unable to compete against their contemporaries in other parts of the country. Moreover, as noted by CIPEV, (2008: 35, 36) many of them moved into towns. Desperation has made them available for hire by politicians bent on using violence to win elections. Besides, they have become easy recruits by ethnic militias and vigilante groups. The government should devise ways of economically empowering the youth such as building of roads and planting trees to restore the forests that have disappeared in the course of the conflict as well as assisting the youth get funds through the Uwezo Fund. A source of income for the youth would be a sure way of dissuading them from being recruited for violent purposes. A wage/salary are one of the ways of addressing the differential distribution of desirables – desirables that have been identified by conflict theorists as a perennial source of conflicts within and among societies (Collins, 1975: 60, 89).

Profiling and compensating of all victims of ethnic violence
To resettle and build houses for victims of violence, the coalition government engendered feelings of victimization and marginalization among the Kalenjin. A journalist with the Standard newspaper noted that: “the government’s efforts to resettle one community while ignoring another was causing disquiet, threatening fragile peace. Residents (Kalenjin) were unhappy because they were viewed as aggressors who never suffered from the violence “if your neighbour gets something and you get nothing, you ask yourself why” (The Standard, July 15, 2011). To eliminate such perceptions, it would be prudent for the government to profile all victims and compensate them.

CONCLUSION AND RECOMMENDATION
This paper has attempted to highlight and critique some of the peace initiatives that have been operational in Molo in the period 1992-2013. Government supported and community based approaches to peace have been interrogated. A key observation is that a peace initiative constructed from above and imposed by either the state or non-governmental organizations have failed to deliver peace in the area. It is also clear that there is lack of coordination between the government and non-state actors in the processes which has in turn jeopardized the prospects for sustainable peace. It has also been argued that there are mechanisms such as memorialization, restitution and restoration of land rights that can be adopted to further the agenda for peace in the area. To realize sustainable peace, grassroots or bottom – up approaches ought to be adopted. The net must be cast wide enough, to bring on board all actors, chiefs, traditional healers, faith based organizations, politicians, political parties, the civil society, women, youth among others. It is only then can the residents of Molo Division experience genuine peace.

REFERENCES
UNIVERSITY GRADUATES’ EMPLOYABILITY SKILLS PREPAREDNESS IN KENYAN ECONOMIC SECTORS

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ABSTRACT
The fast expansion of Kenyan universities has only focused on raising student numbers rather than improving the quality of education and research. These challenges are raising doubts on the level of their preparedness in their employability skills. This study investigated how graduates’ quality compared amongst various universities in Kenya, how university graduates from different sectors in Kenya compare in terms of employability skills, and the link between graduate quality and employability skills. Literature review was done on quality of education globally, in Africa, regionally and locally, while the conceptual framework on quality of graduates and work preparedness was developed to guide the study. The study used descriptive and exploratory designs to conduct qualitative analysis. The target population was 420 graduate employees and 46 supervisors/managers of the COYA 2013 companies who were given a 5 Likert Scale questionnaire ranging from 1 (strongly disagree) to 5 (strongly agree). A survey of 5 public and 5 private universities was done to interrogate the university side of the research to get an all-inclusive perspective. Characteristics of the study variables were analyzed using SPSS and the relationship between variables was tested using Pearson’s correlation analysis. The study results showed that service and education (M = 4.5), finance (4.2), Agriculture (4.0), manufacturing (3.9), ICT (3.5), Regulatory (3.5), Communication (3.1), Hotel (3.0), insurance (2.9) and transport (2.0). Service, education and finance required more employability skills than other sectors. There was a positive link ($P = 0.000$) between present job competence, confidence, involvement and employability skills of graduates. The study recommends that universities should involve the industry in developing curricula to satisfy the university, graduates and labour market requirements.

Key words: Employability, Economic sectors, Graduates quality

INTRODUCTION
Employability skills
Employability is the ability of the student to get a job after graduation and it is concerned with student’s attributes which empower the student as a critical life-long learner. The employability index determines whether the student job within a specific period after graduating from the university. Yorke and Knight (2004) define employability as a set of achievements, skills, understanding, problem solving, teamwork, competence, confidence, involvement, communication skills and personal attributes that make a graduate more likely to gain employment and be successful in their chosen occupations which benefits them, the workforce, the community and the economy. Employability elements differ from one job to another job though the basic outcome remains the same.

These elements make an employee useful and desirable at the workplace. In the dynamic world, employees need to be adaptable and multi skilled with employability skills needed in the labour market (Helyer, 2007). Study by Weligamage (2009) on graduates’ employability skills in the developed countries concluded that universities globally should identify a set of skills that will best serve the future labour markets and align higher education programs to meet those needs. Weligamage documented that with the current dynamic business environment there should be emphasis on the importance education and employment focusing on both the skills and practical experience of the graduates.
Furthermore, Harvey and Knight (2005) posit that in order to enhance competitive advantage for graduates’ employment, students need to develop skills in addition to the acquisition of knowledge from specific subjects. He documents that Higher Education Institutions (HEIs) need to identify ways of incorporating these requirements. For the graduates to be employable, they should have knowledge skills, time management skills, learning skills, team work, problem solving skills, understanding workplace, thinking skills, personal attributes and practical skills that they are able to apply and meet the employer’s needs.

Employer needs survey is critical in any country to match industry needs and the training programs (Yorke and Knight, 2003). Harvey et al., (1996) conducted a survey on developed countries and concluded that most employers identified most common employability skills as: time management, self-understanding, learning, teamwork, leadership, problem solving, working, diversity, understanding skills and risk management skills. Personality, self confident, attitudes, job involvement, were the most preferred attributes by the employers (Weligamage, 2006; Vidal, 2010; Hanlie and Yuzhuo, 2009; Mehta et al., 2011).

This study used these attributes to measure employability of graduates produced from Kenyan universities. All stakeholders including students, graduates, employers, the government and university administrators should be involved into finding out the skill requirements to close this gap (Harvey, 2005). It is important therefore, to measure employees’ performance using Role-Based Performance Scales (RBPS) that consider job, career, innovation, team participation and organizational citizenship as suggested by Erez et al. (2005). Furthermore, a balanced score card can also be used as it gives the view of the employees performance against agreed set indicators to be measured. In addition, Performance appraisals and productivity tests are often used to assess employee performance in organizations.

Harvey (2002) developed a model of employability and emphasized teamwork between Higher education institutions, graduates, employers, employment developers to produce employable graduates for the employment market. Harvey emphasizes the importance of teamwork between all the stakeholders to support of higher education in producing quality output for the global market. He documents that employability model consists of the graduate’s development attributes that includes: employability attributes, work experience, self promotion, career management skills and willingness to learn. However, he notes that, employability development opportunities are also affected by the subject discipline of the graduate to some extent. According to Helyer (2007 pp. 1-2) employability is clearly a complex mixture of elements; these elements may differ from job to job but the basic outcome is the same–they make a person useful, and therefore, desirable employee.

In a rapidly changing society it is also clear that employees need to be adaptable and multi-faceted. It is unlikely that 21stcentury workers will hold one position, or even one occupation, for their working lives. They work for longer than previous generations and perhaps in changing circumstances. There is need for re-invention which requires a receptive and self-aware person and employability skills need to be honed and enhanced by employees and students”. Helyer posits that, increasing government agenda are linking Higher education qualifications with profitability and productivity in United Kingdom (UK).

According to Elias and Purcell (2004), graduates should be well prepared as they do a wider range of jobs today as a result of the changing technology, economic restructuring, and related demand due to changes in the labour market. The study emphasizes development of graduates skill and knowledge at the degree level as it is required by both the graduates and the employer. The main skills required in the labour market are problem solving, decision making, interactive knowledge, leadership, handling new information, ability to acquire new knowledge, coordinating activities, prioritizing, teamwork, communication, technology, imitativeness and enterprise skills (Harvey, 2001).

These variables have been adapted in this study as they also include personal attribute of the employee. The Kenyan employer demands an employee who is fully trained and with knowledge in the areas of their job market. They are less favourable to employing graduates they have to retrain. Hence, graduates that are needed by employers or industry are those who can independently can handle tasks, are, creative, innovative and can set and achieve goals. Although employers are dissatisfied with university graduates in Kenya, universities often operate without involvement and feedback from the employers and the society. There is need to address this disconnect between the training graduates receive from universities and the labour market demands (GoK, 2006).
**How employability skills were measured in this study**

Employability skills in this research were measured by analyzing intellectual ability, decision making skills, interactive knowledge, ability to use new knowledge creatively, leadership skills, ability to coordinate activities and prioritizing activities by the graduate employees working with the COYA (2013) companies. There are other variables found in the literature but were not tested and are recommended for further research. The results indicated that graduates’ mean score in the measured employability skills were ranging from 3.56 to 3.92 which mean that they had not excelled in this area.

Graduates showed poor coordinating activities and prioritizing activities. Employability skills by service, education, finance, agriculture, manufacturing, ICT, regulatory, communication, hotel, insurance, and transport economic sectors were analyzed to compare different sectors in terms of employability skills. According to this research, transport, insurance, hotel and communication required less employability skills. More details are given in chapter four on Principal Component Analysis (PCA).

**Suggested “7 variable model” for measuring employability skills of university graduates**

- Interactive knowledge
- Intellectual ability
- Creative use of knowledge
- Theoretical and practical skills
- Coordination of activities
- Leadership skills
- Prioritizing activities

*Source: Rintari, 2014*

**Economic sectors in Kenya**
The economic sectors considered in this study are service, education, finance, agriculture, manufacturing, ICT, regulatory, communication, hotel, insurance and transport.

**Statement of the Problem**
The fast expansion of Kenyan universities has only focused on raising student numbers rather than improving the quality of education and research. This raises doubt on whether universities are preparing graduates adequately to work in the Kenyan economic sectors, yet these sectors contribute to economic growth.

**Objectives**

1. To investigate how graduates’ quality compared amongst various universities in Kenya.
2. To find out how university graduates in Kenya compare in terms of employability skills.
3. To determine the link between graduate quality and employability skills.

**Beneficiaries of the research**
From the results of this study, different consumers stand to benefit such: the university developers, higher education institutions, lecturers, students, graduates and economic sector players. It will help the industry players to liaise with the universities and other higher education institutions to develop curricula which will prepare the students adequately for the labour market. The graduates will benefit from being well prepared by the universities.

**METHODOLOGY**
The study design was both descriptive and exploratory. Data was collected from 46 of the 53 COYA 2013 companies which were selected by simple random. A return rate of 41 companies was received (87.2 %) The primary data was collected using structured and unstructured questionnaires on a Likert scale of 1-5, strongly disagree, disagree, neutral, agree and strongly agree. The questionnaires were administered to the managers of the COYA companies and to 413 graduate employees who had worked between 1-5 years after completing the university. Data characteristics were analyzed using SPSS and results were presented in charts and tables.

**RESULTS**
It is evident that there was variability and lack of consistency in the public universities as shown by box plot below, their median scores were higher some and lower in others. From these findings the private universities had a higher
consistent median score than public universities. The disparity is clear from the chart where both the ‘narrowing’ and ‘consistency’ factors are displayed. It can be argued that there is an indication that some public universities were weak on consistent on quality. From these findings, the private universities have a higher mean score of quality of their graduates meaning that their quality is better than that of some public universities.

![Box plot for comparing graduates among various universities](image1)

**Figure 1.** Box plot for comparing graduates among various universities is shown below.

![Bar chart showing employability skills by economic sectors](image2)

**Figure 2.** Relationship between graduates in different sectors and their employability skills

**Employability skills by economic sectors**

The second objective of this research was to find out how university graduates from different sectors in Kenya compare in terms of employability skills. The results of this study show that the education (4.5), service (4.5) and finance sectors (4.2) required more employability skills as indicated by the employer. The results indicated that manufacturing had a mean score of 3.9, ICT 3.5 and regulatory 3.4. Additionally, these study findings indicate that insurance and transport needed less employability skills. This implies that for insurance (m=2.9) and transport (m=2.0) do not need a lot of expertise to work in these sectors. In addition, the table below shows a p value of 0.027 <0.05 indicating that there was a significant difference in employability skills of graduates between different economic sectors.
Table 1. Comparison of employability skills by economic sectors

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Pearson’s correction analysis

**Link between graduates employability skills and work preparedness.**

Objective three investigated the link between graduate quality and employability skills. A partial correlation was done comparing the scores for employability and other work preparedness skills. The findings show that employability skills was positively correlated with present job competence, job confidence and job involvement at p value <0.05, with correlation coefficient of 0.596, 0.572 and 0.605. Regression analysis was undertaken to determine the determinants of employability skills, the models was found to be significant. The table shows regression analysis on determinants of employability skills. The details are presented here below.

The table above shows Pearson’s correlation analysis that was done to check the link between employability skills and present job competence, job confidence and job involvement. Employability skills was positively correlated (r = 0.595) to present job competence, job confidence (r = 0.572) and job involvement (r = 0.605). Present job competence is positively correlated (r = 0.596) to employability skill, job confidence (r=0.741) and job involvement (r = 0.797). Job confidence is positively and strongly (r =0.872) correlated to job involvement. Job involvement has a positive strong link to job competence (r = 0.797) and job confidence (r = 0.797)

The findings indicate a strong correlation (p-value 0.000) in that with an increase in employability skills also present job competence, job confidence and job involvement increases positively. In addition, it shows that when each of these variables increases employability skills positively increase. Further the findings imply that work preparedness of the graduate increase with an increase in their job competence, job confidence, and job involvement and employability skills. This correlation was significant at 0.01 level (2 tailed).

**Link between graduates employability skills and work preparedness**

Objective three investigated the link between graduate employability skills and the work preparedness. A partial correlation was done comparing the scores for employability and other work preparedness skills. The findings show that employability skills was positively correlated with present job competence, job confidence and job involvement at p value <0.05, with correlation coefficient of 0.596, 0.572 and 0.605. Regression analysis was undertaken to determine the determinants of employability skills and the models was found to be significant. This means that to improve work preparedness of graduates employability skills should also be increased and improved. Table below shows regression analysis on determinants of employability skills. The details are presented here below.
Pearson’s correlation analysis was done to check the link between employability skills and present job competence, job confidence and job involvement. Employability skills was positively correlated (r = 0.595) to present job competence, job confidence (r = 0.572) and job involvement (r = 0.605). Present job competence is positively correlated (r = 0.596) to employability skill, job confidence (r = 0.741) and job involvement (r = 0.797). The findings of this analysis also show that job confidence is positively and strongly (r = 0.872) correlated to job involvement. Job involvement has a positive link to job competence (r = 0.797) and job confidence (r = 0.797).

These findings indicate a strong correlation indicated by a p-value 0.000 showing that with an increase in employability skills also present job competence, job confidence and job involvement increases positively. In addition it shows that when each of these variable increases employability skills positively increase. Further the findings imply that work preparedness of the graduate increase with an increase in their job competence, job confidence, and job involvement and employability skills. This correlation was significant at the 0.01 level (2 tailed). Moreover, to investigate the link between graduates employability skills and work preparedness, a partial correlation was done comparing the scores for employability and work preparedness skills. This means that to improve work preparedness of graduates employability skills should also be increased and improved.

**CONCLUSION**

The conclusions were done by using each objective as shown here bellow.

**Objective 1:**

Objective one showed that there is no significant difference between graduates quality from public and private universities indicated by a p-value (0.142) which is more than 0.05. The hypothesis Ho failed to be rejected but there was no evidence to accept alternative hypothesis. Further the research findings show that private universities were consistent in quality than public universities as indicated by the box plot on page 4 where both the ‘narrowing’ and ‘consistency’ factors were displayed. From these findings it can be implied that some public universities are in producing quality graduates. However a mean score of 1-5 shows inconsistency of the public universities while private universities have a mean score of 3-5 showing consistency in graduates quality.

**Objective 2:**

Additionally, objective two sought to find out how university graduates from different sectors in Kenya compare in terms of employability skills. The study results showed the following means. Service and education (M = 4.5), finance (4.2), Agriculture (4.0), manufacturing (3.9), ICT (3.5), Regulatory (3.5), Communication (3.1), Hotel (3.0), insurance (2.9) and transport (2.0). It shows that service, education and finance required more employability skills than other sectors. Further the employers indicated that transport, hotels and insurance sectors did not require any employability skills. It can be argued that these sectors do not need any expertise or specialization and the sectors not necessarily employ graduates. The tested hypothesis showed a p-value of 0.27 indicating no significant difference in employability skills of university graduates from different sectors in Kenya therefore, the null hypothesis failed to be rejected.

**Objective 3:**

Objective three investigated the link between graduates employability skills and work preparedness. As seen from these findings, an increase in employability skills increases work preparedness as the two of them are positively correlated. The hypothesis tested showed that there was a positive link (p value 0.000) between present job competence, job confidence, job involvement and employability skills. It can be argued that an increase in employability skills also increases job confidence, job involvement, and job competence. A coefficient of 0.596, 0.572, and 0.605 respectively shows a strong relationship.

**RECOMMENDATIONS**

The curricula should include more practical applications by students, more internships, and incubation centers in each university as well as role modeling. Industry players have to work closely with higher education institutions to offer practical experiences to students in their areas of interest.
REFERENCES

HAWKING OF UNIVERSITY EDUCATION IN URBAN CENTERS IN KENYA: CHALLENGES AND WAY FORWARD

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ABSTRACT
The demand of university education in Kenya has been increasing. Consequently, public and private universities have overenrolled to cater for this demand. Moreover, the universities have used this crisis to generate income to support both human and material resources needed for privately-sponsored students. To make education accessible to students, especially the working class, universities have moved to urban centers where they have strategically positioned themselves in satellite campuses. The main operation points of the universities are central business districts (CBD) in urban centers. Some of the universities that have not secured the coveted CBD premises have moved to the periphery. Proximity to the city notwithstanding, universities are engaged in stiff competition to outdo each other by introducing new and cost-effective courses which are taught in sandwich mode. Thus, the quality of the education offered in urban satellite campuses is brought into critical scrutiny in this paper with a view to establishing the challenges experienced and suggestions on how to improve the situation. This paper will rely on both primary and secondary data particularly records from selected private and public universities with regard to facilities and other resources. Observation and recording of information was utilized in data collection.

Key words: Challenges, Education, Hawking, Resources, University

INTRODUCTION
Evidently, the demand of education, especially higher education is substantial in Kenya and beyond. Precisely, in Kenya, advanced education is among the basic requirements needed for promotion, salary increase, and respect, but only to mention few benefits. Taking a critical analysis of access and quality of education in Kenya, Glennerster et al. (2011) argue that:

“Education is widely seen as one of the most promising paths for individuals to realize better, more productive lives and as one of the primary drivers of national economic development. The citizens and the government of Kenya have invested heavily in improving both the access and quality of education, in an effort to realize the promise of education as well as to achieve the education-related Millennium Development Goals and Vision 2030” (pg. 3).
Indeed, the demand for education and in particular university training in Kenya saw the booming enrollment of students dating back to 1998. This new development was necessitated by the demand to have public universities generate income to sustain their academic programmes and other financial undertakings. Wainaina (2011) concurs with the aforementioned reasons and observes that:

“Over the last ten years, Kenya has witnessed an unprecedented growth of Module II programs in the public universities. The nascent nature of these programs is borne out by the fact that the earliest started in 1998 and the rest have grown over subsequent years. Different terminologies have been used to describe these programs viz; parallel programs, self sponsored programs, direct entry programs, full fee paying academic programs and Module II programs” (pg.96).

Moreover, the Kenya government liberalization of university education gave universities and colleges a leeway to operate freely in order to meet the high demand for university education. Notably, the government has permitted universities to start constituent colleges and campuses, and in turn constituent colleges to open campuses. The government has recognized collaboration between private middle level colleges with universities and constituent colleges in offering diploma and degree courses. Recently, the government has granted charters to 6 long time established public universities and 15 new universities among them few which appear to be regional and politically. Even further, a number of private universities have been given interim letters or charters to operate. All these developments attest the government commitment to meet the demand for higher education

Institutional Framework for University Education in Kenya

Education at university and equivalent institutions has expanded rapidly in Kenya. Since the inauguration of the first university in Kenya in early 1970s, over 30 universities, both public and private, have been established in the country to meet the escalating demand for education. Equally, mechanisms have been put in place to ensure that quality education is provided. For example, the Commission for University Education is prominently entrusted with the responsibility of ensuring that standards in opening and operating universities are in place. Also, university councils, senates, quality assurance departments, faculty and departmental academic boards among others agencies play a big role in the reinforcement of standards. The providers of university education in Kenya are ministry of education, science and technology, religious organizations, communities, private entrepreneurs and other stakeholders. Nonetheless, both public and private stakeholders have highly commercialized provision of education; hence, making it inaccessible to poor in addition to eroding the quality of education.

To fulfill the obligation of the tax payer, the government of Kenya has laws, regulations and policies among other measure that are meant to ensure the conditions for providing university education are in place. For example, the Universities Act, 2012 found the Commission for University Education to pursue the following objectives in promotion of university education.

i. To ensure the implementation of the objectives of university education as spelt out in the Universities Rules of 1989,
ii. Promote, set standards and assure relevance in the quality of education,
iii. Monitor and evaluate the standards of university education system in relation to the national development goals,
iv. Undertake or cause to be undertaken regular inspections, monitoring and evaluation of universities to ensure compliance with set standards and guidelines

In the context of the aforementioned act, the crucial requirement in provision of quality university education is the establishment of adequate and dependable material and human resources to sustain quality degree and diploma programmes for which the university is found and accredited. Although, many universities have fulfilled the basic requirements of being granted the charter or interim letter to operate and offer the programmes, they have with time generated to the level of offering mediocre education in the haste of generating income, and therefore putting university education into doubt and critical interrogation.

Statement of the problem

The expansion of education in Kenya has occurred due to high demand for it. The reasons for this demand are many and they range from desire for knowledge to economic empowerment. Unfortunately, the escalating demand for higher education has in some cases forced hasty provision of education opportunities which leave a lot to be desired. Consequently, the quality of the education offered in urban satellite campuses is critically examined in this paper with a view to establishing the challenges experienced and making suggestions on how to improve the situation. Indeed,
among the multiple of issues scrutinized in the paper are capacity of physical and human facilities, location of urban satellite campuses, access and affordability of education, quality of learners and competence of teachers,

Justification of the Study
This study is timely, especially in the wave of ISO demand for maintenance of high international standards on the delivery of quality services to the consumers in every aspect of life. Thus, there is an urgent need to scrutinize service delivery in higher education sector, especially at the university because it is the pace setter in training of manpower and advancement of knowledge in the society. Also, due to overwhelming demand and expansion of higher education in Kenya, there is an imperative to put in place checks and balances on the provision of quality of education. Indeed, this paper is a thought provoking study that is meant to pave way for further scrutiny of the ever expanding education sector in Kenya and beyond

Review of Literature
The clamour for higher education should be clearly understood in the context of painful social, political, and economic cost. Specifically, Gudo et al. (2011) argue that “[D]espite the pressure to admit more students [, especially] in a double intake, public universities do not have adequate capacity to do so. The demand for university education in Kenya exceeds the capacity of public universities to accommodate all the qualified KCSE candidates” (pg.213) and other qualified, enthusiastic learners. Additionally, the quality of university education is compromised with big enrollments of students. It is argued in the article “Varsities need funds to attract top scholars” that:

“Matters are worse for the newly-established universities, as they cannot attract qualified lecturers, let alone professors. In fact, in such universities, most of which were given charters in the past two months, the only professors available are the administrators. The main reason for this state of affairs is the low pay package and lack of facilities, which make university teaching unattractive” (Saturday Nation 16th March, 2013, Kenya. pg. 12).

In the past, many universities, especially public universities undertook desperate measures to recruit masters’ level staff and part-time lecturers to teach students population which had increased due to double intakes of 1987 and 1990. However, the consequences of this move, were far reaching on quality education given. Precisely, Boit and Kipkoech (2012) maintain that:

“As a stopgap measure, the public universities recruited part-time lecturers from other public as well as private sector institutions such as polytechnics, private universities, and research institutions as well as from each other. Part-timing appears to be getting entrenched with the risk of becoming a permanent feature of the public university education system. In these times of economic stringencies public universities are using part-time lecturers as a short-term cost-saving measure since they do not draw benefits of regular staff such as medical allowance, house allowance, or pension. However, the effect of part-timing is the impact it is likely to have on the quality of university education in terms of teaching and research” (pg.39).

Thus, the immediate imperative in Kenya is to transform the education system, especially on aspects of access and quality, if the country needs to move forward and meaningfully be part of scientific and technologically advancing global village. Other outstanding educationists have appreciated the increasing demand of education in Kenya, while emphasizing the need to improve its quality. In his paper ‘The Transformation of Higher Education in Kenya: Challenges and Opportunities,’ Kinyanjui (2007) candidly observes that:

“Transformation and Paradigm shift in Higher Education: The Public University Inspection Board report has called for a paradigm shift and a radical rethinking on how to address the increasing demand for access and equity; the way students are initiated and socialized into university community life and the way the quality of learning and research is processed, ensured and maintained” (pg.1).

Put in another way, The Public University Inspection Board report and other stakeholders are calling upon a well thought paradigm that will enable students access quality education which will sustain the total transformation of the society. Kinyanjui (ibid) further underlines that:

“The paradigm shift envisaged entails transformation of higher education their concrete context of meeting national challenges of socio-economic development, innovation, creativity, adoption and adaptation of scientific and technological changes for the benefits of Kenyans, and to confront global challenges of competition in the Knowledge economy” (pg. 1).
In response to this challenge, this paper critically scrutinizes the quality of education offered at university level in urban satellite campuses in Kenya with a view to establishing the challenges experienced and offering suggestions on how to improve the situation. Supporting this line of thinking, in the context of escalating demand for education in Kenya, Gudo et al. (2011) emphasize that:

“The demand for university education in Kenya has significantly increased and continues to swell. [Evidently,] Many secondary school graduates and the working class look for opportunities to pursue university education. [Nonetheless,] Universities being accountable to the public as stakeholders need to guarantee that they offer quality teaching, research and community service to its students. With the increasing numbers of students seeking places in public universities, the question of quality is critical and requires urgent attention” (203).

Even as the government endeavours to ensure quality among other things is maintained in higher education, it should not lose sight to offer equal opportunity to all Kenyans to access education. Correctly Kinyanjui (op cit) emphasizes that “The main challenge is how to increase access to higher education to cater for the increasing high number of school leavers and others who desire tertiary education (university), while maintaining quality and ensuring equity and affordability”(pg.2) at all times without other hidden cost.

METHODOLOGY
This study utilized the observation and key informant interview methods of research through which facilities such as lecturer rooms, libraries, laboratories and other supportive infrastructure such as playgrounds and those for indoor games were observed. The observation was made against set standards by the University Rules of 1989 and the Commission for Higher Education (later the Commission for University Education) in its Handbook on Processes for Quality Assurance in Higher Education in Kenya (CHE, 2008). While the observation method used an observation checklist, the key informant interviews were carried out with students, lecturers, and Heads of Academic Departments (HoDs) in six universities with campuses in Meru, Eldoret, Embu and Nakuru towns and the City of Nairobi. In total gender inclusive population of 30 students and 18 lecturers who included heads of university academic departments from different schools/faculties were interviewed in three private and three public universities in a period of 12 moths between January and August 2013.

Findings and Analysis
A close observation shows that provision of higher education in urban centers in Kenya is extremely expensive to students, especially on the accommodation, transport, and subsistence. Majority of the students interviewed agreed that the physical facilities, especially in urban campuses were inadequate, yet the fee is high. They pointed out the existence of poorly equipped libraries, inadequate space in classrooms, and lack of offices for staff among other facilities. Further, they bitterly complained that the burden of paying for transport to the campus and back to residences located far from the university, expensive accommodation, and other miscellaneous cost were frustrating their efforts to learn. Although, most of the lecturers interviewed were hesitant to comment on the status of physical and human facilities in their campuses, they would quip to the interviewer that “it is obvious what you see”. Meaning the aforementioned facilities are inadequate to sustain teaching and learning. Note that on average, a student will pay per semester over Kes 20,000 on rent and Kes 25,000 on transport and subsistence. These figures may vary depending on the location of the campus. Precisely, adding to the cost of about Kes 100,000 for tuition the amount is beyond the affordability of an average parent or guardian. Given this overwhelming cost, it has become increasingly difficulty for students to sustain attendance of required academic sessions and hence several of them drop out of university programmes.

Many urban campuses are located in small spaces and therefore they cannot develop the required infrastructure to support the increasing number of students. Many students interviewed expressively maintained that campuses in the middle of towns need to be relocated to places which are conducive for learning. Even further, most lecturers interviewed admitted that the location of their campuses and glaring limited space were not good for business of teaching and learning. Some campuses are located in buildings, especially meant to serve as offices of small companies. More so, other campuses are housed in former residential houses. Consequently, it has become hard for many universities to have adequate classrooms, offices and good libraries for delivery of quality services. Further, a number of urban campuses lack recreational spaces for students; therefore most of the time students would move out of crowded campuses and loiter in streets and adjacent entertainment joints.
As argued earlier, many urban campuses are located in areas mostly referred as central business districts and peripheries of the same centers. Indeed, as observed, these areas are noisy and have distracting heavy human traffic. Simply, the areas are not conducive for learning. But the irony of it all is that university management teams insist that these centers are strategic and accessible to attract students. Unfortunately, the reality is different because in several cases students and lecturers waste a lot of time wading through human traffic to attend classes at the required time. Even when a student or lecturer manages to overcome such obstacles, he/she will be stressed up to benefit meaningfully from learning sessions.

To attract more learners into programmes that are yet to be okayed by the Commission for University Education, many universities admit to satellite campuses students who have performed below C+, the required university admission cut point. Quite a number of students admitted that they scored below C+ in the Kenya Secondary Certificate of Education examination and had to be subjected to simple and waste of time bridging courses. The attempt to give this caliber of students bridging courses in order to meet the required qualification is unprofessionally done. Part of the problem is the need to make as more money as possible and hence admitting under qualified candidates only to subject them to bridging courses that they obviously pass.

In some universities, the curricula of some programs have been simplified to attract more students and in essence make other universities offering same programs unpopular. It is common for students to prefer enrolling in some universities where programmes are less demanding than others. The whole idea of offering university education is reduced to hawking it to any gullible learner. Even the qualified students who joined Module 11 in public universities or private universities complained of shoddy teaching and inadequate infrastructure, especially in urban campuses. They added that lecturers do not begin teaching on time. They only come the last weeks before the main examination to teach around the questions they have set. And since students want to pass in courses offered they do not bother reporting such lecturers to the relevant university authority.

Some universities do not have required trained manpower to teach and mentor students. This is a fact that the Government of Kenya has ably acknowledged in the Kenya Vision 2030 (Republic of Kenya, 2007). To make the programmes ‘cost effective’, a good number of universities recruit part time staffs that are ill-equipped by training and experience. There were instances where some universities were observed to employ postgraduate students who were yet to complete their studies or engaging tutorial fellows in the teaching of postgraduate students against the fact that this is a training position. Rarely, do some universities engage genuine masters and PhD holders because they are too expensive to pay. Consequently, the courses offered and the products realized exhibit mediocrity. Evidently, the heads of departments interviewed expressed that they are not able to attract and engage PhD holders to teach in their campuses because of poor pay and in some cases the nonpayment of part time teaching. Also, the many lecturers interviewed admitted to have a master degree. But a few reported that they have registered for PhDs which they are not able to complete because they are busy teaching on part time basis in other universities.

Further, the qualification of some lecturers teaching in urban campuses is questionable because as said earlier several universities engage cheap trained manpower. A number of lecturers are mostly recruited from high schools and obviously lack university teaching experience. Worst still, these lecturers lack rigorous training in content and research because majority are graduates of the same makeshift campuses where academic rigor is seemingly compromised. In addition to incompetence of lecturers, the issue of corruption is common in these campuses, especially in allocation of teaching courses. Some heads of departments allocate courses on basis of friendship, nepotism, tribalism, and underhand deals. Even further, when these heads of departments fail to get friends to teach courses, they hurriedly recruit cheap and inexperienced lecturers from neighboring private and public institutions. Worst still, engaged lecturers may teach in more than one campus and in effect compromise the quality of the content in addition to encroaching on time to deliver it.

CONCLUSION
From the foregoing findings, it is arguable that the capacity of physical and human resources to support student numbers, especially in urban university satellite campuses is wanting. The locations of these campuses are not conducive for any serious learning. It is apparent that quality of university education has greatly been compromised leading to production of many half-baked graduates. The recruitment of unqualified students and reliance on part time staff is noted for the deteriorating academic standards and quality of graduates. Where qualified staff is engaged the problem is the payments for part time teaching take many months to be effected even when their service charters give a different waiting period.
Most Heads of Departments live in fear of the university management to flex their muscles and decline engaging mediocre lecturers. Major reforms are urgently needed in the higher education sector particularly the provision of the necessary physical and human resources for quality improvement.

Therefore, the Kenya government should tighten the regulations of checking standards through proper training and adequate funding of enforcing manpower. Universities that do not meet the threshold of the desired conditions to open and operate satellite campuses should be shut down. The students who do not meet university entry requirements could enroll in middle manpower colleges to take bridging programmes before pursuing degree courses. Equally, lecturers who are not productive should be discontinued from teaching at the university until they demonstrate dependable expertise in the aforementioned areas of university scholarship. Further, the government should retrain or fire university managers who are hindrance to processes of creating and sustaining transparent and accountable processes of maintaining high academic and managerial standards at the university. Once the above is done among other things, the quality of university education will improve for the better.

REFERENCES


KENYA'S RELIGIOUS INSTITUTIONS ROLE IN DEVOLUTION FOR SUSTAINABLE DEVELOPMENT

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ABSTRACT
This paper examined the role of religious institutions in the success of devolution in Kenya. Politics influence almost every aspect of life and so does religion. The misuse of power, bad politics, hypocrisy of democracy and corruption were identified as obstacles to devolution and the development of a country. These aspects were championed passively by powerful and privileged minority political elites who hinder national development. It is said that whenever a state fails in the proper governance, people always turn to religious institutions for solace. It would be perilous to wait until the country gets to such a state. The community of faith in Kenya has a big role to play in the success of devolution both at the national level and the county level for sustainable development and for attainment of the Vision 2030. It is a tool for empowering and mobilizing the people to become the agents of their own development and liberating themselves from these dysfunctional structures that devalue them and their dignity. For long the church has been seen to be on the opposing side, opposing transitions, especially the new constitution and blocking the path for reforms,
but not all. Some clerics have bled, been detained and others have died for the course. The article recommends vibrant involvement of the religious society in governance.

**Key words:** Devolution, Development, Governance, Democracy, Religion

**INTRODUCTION**

Churches are viewed as a central institution within people’s life, because religion provides the moral foundation of self-restraint and community awareness necessary for the success of self-government. Many believe that one would not succeed without the moral training churches provide to citizens. Churches, surely, have contributed to the success of Kenya by encouraging virtue. Research has also shown that churches provide direct and indirect economic and social benefits to communities. Churches provide valuable contributions to communities in the areas of direct economic contributions, social services and community volunteering, education and civic education training, and reduced levels of deviance and illiteracy.

These benefits positively improve communities in direct and indirect manners, and they enhance political stability and the long-term health of communities. This paper will outline some examples of each cited by prominent social science researchers, developing the argument that churches bring benefits to communities that outweigh the loss of revenue from their tax exempt status. In fact, if it were not for churches, government would have to expend public funds to replace the community benefits that churches provide. Overall it is clear that churches bring positive benefits to communities, and their role in the community as a beneficial, nonprofit institution should be maintained.

**Statement of the Problem**

For long, Kenya has experienced episodes of political instability which have had adverse effect on the country’s economic performance and social cohesion. For example, the 2007 PEV Kenya witnessed following the disputed national elections. Kenya also experiences other problems from time to time i.e. corruption, economic stagnation, inequalities and poverty. These can be attributed to the quality of governance (Kimenyi and Meagher, 2004). Quality of governance is in turn dependent on institutions. These institutions can take different forms ranging from constitution to local authority by-laws to self-regulation in informal businesses. It is these institutions that collectively determine governance framework in a country which in turn determines development plans in a country. If then this is the case, then faith based institutions will have to be incorporated in development and success of devolution through the private-public partnership for sustainable development in the path of achieving vision 2030.

**Objectives**

- To determine the position of the church in devolution
- To determine the role of faith based institutions in development of community and country at large
- To encourage the church to take up a bigger part in devolution
- To encourage the clergy to be included in vetting commissions

**Significance of the Study**

The information obtained will enhance better strategies and measures to promote involvement of churches. The results of the study will help us come up with new and improved ways of supporting devolution. This knowledge will help enhance better planning, improve development programs and proper government policy making.

**Justification of the Study**

The relation between religion and politics continues to be an important theme in political philosophy, despite the emergent consensus on the right to freedom of conscience and on the need for some sort of separation between church and state. One reason for the importance of this is that religions often make strong claims on people’s allegiance, and universal religions make these claims on all people, rather than just a particular community. Religious beliefs and practices also potentially support politics in many ways. The extent and form of this support is as important to political philosophers as is the possibility for conflict. Moreover, there has been a growing interest in minority groups and the political rights and entitlements they are due. One result of this interest is substantial attention given to the particular concerns and needs of minority groups who are distinguished by their religion, as opposed to ethnicity, gender, or wealth.

**LITERATURE REVIEW**

African countries have increasingly adopted devolution as a strategy to improve governance and remedy institutional
deficiencies. In November 2005, Kenya held its first ever national plebiscite to ratify a new constitution for the country. The National referendum was the culmination of a process in the quest for constitutional reforms. It involved the setting up of the Constitution of Kenya Review Commission (CKRC) to examine the existing constitution and draft a bill on a new constitution.

A National Constitution Commission (NCC) was then convened to deliberate, amend and adopt the draft Bill. Held in several phases, the deliberations of the NCC, culminated in an initial draft known as the Bomas Draft. There was failure to arrive at a consensus between a section of the government and other members of parliament (MPs) on certain provisions. This led to the amendment and development of a final draft constitution by the government section opposed to the Bomas Draft. The draft termed as WAKO draft was presented to a Referendum and Kenyans rejected the proposed constitution therefore generating a the constitution review process.

Devolution of power was among the key contentious issues that precipitated the statement between the government and other policy makers ensuing rejection of the Wako Draft. Devolution entails an understanding of the complex dynamics of decentralization from which devolution is premised. Scholars have come up with several definitions of devolution/ decentralization Ndegwa (2002), Muia (2008) argue that decentralization refers to the transfer of public authority and resources including personnel from national to sub-national jurisdiction.

Rondenelli’s and Neli’s (1986) as cited in Muia (2008) define decentralization as the transfer of delegation of legal or political authority to plan, make decisions and manage public functions from central government or functional authorities and local government or non-governmental organizations. Presently in Kenya we are operating under the devolved government both at the national level and the county government level. In this, despite the fact that the church has always had a direct influence in the political arena, there has not been active engagement in the enhancement and support for the success of devolution. Religion in a community plays a vital role in shaping it.

The opposition of Kenya’s Christian churches to constitutional reforms is in part rooted in a new and disturbing hostility to Islam. This attitude marks a significant retreat from the churches’ past role in Kenya’s democratization, Branch. D. (2010). Many Kenyans as well as foreign observers have welcomed the result of Kenya’s constitutional referendum on 4 August 2010, which gave overwhelming approval to the document. The relief at the clear outcome and peaceful process indeed makes it tempting to see this moment as a new beginning. But it is also well to be cautious, for we have been here before. Over the past fifty years, Kenya has witnessed many moments of apparent transformation followed by disillusionment and despair.

Most pertinent of all in this series is the lesson of the constitutional referendum of 2005. Then, a large majority of Kenyans angered by government manipulation of the reform process rejected a much watered-down constitutional draft as it failed to deliver the widely demanded devolution of power and limits on the presidency. The peaceful conduct of that referendum, coming so soon after the similarly (relatively) calm elections of 2002, fooled many into believing that Kenya had turned a page in its political history. But that hubris was shattered by the violence that followed in the wake of the elections of 27 December 2007.

In this perspective, the most striking feature of the constitutional referendum was not the result. Instead, it was the stance taken on the new constitution by Kenya’s churches. In the 1980s and 1990s, the churches were at the forefront of the sustained campaign for constitutional reform. Today, the churches stand accused of attempting to block the path of reform. The men and women of the cloth stood alongside an unedifying bunch of politicians at the head of the “no” campaign on the grounds of the inclusion in the draft constitution of clauses related to abortion and Islamic courts. The religious opposition to the proposed constitution was led by the National Council of Churches of Kenya (NCCK, the main umbrella-body of the Protestant church), the Catholic hierarchy in the country, and some of the largest Pentecostal churches.

Church leaders followed the lead of Canon Peter Karanja, the NCCK’s secretary-general, in actively campaigning for Christians to vote “no” in the referendum. True, not all clergy agreed. Some veterans of the democratization struggle (including Reverend Timothy Njona, Archbishop David Gitari and Father Ambrose Kimutai), as well as individual independent churches, supported the proposed constitution. The churches here are revisiting much older arguments. For despite the churches’ role in Kenya’s democratization movement from the mid-1980s onwards, there has been continuing if only half-voiced internal dissent to that involvement in secular affairs. Indeed, the uneasy relationship
between religious groups and the Kenyan state is the ostensible reason for at least the Protestant churches’ objections to the proposed constitution. Timothy Njoya of the Presbyterian Church, although retired as a church leader, was an active campaigner in the referendum campaign as part of the Katiba Sasa (“Constitution Now”) consortium of civil-society groups. When Njoya speaks about constitutional reform, Kenyans listen. He has been a consistent and courageous advocate of reform from the mid-1980s onwards, even in the face of consistent harassment by the state. On Easter Sunday, 4 April 2010, Njoya spoke to the press of the price the churches will likely pay for their opposition to reform. “If the church campaigns for a “no” vote and fails to garner support among Kenyans, that will be the end of its responsibility for the Kenyan society. It will have caused its own abortion.” That has now come to pass, and as a result Kenyans are all the more vulnerable to the excesses of the powerful.

RESULTS

Faith-based institutions Provide employment

Presence of churches in the community brings direct economic benefits to the local area. Church organizations provide jobs for the community, and churches support a variety of local businesses. Churches bring individuals from surrounding areas to the community where the church is located, and these individuals provide economic support to local establishments. Thus, churches aid in bringing additional revenue communities. Churches are also an attractive component to local communities. Much like strong school systems, many families and individuals consider the presence of local religious organizations when making decisions about moving to communities and purchasing property. The presence of churches aids in families choosing to establish residence in a local community. This, in turn, helps support local businesses and contributes to property tax payments. Therefore, churches provide direct economic benefits to the community by encouraging growth, job creation, and overall economic vitality.

Churches Provide Social Benefits

Beyond direct economic benefits, churches also provide social benefits that have economic value. Several researchers have identified the social benefits that churches bring to communities, including: providing help to poor and vulnerable individuals in the community, improving marriage relationships, decreasing violence among women, increasing moral community obligations, and promoting charitable contributions and volunteering. Social scientists consider it irrational to participate in moral and volunteer projects, because they have such a low personal benefit. However, being a member of a religious community increases one’s duty to serve others in the community, countering the “free rider” problem. Churches help communities complete vitally important social projects, for which the government would need to fund if churches did not provide such support.

A comprehensive study of religious congregations in six metropolitan communities found that 91 percent of religious congregations provided at least one social service (Cnaan et al. 1999), and, similarly, 87 percent of the congregations in a Philadelphia survey provided at least one social service to the community (Boddie et al. 2001). While some argue that this percentage of churches is overestimated because it overlooks smaller churches, even conservative estimates claim that larger congregations, representing approximately 75 percent of the religious population in America, provide at least one social service to the community (Chaves 1999).

In a recent, detailed study of churches in Philadelphia, researchers found that churches do much more community aiding work, including helping the poor and making positive social inroads in the community, than previously realized by scholars. The authors declare, “If it were not for the impressive collective effort of some 2,120 local religious congregations, life in Philadelphia would have become extremely harsh” (Cnaan et al. 2006; p. 291).

In a similar study in Philadelphia, congregations, on average, provided 2.33 different social programs (Boddie et al. 2001). Another study shows that a typical church provides financial support, volunteers, space, and in-kind donations to six community programs each year (Ammerman 2001). In categorizing these community programs, Ammerman finds that congregations, on average, aid two direct service programs, two educational, health, or cultural programs, and one community development or political/social advocacy program (Ammerman 2001).

The presence of churches in the community will also increase the religiosity of locals, and increased religiosity results in positive social contributions for the community. For example, religiosity influences individuals’ obligations to perform non-religious moral acts. Individuals who are religious have been shown to have increased propensity to participate in community-building, moral projects, such as giving blood (Ortberg, Goruch, and Kim 2001). Additionally, church affiliation and religiosity increase community volunteering as well as intra-church volunteering (Park and Smith
One scholar finds that churches contribute volunteers to three organizations on average, though some churches provide dozens of volunteers to different projects (Ammerman 2001). A 1990 national study finds that church members volunteer 56 million hours each year to organizations outside their local congregations, aiding with human service projects, educational attainment, cultural awareness and training, and environmental improvement (Hodgkinson 1990).

Because it can be difficult to quantify the exact value of the volunteering and community building benefits churches provide to local areas, many scholars have sought to quantify the “replacement value” of the social and volunteering benefits that churches provide to communities. The replacement value calculates monetary donations and in-kind support, staff and congregant volunteer hours, utilities, and the value of space (Tirrito and Cascio 2003). Cnaan valued that churches in large metropolitan communities provide support equal to one full-time social service employee (Cnaan 1999), and in a comprehensive study of Philadelphia scholars valued community services at $115,009 per congregation and $230,018,400 for all the religious congregations in the city (Boddie, et al. 2001). The accuracy of this figure can be debated, but it is clear that by building up and sending out volunteers to the community, churches provide significant economic and social benefits, helping improve communities.

**Churches Promote Education and Civic Engagement**

Along with creating social programs and serving as a foundation for community volunteers, churches also improve the educational success of students and provide training and skills that promote civic engagement. For students, religious involvement is positively correlated with higher math and reading scores and greater educational aspirations (Regnerus 2000; Regnerus 2001).

Students who frequently attend church have improved ability to allocate time and achieve goals (Freeman 1985), and religiously connected students are five times less likely than their peers to skip school (Sloane and Potvin 1986). Parents’ involvement in churches also improves their children’s educational capacities and achievements. Parents with higher levels of religiosity raise children who more consistently complete homework, attend class, and complete degree programs (Muller and Ellison 2001).

Churches provide educational, psychological, and moral training and resources, which result in positive present and future educational outcomes for students. Several cross-national and community based studies also show that churches help members obtain civic skills, such as public speaking, networking, organizing, and participating in politics (Schwadel, 2002).

The church environment provides a training ground for individuals from all socioeconomic backgrounds, affording individuals the skills to succeed in industry, business, education, and politics. In sum, the education and civic engagement training and motivation that church institutions foster has great social and economic benefits to societies. As education and civic engagement increase, deviance and crime decrease and economic growth and political stability increase. Churches are important institutions in the development of educational, life, and social skills necessary to succeed in society.

**Churches Help Decrease Crime and Deviance**

In addition to providing social programs and community volunteers, churches decrease the occurrence of crime and deviance in communities and among local youth. Reduced levels of crime and deviance make communities more safe, stable, and productive, and safe and stable communities encourage economic growth, through business expansion and attracting new residents. Several studies find that churches decrease crime and deviance, helping promote these economic benefits of a safer community.

Being involved in a church consistently decreases levels of deviance and crime. Religious involvement decreases domestic violence among both men and women, according to a national study (Ellison and Anderson 2001). Church attendance has also been associated with decreased levels of assault, burglary, and larceny (Bainbridge 1989), and religiosity promotes decreased levels of violent crime both at the individual and the state level (Hummer, et al. 1999; Lester 1987). Increased levels of religiosity also directly decrease deviant behavior, such as drug use, violence, and delinquency among at risk youth (Fagan 2006). Decreased levels of deviance aid in bringing about social order, increase the likelihood that businesses will expand into local areas and bring economic opportunities, and decrease government expenditures into programs and institutions that reduce, punish, and compensate for deviance.
Churches Promote Mental and Physical Health

Churches also promote a variety of health benefits for the community, improving the vitality of the community and decreasing government expenditures. Studies have consistently shown that religiosity is related to increased longevity (Johnson et al., 2002; Fagan 2006). The average religious individual lives seven years longer than the average nonreligious individual (Hummer et al., 1999; Fagan, 2006).

Research by Johns Hopkins scholars shows that nonreligious individuals have increased risks of dying from cirrhosis of the liver, emphysema, arteriosclerosis, cardiovascular diseases, and suicide (Comstock and Patridge 1972; Fagan 2006). Religious attendance has also been shown to decrease alcohol abuse and drug use (Fagan 2006; Gartner et al., 1991; Hasin et al., 1985). A study in San Diego, California also shows that nearly two-thirds of all churches provide health promotion programs and participate in community health programs (Elder et al., 1989).

Church programs and religious practices promote physical health, and a healthy community is more productive and less of a strain on local resources. By helping improve physical health, churches provide a significant benefit to the community. In addition to physical health, church attendance also promotes mental health. In a comprehensive survey of mental health studies, 81 percent of 91 studies showed that religion is positively associated with mental well-being (Johnson et al., 2002; Fagan 2006). Religious attendance has been shown to decrease stress, increase self esteem, and give individuals hope and a greater sense of life purpose (Fagan 2006; Johnson et al., 2002).

Increased religious practice also is associated with decreased levels of depression and suicide (Johnson, et al. 2002; Ellison, 1995). In sum, church involvement has been shown to improve mental health, and having strong mental health makes individuals more productive and less at risk for committing crimes. Churches provide mental health benefits to individuals, and improved mental health directly aids communities.

Recommendations

Churches have diverse positive impacts on communities, ranging from increased trust, improved mental and physical health, decreased crime, and enhanced levels of volunteering and community outreach. These attributes build norms and values that encourage political stability and economic performance. Churches contribute to vitally important components of successful societies, and their presence in communities provides many benefits that cannot be measured solely by direct revenue.

References


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ABSTRACT

The study assessed the level of community engagement in the National Agriculture and Livestock Extension Programme (NALEP) in Chuka Division, Meru South District, Eastern Kenya. It focused on the community’s knowledge about the programme, participation in the programme and evaluation of the programme to include their suggestions. Questionnaires were distributed to 20 respondents in Gitareni location and 20 respondents in Mugwe location. The questionnaire consisted of 22 closed-ended questions and 2 open-ended questions. In addition, 3 focus groups were held, two in Gitareni and one in Mugwe. The study found that the two communities were engaged in the programme and that only a small proportion of the participants had limited engagement. Engagement was across all occupations, ages and gender. The main reason given for participation was to improve their farms. Organisation structures in the community affected participation. There were no significant differences in the level of engagement of the two communities. The study recommended five ways which can improve the engagement of the farmers. These are improved decentralised training programmes, flexible modes of engagement, coordination of stakeholders, use of revolving funds and inclusion of all.

Key words: Community engagement, Participation, Organizational structures, Sector Coordination

INTRODUCTION

The role of agriculture in the Kenyan economy is very significant. Agriculture directly contributes 26% of GDP and a further 27% indirectly through linkages with manufacturing, distribution and other service related sectors. About 45% of government revenue is derived from agriculture while the sub-sector contributes over 75% of industrial raw materials (Republic of Kenya 2006). Of more importance is agriculture’s contribution to achievement of national food security, foreign exchange earnings and as a stimulus to create off-farm income generating activities. In Kenya, 82% of the 36.1 million (Kenyan Central Bureau of Statistics, 2006) people live in the rural areas and derive their livelihood from agricultural activities (Government of Kenya 2005:8).

However, like many other developing countries, Kenyan agriculture is confronted with changes in the global food and agricultural system, including the rise of supermarkets and the growing importance of standards and labels. Consequently, agriculture is also affected by growth in non-farm rural employment and agribusiness coupled with the deterioration of the natural resource base and the emerging need to cope with climate change.

The importance of agriculture extension in rural development is widely acknowledged. In developing countries such as Kenya, where the majority of the populations live in rural areas and agriculture is the main source of livelihood, agricultural extension is considered to be one of the key drivers and a vital catalyst in rural development (Wanga 1999).
In Kenya, the National Agriculture and Livestock Extension Programme (NALEP), a policy framework that assists in the implementation of the National Agricultural Extension Policy (NAEP) was an attempt to find a different path of adequately resolving the complex, systemic issues that face rural communities in Kenya today (Amudavi 2003). NALEP was founded on three pillars; participation, collaboration and partnerships. It was implemented by Ministries’ of Agriculture (MOA) and Livestock and Fisheries Development (MOLFD) and targeted the entire rural population in Kenya who were engaged in agriculture, livestock and fisheries production. NALEP delivered advisory services with an aim to achieving increased production, food security, higher incomes and improved environment.

NALEP advocated, facilitated, and promoted establishment of grass root institutions that took control of development initiatives in their areas. Some institutions established included Stakeholder Forums (STF), Focal Area Development Committees, Common Interest Groups and marketing federations. This made community engagement very important in order to achieve those results, corresponding with an international trend towards more participatory and deliberative approaches to democratic governance (Queensland Government 2005:3).

This study assessed the level of community engagement in NALEP implementation in two locations in Meru South District, Eastern Province Kenya. It focused on information about the program, participation in the program and evaluation of the program by the community drawn from a series of interviews and focus groups conducted in February 2009. The study also focused on the community capacity to identify their problems.

LITERATURE REVIEW

The importance of agriculture extension in rural development is widely acknowledged. In developing countries such as Kenya, where the majority of the population lives in rural areas and agriculture is the main source of livelihood, agricultural extension is considered to be one of the key drivers and a vital catalyst in rural development (Wanga 1999). Agricultural extension services aims at increasing farm productivity and improving the welfare of the rural people by educating farmers on advanced farming techniques and promoting an innovative environment. This is achieved by linking researchers, government planners, NGOs, community based organizations and private sector with farmers by offering an open platform for the exchange of ideas and services (Barrett et al 2007:84).

However, the role of agriculture extension has been evolving to integrate farmer knowledge with formal science and build a culture of dialogue among various actors and planners. This evolution is due to the realization that sustainability is best achieved if farmers take more active and participatory roles in agriculture extension. In addition, there is an increasing recognition that the socio-economic and agro-ecological conditions of resource poor farmers are complex, diverse and risk-prone (Farrington 1998 cited in Amudavi 2003) and the general realization that research and extension agencies do not have the capacity to generate a mix of technologies to the level required by farmers (Thrupp and Altieri, 2001 cited in Amudavi 2003).

METHODOLOGY

The study population lived in a focal area which covers an administrative location. The target population was both those who participated in the NALEP and those who did not. The main criterion was that they were residents of the area during the implementation period. There are about 2040 farm families in Mugwe and 1800 in Gitareni. Each NALEP Focal Area is divided into 4 blocks (of about 500 farm households) for the purpose of implementing NALEP activities. For the purposes of this study one of these blocks was selected randomly in each of the two communities and questionnaires administered systematically at every 25th home in a block. This resulted in 20 questionnaires in each focal area, a total of 40 for the entire study. A sample of 40 was chosen because it would provide a good range of responses. Additionally, three focus group interviews were conducted in the Focal Areas; two in Gitareni and one in Mugwe. Data was also collected from primary sources through a survey that involved conducting focus group interviews and administering semi-structured questionnaires. The questionnaires were administered by the researcher in February 2009. The survey was directly administered as there was a possibility of some participants being illiterate. Before the administration of the questionnaire, a brief meeting was held with the area Chief, the Provincial Administration Officer in charge of a location, to gain permission to enter the local area.

RESULTS

The study found that the Mugwe community had a greater knowledge of the program (50% respondents knew about the program) than did the Gitareni community (35%). In Mugwe, the respondents were more involved in the program activities and 40% gauged their engagement in the program as ‘very high’ compared to only 15% in Gitareni. Comparatively, the Mugwe Focal Area Development Committee (FADC) was very conversant with the program’s operations and was articulate about the outcomes while there was a lot of debate within the Gitareni FADC before they agreed on any outcome. It is interesting to note that participants between the ages 21 and 30 had no idea about the program. Despite this, there was no clear evidence of level of knowledge being influenced by age, sex or occupation. It
was found that a higher percentage of respondents participated in NALEP activities in Gitareni (65%) than in Mugwe (50%). In Mugwe 80% of those participating in NALEP activities contributed money or materials, while only 31% did so in Gitareni. This can be interpreted to indicate a higher level of engagement. Of all the NALEP activities, CIG training was rated to be the most useful to the respondents followed by the field days.

There was a higher percentage of respondents from the farming and business category who participated in NALEP activities and this could be attributed to the focus of NALEP, that of ‘farming as a business’. Such an interpretation is confirmed by the focus group quote that ‘the word business influenced many people; the idea that local crops like bananas can be business was thrilling’. Women had a higher level of participation. However, the sample of women was too small to enable conclusive findings to be made.

Respondents in both areas participated in the program so as to improve their farms. It is evident therefore; that participation is influenced by perceived benefits. This interpretation is confirmed by Wandersman et al (1987:537) who argue that participation is caused by goals or motivations. It is also apparent that, from the farmers’ point of view, extension still plays an important role in the introduction of new farming technologies. From one of the focus groups (Amani and Gatugi women group) it was clear that the women gained social benefits such as higher status in the society, recognition, self-confidence and public image. This is in line with what Butterfoss (2006:331) outlines as the potential benefits for participants.

Findings revealed that the level of community engagement was between ‘fair’ to ‘very high’ (over 80% in both areas). However, there was no clear distinction between the two areas. This is because from the questionnaires, Mugwe community was more engaged than Gitareni, the Mugwe FADC was more articulate than the Gitareni FADC, and had a merry-go-round activity to enhance cohesion. However, the Gitareni Common Interest Group (CIG) was also very articulate on issues concerning the program implementation and how they had participated and benefited. No CIG group was interviewed in Mugwe to provide a comparative basis. Age and occupation did not seem to influence the level of engagement. However, women were found to be more engaged as compared to men.

From the secondary data, it is not obvious that either of communities had a higher level participation in terms of people attending various NALEP activities than the other. From the analysis of the results, there were more people attending the sensitization baraza, CAP baraza and field days in Mugwe, while there were more who attended CIG trainings in Gitareni in addition to there being more CIGs in Gitareni than in Mugwe.

CONCLUSION
The interplay between the communities, private sector, the government and other development partners is crucial for sustainable development, not only in the agriculture sector but in all aspects. Total commitment is a prerequisite for each of these stakeholders for the three pillars (participation, collaboration and partnership) of NALEP to be fully realized. The translation of the program success into development (social, economic and physical) is affected not only by the level of community engagement but also the political environment, program aspects, governance structures and global factors such as globalization, climate change, and liberalization among others.

RECOMMENDATIONS
i) Improved decentralized training program
Increasing decentralization is correlated with increased knowledge of potential sources of information, as well as higher rates of participation in various community organizations and knowledge of various available channels of extension service delivery. Therefore, it is necessary for the program to persist in training at a local level to ensure that the people receive the knowledge and skills to better implement development in their areas. The training program should be tailored to suit the needs of the community.

ii) Flexible models of engagement.
A model of engagement that might work in one area may not necessarily work in another area and it is therefore important to adopt a flexible mode of engagement other than a ‘one size fits all’ approach. The facilitators need to have a good understanding of the dynamics of the community and seek to engage with them rather than impose externally designed solutions.

iii) Coordination between stakeholders
Collaborative engagement between all stakeholders is an excellent opportunity for delivering networking opportunities and providing access to information and resources. It is also excellent in ensuring personal recognition, contributing towards skill enhancement, and providing a sense of contributing to the community. The stakeholders need to treat the community residents as peers and not as ‘customers, clients, objects of concern, sources of data, or targets of problem solving effort’. All stakeholders should listen to and make an effort to understand the needs of the community.
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INNOVATIONS & CREATIONS FOR ENTREPRENEURSHIP

INVENTION, INNOVATION AND CREATIVITY MANAGEMENT IN EDUCATION FOR SUSTAINABLE DEVELOPMENT TOWARDS ATTAINMENT OF VISION 2030

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ABSTRACT
Ideas, inventions and innovations are like butterflies. They are transient, fleeting and often incompletely formed. Unless we invite them to stay by having innovation management skills they tend to wander off. The myriads of Annual High School Science Congresses and student innovation conferences in universities reveal abundance of “ideas people”, who unfortunately fade off to obscurity due to lack of management skills. Since these are not products of necessity but curiosity it calls for innovation and creativity management for sustainability by incorporating patenting of innovation in curricula to be taught just like printing, publishing and copyrighting is taught in literature. This research was pegged on John Dewey theory of education which integrates the school with the society, and the process of learning with the actual problems of life by a through application of the principles and practices of democracy. It adopted the descriptive survey research design, data was collected using interviews, phones and emails conducted to 2013 National Science Congress presenters, researchers of 2014 at the Laikipia University 2nd International Conference and Kabarak 4th International Conference, which also incorporated students’ innovation. There is no coordination of research activities among the various institutions to ensure synergy and to avoid duplication. Proven technical knowledge produced in high schools, tertiary institutions, including universities has been going down the drain with failure to transform into technologies and protect it as intellectual property in patents which are sources of information for new inventions, technology transfer to encourage research and development. Thus, educational curricula should be reviewed to include educational leadership and management of innovation and creativity with the process of protecting proven technical knowledge as intellectual property rights becoming heuristic.

Key words: Education, Management, Intellectual Property Rights

INTRODUCTION
Kenya Vision 2030 is the new long-term development blueprint for the country. It is motivated by a collective aspiration for a better society by the year 2030. The aim of Kenya Vision 2030 is to create “a globally competitive and prosperous country with a high quality of life by 2030”. It aims to transform Kenya into “a newly-industrializing, middle-income country providing a high quality of life to all its citizens in a clean and secure environment”. Simultaneously, the Vision aspires to meet the MDGs for Kenyans by 2015. The Vision is anchored on three key pillars: economic; social; and political governance. The economic pillar aims to achieve an average economic growth rate of 10% per annum and sustaining the same till 2030 in order to generate more resources to meet the MDGs and vision goals. The Vision has identified a number of flagship projects in every sector to be implemented over the Vision period and to facilitate the desired growth rate. The identified flagship projects directly address priorities in key sectors such as agriculture and education. The social pillar seeks to create a just, cohesive and equitable social development in a clean and secure environment. The political pillar aims to realize an issue-based, people-centered, result-oriented and accountable democratic system.

Foundations for Kenya Vision 2030
The economic, social and political pillars of Kenya Vision 2030 will be anchored on a number of foundations among them being: macroeconomic stability; continuity in governance reforms; enhanced equity and wealth creation opportunities for the poor; science, technology and innovation (ST&I); and human resources development.

Macroeconomic Stability for Long-Term Development
A stable economic environment also works in favour of the poor who stand to lose the most in periods of high inflation. All the projects proposed under Vision 2030 will, therefore, be implemented subject to the parameters set under the macroeconomic stability framework.
Enhanced Equity and Wealth Creation Opportunities for the Poor

No society can gain the social cohesion predicted by Vision 2030 if significant sections of it live in abject poverty. To that extent, Kenya Vision 2030 includes equity as a recurrent principle in all its economic, social and political programs. Special attention has been given to investment in the arid and semi-arid districts, communities with high incidence of poverty, unemployed youth, women, and all vulnerable groups.

Science, Technology and Innovation (S, T and I)

Vision 2030 proposes intensified application of science, technology and innovation to raise productivity and efficiency levels across the three pillars. It recognizes the critical role played by research and development (RandD) in accelerating economic development in all the newly industrializing countries of the world. The Government will create the STI policy framework to support Vision 2030. More resources will be devoted to scientific research, technical capabilities of the workforce, and in raising the quality of teaching mathematics, science and technology in schools, polytechnics and universities.

Human Resource Development

Kenya intends to create a globally competitive and adaptive human resource base to meet the requirements of a rapidly industrializing economy. This will be done through life-long training and education. As a priority, a human resource data base will be established to facilitate better planning of human resources requirements in the country. Furthermore, steps will be taken to raise labour productivity to international levels. Other steps will include the establishment of new technical training institutions, as well as the enhancement of closer collaboration between industry and training institutions.

Continuity in Governance Reforms

Kenya remains fully committed to continuing “a society free from danger and fear”. The Government is determined to improve security in order to attract investment, lower the cost of doing business and to provide Kenyans with a more secure living and working environment. Specific strategies will involve: improving the practice of community policing; reducing the police to population ratio to recommended UN standards; adopting information and communication technology (ICT) in crime detection and prevention; enhancing police training and use of modern equipment in law enforcement. All these measures will be supported by accelerated reforms in the judiciary. The country will also implement reforms in the prison service, starting with reduction of the number of suspects in remand homes, improved training and working conditions for prison staff; and a reorientation of the service to correctional activities.

Public Service

An efficient, motivated and well-trained public service will be one of the major foundations of the vision. Kenya will build a public service that is citizen-focused and results-oriented, a process whose achievements so far have received international recognition and awards. The Government will intensify efforts to bring about an attitudinal change in public service that values transparency and accountability to the citizens of Kenya. Results based management and performance contracting will be pegged to the implementation of the Vision’s goals, making it easier to reward public servants on merit and performance. Reforms in the public service will further enhance strategic planning in government, continuous improvement, and stakeholder engagement. A Kenya School of Government will be established to provide research and training for transformative leadership to the highest international standards. This is where critical and creative thinkers and civil servants like chief Kariuki should be the first in the faculty of e-governance and in particular security where he has demonstrated how to fight crime digitally by twitter.

Economic Pillar

Moving the Economy up the Value Chain. After a comprehensive analysis of Kenya’s global competitiveness, six key sectors have been identified to deliver the 10% economic growth rate per annum are: tourism; agriculture; manufacturing; wholesale and retail trade; business process outsourcing (BPO); and financial services.

Social Pillar

Investing in the People of Kenya. This quest is the basis of transformation in some key social sectors, namely: Education and Training; Health; Water and Sanitation; the Environment; Housing and Urbanization; as well as in Gender, Youth, Sports and Culture.
**Education and Training**

Under education and training, Kenya will provide a globally competitive and quality education, training and research. Kenya aims to be a regional centre of research and development in new technologies. This will be achieved through: (i) integrating early childhood education into primary education; (ii) reforming secondary school curricula; (iii) modernizing teacher training; (iv) strengthening partnerships with the private sector; (v) developing key programs for learners with special needs; (vi) rejuvenating ongoing adult training programs; (vii) revising the curriculum for university and technical institutes to include more science and technology; and (viii) in partnership with the private sector, the Government will also increase funding to enable all these institutions to support activities envisaged under the economic pillar.

**Statement of the Problem**

The transient, fleeting and often incompletely formed; butterfly-like characteristic of ideas inventions and innovations to wander off leaves us with no option apart from invite them to stay by having innovation management skills. The appropriate invitation is what this research brands as incubation. Incubation refers to the gradual development: the slow development of something, especially through thought and planning by activities similar to those of a hen when it broods over the eggs in line with nature which calls for production of fine chicks by hatching and not by smashing. The myriads of annual High School science congresses, the students innovation conferences in universities together with research conferences reveal abundance of skilled “idea people” who unfortunately fade off to obscurity for lack of ideas management skills. Since these are not products of necessity but curiosity it calls for innovation and creativity management for sustainability by incorporating patenting of innovation in our education curriculum to be taught just like printing, publishing and copyrighting is taught in literature. If the citizenry of every civilized country looks up to the education planners and implementers for thought and concepts leadership in clarifying the nation’s development agenda and keeping the records straight; then education sector (especially higher education) fits well in its role of helping to attain this since it provides quality teaching, research and consultancy and community service in ensuring that the satisfaction of their stakeholders exceeds their expectations. This research amongst similar others posit that the days of the all-powerful manufacturing industry are dwindling as service industries are becoming saturated and knowledge workers commoditized. The begging question which follows is: ‘what values, beliefs and attitudes need to be embraced by the next generation to prosper in the future?’

**Objectives of the Study**

The specific objectives of the study were to:

1. Establish need for missing link of invention, Innovation and Creativity Management Education for Sustainable Development
2. Assess the effectiveness of invention, Innovation and Creativity Management Education for Sustainable Development
3.Ascertain assess the place and profitability of establishing invention, Innovation and Creativity Management Education for Sustainable Development in form of ideas incubators.

**Limitations**

Although the research was limited to the 2013 National Science Congress presenters, researchers in year 2004 at the Laikipia University 2nd International conference and Kabarak 4th International conference it captures the wider picture on the landscape of the Kenya field of research for invention, innovation and creativity.

**Assumptions**

The study was based on the following assumptions since there has been paradigm shift in the definition of resources from the natural to information the problem in the developing nations is tied to its education system whether it is current with the global modern trends. The developing nations education is not programmed to be lead by stimulation for innovation and invention but rather by needs and lack as the old adage goes that “necessity is the mother of invention” since necessities enough are in this nations in disproportional levels compared to solutions by innovation. The developed nations have the management of the inventions ideas in the incubators from where they are brought to hatching and not smashing according to the lessons of nature.

**Justification of the Research**

Every developed nation today began as a developing nation and for every developing nation to get there it must pass through the same way to get there. The wealth trends have changed from natural resources to information resource
which announces this as the age of information which is ushering in a transition for the coming imagination age when whatever imaginable by man will be workable. The path for this progress is well marked as beginning at the invocation for the new ideas that lead to redefinition of things, rearrangement of processes, innovations and creativity. Critical thinking is the precursor for creative thinking. Critical thinking entails the development of the innovation and creativity management education which helps to crystallize the unique ideas and the development of incubation centres which midwife the realization of ideas.

Theoretical framework
The research was pegged on various Interpersonal as well as intergroup theories. Firstly, it was pegged on John Dewey theory of education which integrates the school with the society, and the process of learning with the actual problems of life by application of the principles and practices of democracy. Secondly, the research was pegged on the Mead’s (1934) theory of social roles, which states that people engage in human-helping roles; they gain a greater capacity to set aside their ego, thereby improving their ability to look at problems from multiple perspectives. When thinkers are brought together to form think-tanks, the experience is more effective than other exchange initiatives at encouraging empathetic, perspective-taking learning that is required for mutual understanding. In this sense, the means to this end begins with education planners and curriculum developers instituting innovation and creativity management skills education for the gifted students. Thirdly the research was pegged on (1982) Social Identity theory which posits that greater exposure to any group widens opportunities for self-integration into external group membership, ultimately leading to greater understanding, acceptance of out-group differences, and re-identification with previous out-groups. Pettigrew (2006) contemporary contact theory and social learning theories stress that the more time people spend interacting, the greater likelihood they will converge on superordinate shared goals, and the greater the likelihood that they will experience cognitive dissonance, which is necessary to stimulate reflection and ultimate intergroup understanding which fosters synergy.

METHODOLOGY
The research adopted the descriptive survey research design data being collected by interviews, phones and emails conducted among the 2013 National Science Congress presenters, researchers in year 2004 at the Laikipia University 2nd International conference and Kabarak 4th International conference which also incorporated the students' innovation.

LITERATURE REVIEW
The secret of shifting from being a developing nation to a developed nation is hidden in a nation's education it is still the traditional one according to what Heidegger (1972) posited as ‘memory testing based’ to what the one based on critical thinking which refers to the thinking before the thinking begins so as to make the thinking of the unthinkable clear. Razeghie (2008) in his masterpiece the riddle models the process of establishing an incubator by an by enumerating the different forms of creativity and innovations namely:

(i) Artistic creativity,
(ii) Conceptual creativity
(iii) Process of scientific discovery,

Artistic creativity (consists of the ability to render things that attract attention for their inherent beauty this may not solve a problem like the sculptures and paintings of Michelangelo. The myriads of annual High School science congresses and the students innovation conferences in universities reveal abundance of “idea people” in what Razeghie (2008) terms as conceptual creativity. This form of invention and innovation is guided by a goal which is to solve any particular problem, or fill unmet need, want or desire. The universities research conferences are basically structured in the mode of the process of scientific discovery which according to Razeghie (2008) mostly deal with nature in attempting to unearth the laws that govern its operation with the intent of aligning humanity to them to reduce friction or manipulate them to make life better. This involves absolute truth and so scientific discover involves discovery (truth) whereas conceptual creativity involves bringing something into being (ideas).

The problem why new ideas fail in the market place creeps up when there is a mixture between inventing unique things and solving problems too many individuals and organizations fail at innovation by focusing too much on artistic creativity while in the process of introducing new ideas to solve problems. Razeghie (2008) quotes Andrew Hargadon who revealed that Henry Ford’s real creative genius was revolutionary because its origins drew on existing technologies. Our modes of examination should have a course work on creativity exercise where students are expected to look around and pick a familiar object, and study it. Touch it, pick it up, smell it. Keep studying it until they have
learned something about it that you didn’t know before. The innovation management skills begin with understanding what thinking outside the box means. This is what it means to think outside the box. The box is what you know. When you get through that wall, those new ideas will come easier. You’ll come up with things you never thought of before. This is the process which is popularly termed as breakthrough! They are the obvious things you already know. When you get to the end of those, it will suddenly get very hard. That’s the wall of the box. This is the place where you must press on. Think outside the box. When you get through that wall, those new ideas will come easier. You’ll come up with things you never thought of before. The ideas management education comes to a close but not an end by ensuring the new ideas and knowledge is patterned as intellectual property to secure them against manipulation and undue exploitation.

A witty way might be to give children the tools and experiences that encourage them to think the unthinkable. This is the mid-wifery process which creates new working knowledge. If the next generation will not be disadvantaged in their role to enhanced the advancement of the course of humanity on earth in the context of the times when things are constantly changing and evolving making almost all the tricks in the good old books obsolete in solving mutating problems which require dynamic critical thinking for innovation and creativity or improvising solutions to not only the known problems but also to the unknown problems the world will be facing. The future is happening all around us as we are already in the transition phase from the information age towards the imagination age. This means if this generation continues look only straight ahead, in the direction that conventional wisdom and ‘futurists’ suggest you look, you will never see it coming. Currently in the competitive global village when everything is on the first lane these skills have become so wide spread that one cannot make a good living without expanding one’s horizons beyond these basics.

Current trends indicate that the knowledge based and creative economies calls for individuals with values, beliefs and attitudes that foster a creative reinvention of how meaning will be defined in our world. Developing creative individuals takes a society that values and promotes curious, proactive qualities, interdependence, responsibility and accountability. The process of building these well-rounded citizens starts with kindergarten level of education and is advanced to the higher institutions of learning where more is learnt from less and less and this is catalyzed to continue throughout life, constantly disseminating and transferring learning to the next generation. Innovation and creativity management begins with fostering a right environment which makes plain according to Razeghie (2008) that necessity in practical life is the mother of invention while from the root of the word school as used in the universities (school of education, medicine, business studies etc) Curiosity in schools of learning is the mother of invention where curiosity is an intrinsic motivation. The motivation is a hidden factor at play; it was not the pursuit of being prominent and important which was Henry Ford’s driving force but his desire to answer a bothering problem on how to make cars which were better, faster, and affordable.

In the field of creativity intrinsic motivation is required. A premium is placed on passion. You must care and seem be hurting with others to want to find a solution and solve a problem. It is one knows which matter but how much one cares with what he knows and this is empathy or the ability to seem to be hurting with others to with the desire to find a solution and solve the problem. There is evidence both scientific and anecdotal to suggest that people are more creative when intrinsically motivated (am on this path and project because I care and I love it; I care to solve this problem) more than those who are on it by being extrinsically motivated (I am on this path because of the incentives and profits I can bank on) It was the founder of Honda motor who well said that “People work harder and are more innovative if working voluntarily compared to a case when people are compelled to do something” He believed creative innovation was tied to intrinsic motivation that he promoted free-rein experimentation and banned organizational hierarchies his business.

Concepts are idea systems. Although the individual components of the concept may not be new, the combination of ideas – what could not be seen earlier until then. Henry Ford for instance envisioned the invisible (assembly line) He combined three different ideas he had observed I other industries and throughout history, ford created a concept that was both unique and relevant; the modern automobile manufacturing plant. Conceptual creativity demands that an idea performs on three levels,

(i) the idea must be aligned with a well fined problem,
(ii) the idea must be unique in its response to the problem, (the idea may not be new to be innovative but it must be unique only to the situation)
(iii) the idea must be relevant to the intended audience.
The creative combination key can be summarized by a phrase as; a unique and relevant to an existing problem. Prior information and creativity. Current trends reveal that innovation and ideas management is an improvement and an advancement in education from memory based mode to thinking the unthought-of pre-think in order to solve the unknown problems. Thinking in the box entails knowing well all that is in the box and it is what provokes the urge to think outside the box. Archimedes had a problem to solve; how to compute the volume of an irregular object, namely, the king’s crown, since the king was unsettled whether his royal helmet or crown was made of pure gold or of the fool’s variety, a mixture of silver and gold. The King’s question and concern was whether the smith who made his crown had cheated him. Cognitive tricks inform of prior knowledge exist in form of precursors.

CONCLUSIONS

The findings of this research revealed that Kenya in investing to its people under the social pillar has the right focus in Education and Training: Under education and training, Kenya envisages to give its citizenry a cutting edge that will position them as a globally competitive in their individual capacities as well as multinational companies by reason of quality education, training and research. Kenya aims to be a regional centre of research and development in new technologies. This will be achieved through: (i) integrating early childhood education into primary education; (ii) reforming secondary school curricula: (iii) modernizing teacher training; (iv) strengthening partnerships with the private sector; (v) developing key programs for learners with special needs, (vi) rejuvenating ongoing adult training programmes; (vii) revising the curriculum for university and technical institutes to include more science and technology; and (viii) in partnership with the private sector, the Government will also increase funding to enable all these institutions to support activities envisaged under the economic pillar. Moving to a middle income economy is hitting the road running and where the rubber meets the road is in advancing the education system’s operation principle from memory based to thinking outside the box which is critical and creative thinking as the operation principle for managing the ideas of new knowledge generated by innovation researches. The commencement power in documenting the development vision 2030 is very recommendable; the continuing power should be revived while the completion power should be reinvented as enumerated by this research’s recommendation.

Recommendations

This research makes the following recommendations for Kenya to realize it’s national development Vision 2030

(i) move swiftly and turn its good ideas to good actions beginning with the establishment of the Kenya school of government (which is a step in the right direction) as the incubation centre for Creativity Management Education for reforms in government, security and the public service for Sustainable Development towards attainment of Vision 2030. This research’s first recommendation to have at the helm critical and creative thinkers like chief Kariuki of Lanet who has shown himself to be thinking globally and acting locally by combating crime digitally by the use of the commonly abused social media the twitter.

(ii) On the social pillar if Kenya will realize her position for collaboration in global competition on the substructure of Science, Technology and Innovation (STI) Kenya education planners and curriculum developers must entrench the innovation, talent and creativity education in its education system right from the Early Childhood education to the higher institution of learning which shall culminate establishment of ideas incubation centres.

(iii) Education concerning the process of protecting proven technical knowledge as intellectual property rights should made heuristic right from high school to the technical schools and universities.

(iv) With Vision 2030 proposing intensified application of science, technology and innovation to raise productivity and efficiency levels across the three pillars the government to increase its budgetary allocation towards research and development as well as grants.

(v) It recognizes the critical role played by research and development (R&D) in accelerating economic development in all the newly industrializing countries of the world. The Government will create the STI policy framework to support Vision 2030. More resources will be devoted to scientific research, technical capabilities of the workforce, and in raising the quality of teaching mathematics, science and technology in schools, polytechnics and universities.

Education planners should incorporate the element of inspiration for innovation going by the secrets of the inventors and innovators trail blazers who attributed their achievements to the Bible inspiration since religion and science have been proven to complement each other. for instance George Washington Carver who discovered three hundred products from sweet potato and one hundred and eighty products from peanut which were the main products of the African American after the emancipation proclamation the south.
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INFLUENCE OF ENTREPRENEURSHIP TRAINING ON PERFORMANCE OF YOUTH SMALL AND MEDIUM ENTERPRISES IN MAARA SUB-COUNTY, THARAKA-NITHI COUNTY, KENYA

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ABSTRACT
Youth-owned Small and Medium Enterprises (SMEs) provide social and economic advantages to Youth who are unable to find salaried employment in the formal sector. The SMEs are widely recognized as major sources of employment, poverty alleviation and economic development. The Kenya Government has initiated several policies to stimulate growth in small business ownership and entrepreneurship. Such policy initiatives include: the Session paper number 2 of 2005, poverty reduction strategy paper of 1999-2015 and MSE Bill of 2006. The Ministry of Youth Affairs (MOYA) established Youth Enterprise Development Fund (YEDF) in 2007 as a source of capital for Youth registered groups to start and grow their businesses. However, many youth-owned enterprises face numerous challenges with low productivity, stagnation in growth and high failure rate. Subsequently, entrepreneurship education and training is increasingly becoming recognized as a critical element to tackle global unemployment challenges by involving the
youth to participate in business ownership and entrepreneurship. This study explored the influence of entrepreneurship training in the sustainability and performance of youth-owned enterprises in Maara District. It adopted a descriptive research survey design and targeted 230 registered youth-owned enterprises with 147 enterprises as the sample. Youth who attended entrepreneurship training performed better in their businesses. Thus entrepreneurship training was important and critical to the survival and performance of Youth-owned enterprises. Thus, provision of YEDF should go hand in hand with entrepreneurship training.

**Key words:** Sustainability, Business growth/survival, Youth employment, Youth Enterprise Development Fund

### INTRODUCTION

The importance of Small and Medium enterprises (SMEs) in contributing to job creation and output growth is now widely accepted in both developed and developing countries. Small and Medium Enterprises are regarded as the backbone of the economy (Welter and Smallbone 2011). Entrepreneurship on the other hand is also widely recognized as a major player in the economic and social development with the entrepreneurs as prime movers of this development. The term entrepreneurs and small business owners though sometimes used interchangeably are somehow different. Bula (2012) observes that the classical and neo-classical theories have labored in trying to define entrepreneurship, but there is no single definition. Entrepreneurs are persons with certain behavioural characteristics while entrepreneurship is what entrepreneurs do in the process of coming up with a business venture. Entrepreneurship research defines entrepreneurs as individuals who discover, evaluate and exploit profitable opportunities (Shane and Venkataraman, 2000). Entrepreneurs are innovators, risk takers and persistent in the pursuit of their business objectives while non-entrepreneurs or merely business owners lacks in innovation and their businesses may never grow.

There is no single criterion for classifying business enterprises as small or medium scale globally. In a study carried out by International labour Organization (2005), over 50 definitions were identified in 75 different countries. However, evidence from literature shows that in defining small-scale business, reference is usually made to some quantifiable measures such as: number of people employed by the enterprises, investment outlay, the annual turnover (sales) and the asset value of the enterprise or a combination of these measures. Small and Medium enterprises has a number of benefits. One of its major significant benefits is that Small and Medium enterprises contributes to the creation of self-employment among those youth operating businesses and jobs to those who are employed in those enterprises amidst high level of unemployment.

Youth unemployment has always been a major concern in Kenya given the fact that only 2.1 million people work in the formal sector while 9.3 million are self-employed according to Ministry of Kenya Ministry of Labour estimates. According to International Labour Organization (ILO) (2013) Global Employment Trends for youth, rate of unemployment among the youth aged 15-24 is 12.4% globally up from 12.3% in 2011 and the rate is expected to go up to 12.6 in 2013 with estimated 73.4million young people out of work. According to the report, the world is facing the worst ever youth unemployment piling renewed pressure to take targeted actions to resolve the crisis for the generation at risk. The ILO is therefore calling on both the government and social partners to take urgent action on the youth unemployment. Some of the suggestions that have been put forward include the macro-economic policies, employability skills, labour market policies and youth entrepreneurship training.

Since the beginning of the 1990s, small and medium-sized enterprises have remained one of the main avenues for building a vibrant and competitive private sector in many countries. Support for the SME sector has also become an increasingly important part of the industrial policy of the European Union (EU) over the last 10 years. The SMEs, has been a central pillar for the creation of the world’s most dynamic and competitive European economy. According to data from the European observatory (ENSR, 2005) Small and medium enterprises that employing up to 100 people accounted for 68 million jobs in the European Union in 2005. In Botswana small and medium enterprises employs majority of youth and women which youth accounts for 49 percent. In bid to improve the youth owned small and medium enterprises government of Botswana created government credit schemes youth development fund to provide credit to youth owned SMEs at affordable interest and also provide capacity building (Friedman, 2009).

In recognition of the importance role played by youth owned SMEs, the Kenya Government has over time initiated several policies and programmes aimed at stimulating growth in this sector. Such initiatives include the Economic Recovery Strategy for Wealth and Employment creation (2003), policy initiative such as Session Paper No.2 of 2005 on the development of Small and Medium Enterprises (SMEs) for wealth and employment creation (Republic of Kenya, 2005), establishment of Youth Development Fund (YEDF) of 2007, ‘Kazi Kwa Vijana’ Jobs for the Youth initiative.
launched in 2009 and Uwezo Youth Fund in 2013 among others. While these interventions have been initiated, the rate of unemployment remain high with many young people reluctant to engage in small business ownership and those starting small enterprises showing dismal performance and high failure rate. Entrepreneurship education and training is however, increasingly becoming recognized as an important element in the broader effort in tackling the Kenyan youth unemployment challenges by involving the young people participate in small business ownership. Kourilsky and Esfandiani (1997) argue that economic growth heavily relies on entrepreneurship training and education and can open major access to prosperity. Entrepreneurship orientation is a management focus in relation to innovativeness, pro-activeness and risk-taking as been recognized as one of the most important factors for a business growth and profitability.

The promotion of youth owned Small and Medium enterprises (SMEs) is fundamental to the achievement of MDG 8, target 16 which focuses on developing decent and productive work for youth. This has a significant effect of bringing back the alienated and marginalized youth into the economic mainstream thereby addressing some of the socio-psychological problems and delinquency which occur due to joblessness (Welter and Smallbone 2011). Action on youth unemployment must be integrated as a central platform for achieving; MDG 1 on poverty reduction and hunger as well as Kenya Vision 2030. The achievement of MDG 1 has a bearing to the achievement of other MDGs in particular MDG 3, target 11 which promotes an increase in the share of women on wage employment in Nonagricultural particularly in Africa where socio-cultural constraints tend to affect the participation of female youth in self-employment.

Maara sub-county has a total population of 107, 125, out of which 35,238 are aged between 15-34 years representing approximately 32.9% of its total population (KNBS, 2010). The sub-county is characterized by high potential of both agricultural and non-agricultural activities as well as multiple of small and medium businesses. Data from the sub-county youth office indicates that the youth owned enterprises are in both the informal sector like agriculture, kiosk, building and construction and formal sector like legal, medical, business consultancy services. The mortality rate of Small and medium enterprises in Africa remain very high for example Mead (2010) in the study of five African countries found that most firms started with 1-5 employees and never expanded. Furthermore less than 1 percent grew to a size of about 10 employees. Friedman (2009) in his study of 214 small enterprises in the northern region of Nigeria within an eight year period reported that only 4 had graduated into medium firms. It is against this background that this paper seeks to study the influence of entrepreneurship training and the performance of Youth owned SMEs in Maara Sub-County of Tharaka-Nithi County.

Statement of the problem
Small and Medium Enterprises (SMEs) sector plays an important role in income and employment creation as well as poverty alleviation in Kenya and Youth owned SMEs play a critical role. In recognition of this important role the Kenyan Government has initiated several policy initiative and other programmes aimed at the promotion of youth owned enterprises. Despite these interventions by the government and private sector to boost the performance of SME sector, the Youth SMEs have not been performing as expected (Wanjohi, 2010). According to the data from Chogoria town council many Youth owned enterprises are performing poorly with high failure rate. Studies elsewhere have identified factors influencing SMEs in general but with no specific focus on the influence of entrepreneurship training and the performance of Youth owned SMEs in Maara Sub-county of Tharaka- Nithi County in general. This is despite entrepreneurship training being recognized as an important element in the broader effort in dealing with unemployment and helping improve small business performance. It is in view of this that this paper seeks to establish the influence of entrepreneurship training on the performance of Youth owned SMEs in Maara sub-county of Tharaka-Nithi County.

REVIEW OF LITERATURE
Small and Medium Enterprises (SMEs) in Kenya
SMEs contribution to the Kenyan economy is widely acknowledged, they cut across all sectors of the economy and provide many employment opportunities and generate widespread economic benefits (Government of Kenya, 2005). The National Census Survey of Kenya (2009) revealed that 64 percent of its population was engaged in Small and Medium-Enterprise (KNBS, 2010). According to the economic survey of 2003, the SMEs sector accounted for 74.2% of the total persons engaged in employment and contributed up to 18.4% of the Kenya’s GDP in 2003. Economic recovery strategy for wealth and employment creation 2003-2007 recognized the need to establish and maintain a favorable environment for the growth and transformation of small businesses into medium sized enterprises that can have capacity to create more employment opportunities (GOK, 2005).
In Kenya today, businesses employing between 1 to 99 people account for about 48 percent of all businesses; with a majority of these being managed or owned by the young people (25-34 years) (Njonjo, 2010). According to Government of Kenya (2007), three out of five of these businesses fail within the first three years of operation and those that continue 80 percent fail before the fifth year. This failure of enterprises performance is marked by poor return and bankruptcy proceedings, (Saleemi, 2009), having noted how important the contribution of SMEs sector is in Kenya; despite their poor performance. Leadership must be increased to effectively respond to the challenges of creating productive and sustainable employment opportunities in the country amongst the youths, (Kariuki, 2010).

**Influence of entrepreneurship training on performance youth owned SMEs**

Training and entrepreneurial learning has widely been understood as how people acquire knowledge and enact new behaviors in the process of recognizing and acting on opportunities and of organizing and managing enterprise. Hyness (1996) defined entrepreneurship training as comprising planned and systematic process which aim to modify or develop knowledge or skills that enables an individual to achieve an effective performance. It conveys entrepreneurial knowledge and develops focused awareness relating to opportunity, recognition and the creation of new ventures. Entrepreneurship training should be mainly focused on starting a business and subsequent sustainability of such business.

McClelland theory of acquired needs advocates that increasing level of need-achievement in a society through modeling and learning such behavior stimulates entrepreneurship and economic growth. This need is inculcated through child rearing practices, which stresses standards of excellence, material warmth, self-reliance, training and low father dominance, (Saleemi 2009). Entrepreneurial education based on solid learning theory can thus explain the need to develop entrepreneurs by increasing business knowledge, and promoting characteristics associated with entrepreneurs. Saleemi (2009) argue that entrepreneurship training has traditionally focused on teaching individuals, but many initiatives are increasingly becoming more action-oriented, emphasizing learning by doing.

Given that past research results have consistently found SMEs training to result in better company performance, even under different cultural settings such as the Netherlands, Spain, Hungary, and China (Mullei, 1999), it is expected that training programs offered by government agencies and private sector will lead to higher firm performance in youth SMEs. This statement underpins the importance of training and development in the national economic development process. It becomes significant point of reference especially since most developing countries are responding to many challenges of the industrial development by implementing new programs, which calls for new expertise and new orientation of work. McMullan and Gillin (1998) argue that entrepreneurship training and education may be one of the few unexploited, cost effective micro-economic tools governments have for developing local economies.

**THEORETICAL PERSPECTIVE**

**Resource Based Theory**

Alvarez and Busenitz (2001) argues that access to resources by founders of business is an important predictor of opportunity based entrepreneurship and new venture growth. Access to resources according to Davidson and Honing (2003) enhances the individual’s ability to detect and act upon discovered opportunities. These resources include financial, social and human resources. However, some studies contest this theory as it is demonstrated that most founders of business start with little capital and that financial capital is not significantly related to the probability of being nascent entrepreneurs (Kim, Aldrich and Keister, 2003).

**METHODOLOGY**

This study used descriptive research design. The design was found necessary because it will allow gathering of the information, summarizing, presenting and interpreting the data in a clear way. According to Robson (2002), the objective of descriptive research design is to reveal an accurate profile of a person’s situations or events. The target population of the study was 230 SMEs owned by Youths in the Maara sub-county that were registered by Chogoria town council by December 2013 reason being that December 2013 data was the most current data that was available. The SMEs owners were the primary respondents.

Sampling was done because a complete coverage of the population was not possible and also small unit (sample) offer more detail information and high degree of accuracy. The Youth SMEs registered were then clustered into five clusters according to the geographical areas (wards) which included Chogoria, Mwimbi, Ganga, Muthambi, Mitheru). The sample size which was used was obtained by using the following equation given by Yamane (1967).
n = \frac{N}{1 + N(e)^2} \text{ where } n = \text{Sample size}
\begin{align*}
N &= \text{population proportion} \\
e &= \text{Level of significance (5%)}
\end{align*}
\begin{align*}
n &= \frac{230}{1 + 230(0.05)^2} \\
&= 146.03 \approx 147
\end{align*}
A sample size of 147 youth SMEs owners were selected from the target population and the questionnaires were used to obtained information from the business owners or their representatives.

Instrument validity and reliability
Validity refers to how far a research instrument measures what it is intended to measure or the degree to which the test items measures the traits for which the test is designed (Mugenda and Mugenda (1999). Kasomo (2007), points out that it is the accuracy of research instrument. In the study two experts in the field of research were given research instruments to assess the relevance of each item in the instrument based on the objectives of the research. Reliability is a measure of how consistent the results from a test are. It measures the stability of the research instruments across two or more attempts. Mugenda and Mugenda (2003) define reliability as a measure of the degree to which research instruments yield consistent results or data after repeated trials. This was confirmed by pilot testing the research instruments.

RESULTS AND DISCUSSION
Entrepreneurship training
The researcher sought to determine the influence of entrepreneurship training on performance of youth owned small and medium enterprises. Out of the 147 respondents, 64.6% had attended entrepreneurship training since the start of their businesses. The respondents had been trained on the following topics; 51% on business planning, 25.2% on financial management, 36.7% on bookkeeping, 29.3% on customer relation and 32.7% on marketing.

Table 5.1 shows the duration of the training attended by respondents.

<table>
<thead>
<tr>
<th>Duration of training</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than 1 week</td>
<td>73</td>
<td>58.4</td>
</tr>
<tr>
<td>1-2 weeks</td>
<td>28</td>
<td>22.4</td>
</tr>
<tr>
<td>3-4 weeks</td>
<td>10</td>
<td>8.0</td>
</tr>
<tr>
<td>more than 4 weeks</td>
<td>14</td>
<td>11.2</td>
</tr>
<tr>
<td>Total</td>
<td>125</td>
<td>100.0</td>
</tr>
</tbody>
</table>

From the table, 58.4% had attended trainings for less than 1 week, 22.4% attended for 1-2 weeks, 8.0% for 3-4 weeks and 11.2% for more than 4 weeks. The researcher sought to determine the influence of entrepreneurship training on performance of youth owned small and medium enterprises. A cross tabulation of attendance of entrepreneurship training and average profit of youth owned SMEs per month was done and tabulated in table 5.3.

Table 5.2 Relationship between attendance of entrepreneurship training and average profit of youth owned SMEs per month

<table>
<thead>
<tr>
<th>Average profit of youth owned SMEs per month ('000')</th>
<th>&lt; Ksh. 30</th>
<th>31-50</th>
<th>51-100</th>
<th>above 100</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>If respondent had attended entrepreneurship training</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>21.1%</td>
<td>13.6%</td>
<td>17.7%</td>
<td>12.2%</td>
<td>64.6%</td>
</tr>
<tr>
<td>No</td>
<td>10.9%</td>
<td>15.6%</td>
<td>4.1%</td>
<td>4.8%</td>
<td>35.4%</td>
</tr>
<tr>
<td>Total</td>
<td>32.0%</td>
<td>29.2%</td>
<td>21.8%</td>
<td>17.5%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Spearman rank correlation was estimated between attendances of entrepreneurship training and average profit gained per month for each respondent. The resulting value was \( r = 0.52 \) indicated a positive correlation between the two variables. To test the null hypothesis of no correlation between the two variables in the population against the alternative of positive correlation, the test statistic \( z = r \sqrt{n} (n-1) \) was used. The result \( z = 6.28 \) indicates that the positive correlation was statistically significant at higher than 5% level supporting the conclusion that attendance of entrepreneurship training was associated with higher average profit per month.
The study sought to establish the influence of entrepreneurship training on the performance of youth owned SMEs by asking Likert-like type question to the respondents. The results were displayed in the table 4.4

<table>
<thead>
<tr>
<th>Statements</th>
<th>SA</th>
<th>A</th>
<th>UD</th>
<th>D</th>
<th>SD</th>
<th>$\chi^2$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing number of entrepreneurship trainings improves performance of youth owned SMEs</td>
<td>o</td>
<td>68</td>
<td>42</td>
<td>17</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>e</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>The more the number of topics covered the better the performance of the youth owned SMEs</td>
<td>o</td>
<td>39</td>
<td>66</td>
<td>12</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>e</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>The duration of training attended influences the performance of youth owned SMEs</td>
<td>o</td>
<td>41</td>
<td>39</td>
<td>24</td>
<td>24</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>e</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

Critical $\chi^2$ (with DF = 4 at 5% level of significance) = 9.488

To test the null hypothesis of no correlation between the two variables in the population against the alternative of positive correlation, the test statistic $z = r \sqrt{(n - 1)}$ was used. The result $z = 4.71$ indicates that the positive correlation was statistically significant at higher than 5% level supporting the conclusion that of number of years the business was in operation was associated with higher average profit per month.

### Table 5.5 Number of employees during start-up and current employees

<table>
<thead>
<tr>
<th>Employees</th>
<th>During start-up</th>
<th>Currently</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percentage</td>
</tr>
<tr>
<td>None</td>
<td>80</td>
<td>54.4</td>
</tr>
<tr>
<td>1 - 5</td>
<td>36</td>
<td>24.5</td>
</tr>
</tbody>
</table>

Performance of youth owned small and medium enterprises.

Spearman rank correlation was estimated number of years the business was in operation and average profit gained per month for each respondent. The result value was $r = 0.39$ indicating a positive correlation between the two variables. To test the null hypothesis of no correlation between the two variables in the population against the alternative of positive correlation, the test statistic $z = r \sqrt{(n - 1)}$ was used. The result $z = 4.71$ indicates that the positive correlation was statistically significant at higher than 5% level supporting the conclusion that of number of years the business was in operation was associated with higher average profit per month.
From table 3.5, Youth owned SMEs had increased the number of employees since 54.4% of the respondents with no employees during the start-up of their businesses reduced to 25.2%.

Table 5.6 Number of years the business was in operation against average profit per month

<table>
<thead>
<tr>
<th>Number of years the business was in operation</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less 1</td>
<td>11.6%</td>
</tr>
<tr>
<td>1-3 Years</td>
<td>12.9%</td>
</tr>
<tr>
<td>Above 3</td>
<td>7.3%</td>
</tr>
<tr>
<td>Respondent’s average profit per month in the</td>
<td></td>
</tr>
<tr>
<td>last one year (‘000’ )</td>
<td></td>
</tr>
<tr>
<td>&lt; Ksh30</td>
<td>8.8%</td>
</tr>
<tr>
<td>31-50</td>
<td>10.9%</td>
</tr>
<tr>
<td>51-100</td>
<td>12.2%</td>
</tr>
<tr>
<td>&gt; 100</td>
<td>4.8%</td>
</tr>
<tr>
<td>Total</td>
<td>36.1%</td>
</tr>
</tbody>
</table>

The results of the study confirm earlier studies that show that high growth correlates with a firm’s entrepreneurial orientation. Kourilsky and Esfandiari (1997) asserts that economic growth heavily relies on entrepreneurship and that entrepreneurship training is potentially beneficial and may be possible solution to high unemployment rates and as a recipe for economic prosperity (Goravan and O’Cinneide, 1994).

CONCLUSION AND RECOMMENDATIONS

Objectives | Findings
--- | ---
To determine the influence of entrepreneurship training on the performance of youth owned SMEs in Maara in Sub-County. | - Youth access to entrepreneurship training was 64.6% which is quite high.
- Spearman rank correlation was estimated between attendances of entrepreneurship training and average profit gained per month for each respondent. The resulting value was \( r = 0.52 \) the test statistic was \( z = r\sqrt{n - 1} = 6.28 \) indicating that the positive correlation was statistically significant at higher than 5% level supporting the conclusion that attendance of entrepreneurship training was associated with higher average profit per month.
- Response to the statement that increasing number of entrepreneurship trainings improves performance of youth owned SMEs \( \chi^2 = 85.26 \) thus number of responses were different with more respondents tending to strongly agree or agree with the statement.
- Response to the statement that the more the number of topics covered the better the performance of the youth owned SMEs \( \chi^2 = 71.7 \) thus number of responses were different with more respondents tending to strongly agree or agree with the statement.
- Response to the statement that the duration of training attended influences the performance of youth owned SMEs, \( \chi^2 = 13.16 \) thus number of responses were different with more respondents tending to agree with the statement.

The study established that there is relationship between entrepreneurship training and profit gained by the SMEs thus there is need to promote the youth entrepreneurship training effectively. The study also found out that although entrepreneurship training is important and beneficial, the content and mode of delivery is critical.

Based on the findings of this study, the researcher recommends that special needs of the youth to be factored out when government policies on economic activities are being crafted in order to realize the full potential of SME sector as an equal employment contributor in the economy. The Government to develop policy framework to coordinate education and training activities at all levels of education. The study also recommends the adoption of learner-centered curriculum at all levels to allow for link between theory and practice. Before the disbursement of funding to the Youth SMEs, it’s important for the owner to undergo entrepreneurship training which should equip the Youth with skills and knowledge to identify viable business opportunities, become innovative, some basic marketing and management to help them run their business profitably.
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TRADITIONAL POSHO MILL AMONG THE ABAGUSII AS INDIGENOUS INNOVATION IN ENTREPRENUERSHIP

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ABSTRACT
African indigenous knowledge is important in innovations, but due to negative perceptions by foreigners, some were discarded and became extinct due to lack of handover to subsequent generations. This could have been avoided if African culture had been incorporated in western education to bring the young and old together in common task of knowing, bettering and sustaining what was ideal in their environment. The Abagusii invented the traditional posho mill [etinga] as an enterprise for the business of grinding cereals. It was widespread in different regions in gusiiland of western Kenya. However, instead of research being done to modify and improve its speed and preservation, it was left to become extinct. This study assessed how the posho mill could be modified and used in modern times. It used both interview and observations in collecting data from older people with indigenous technical knowledge of the invention and operation of etinga that can be one of Kenya’s and Africa’s innovations through branding. It is advantageous as it uses water energy in turning turbines, does not pollute the environment; has readily available water, and minimal maintenance once installed. Thus etinga should be modified and used in modern society.

Key words: Posho mill; Modification; Knowledge

INTRODUCTION
The African knowledge was key in innovations, but due to negative perceptions of the foreigners, some important innovations were discarded and the indigenous knowledge became extinct due to deaths and burial of knowledge due to lack of handover to other generations. According to Bogonko[1994], these negative developments could have been avoided if African culture had been considered in the western education. Such policy would have brought the young and old together in common task of knowing, bettering and sustaining what was ideal in their environment. The Abagusii invented the traditional posho mill [etinga] as an enterprise for business and used to grind cereals, and were widely spread in different regions in gusiiland of western Kenya. Innovation is a term applied to mean the creations and revelation of certain works, information and ideas which has never been disseminated to any school of thought. Innovation is a term used in this study to refer to both radical and incremental changes to Information Communication Technology ICT products and processes. In the university context, innovation is linked to performances, and growth through improvements in efficiency, productivity, quality competitive positioning market share, etc [Wikipedia, the free encyclopedia].

Epistemology of traditional posho mill [Etinga]
The traditional posho mill [etinga] was the second phase of the inventions of the techniques or methods used in grinding cereals among the abagusii, the first phase was the invention of the simple African technology of the available materials. They innovated a rectangular big stone [Orogena] sculptured from a special rock and a smaller stone [Ensio], which used concurrently by rubbing the cereals against the two surfaces of the big stone intact on the floor and the smaller stone held by the hands to and fro on the surface of the big stone. The person who grinded knelt down on one side near the end of big stone and held the Ensio [small stone] to grind using hands. The cereal was placed on the surface behind Ensio [small stone], small quantity was placed to allow quick grinding, to and fro. The grinded flour falls at the end of the tip of the big stone, and then it was collected from the skin which was placed on the flour for collection after accumulation of flour grinded. As illustrated in Figure 1.
There were steps made before the grinding started as follows: first, the cereals was to be perfectly dried up; second, the big stone to be knocked on the surface to make it rough so that when rubbed with small stone [Ensio], it grind faster without which, the slippery surface was slow and because the to and fro movements of the hand will also be slippery; third, the small stone [Ensio] was also knocked on the surface to be rough so as to be in contact with surface of the big stone [Orogena] and grind faster; four, the big stone [Orogena] was to be uplifted at background where the person grinding knelt, so that gradient was sloppy to enable the faster movement of the hands holding small stone [Ensio]; fifth, the cereals placed the background surface of big stone [Orogena] depended on the quantity to facilitate quick grinding; therefore, the smaller the quantity the faster the grinding and vice versa.

Statement of the problem
The problem is instead of researches done to modify and improve the speed and preserve the knowledge, it is in extinction.

Objective of the research
The objective is to study how the posho mill can be modified and used in the modern times.

METHODOLOGY
The research will use both interview and observation in collecting data from the old people surviving having the indigenous technical knowledge [ITK] of the invention and operation of Etinga [posho mill].

Data collection and Analysis
Data collected from the surviving old people in Gusii land having the Indigenous Technical Knowledge [ITK] and Know-How [KH] of the innovation and operation of etinga [posho mill], gave the information in the oral form and recorded down by the research for academic and reference purposes. The data collected was tabulated and illustrated by use of diagrams.

The traditional posho mill [Etinga] was the second phase of the inventions of the techniques or methods used in grinding cereals among the abagusii. The first phase was the invention of the simple African technology of the available materials. They innovated a rectangular big stone [Orogena] sculptured from a special rock and a smaller stone [Ensio], which are used concurrently by rubbing the cereals against the two surfaces of the big stone intact on the floor and the smaller stone held by the hands to and fro on the surface of the big stone. Since the person grinded used energy as a method of propulsion, the hands became tired and required several people to grind so that to grind the quantity required to be cooked to satisfy the whole family members. The traditional Technique or Method, although helped in grinding the subsistence food in the family, it could not be used as an enterprise for commercial purposes because it had a lot of challenges and shortcomings as follows: it was very slow; it used people’s energy as a method of propulsion; the quantity of the flour grinded was smaller or low; it was cumbersome to grind the flour during the special occasion like during ceremonies when plenty of flour was needed to prepare food to satisfy many people in the ceremony such birth, circumcision, marriage, and death ceremonies; it caused health hazards to the person who grinded such as backaches and fatigues; it was not used for commercial and entrepreneurship.

Since the first phase of the traditional posho mill method or technique had shortcomings or drawbacks, the abagusii invented the traditional posho mill which was faster because was using water as source of energy to grind the stuff. The traditional posho mill could be used for commercial purposes and it had the following advantages as compared to the
first method of grinding cereals: [i]it used water as source of energy for grinding; and [ii] because it was water energy to rotate the turbines, the speed was high and it grinded faster; [iii] the quantity of flour grinded was high to cater for preparation of food to satisfy the whole members of the family; [iv] it was used to grind a high quantity of flour used during important occasion such as ceremonies; [v] it never caused health effects to the operator or attendant; [vi] it was used for entrepreneurial purposes in the ancient times; [vi] Led to economic growth and development by improving the standards of living of people who owned etinga [Posho mill].

It is not clearly known who invented traditional posho mill [Etinga], where was it invented among the abagusii region and when was it invented. But from the Anthropological studies indicate that it was probably invented in early 1800. Because of poor records and lack of handing over information from one generation to another, it is not possible to trace and track sufficiently and effectively the origin of its innovation.

Traditional posho mill [Etinga] was invented and used for grinding cereals. It was a form of enterprise or business among the abagusii in the medieval period. Whoever who owned the posho mill [etinga] in the village, became a source of business and a source of accumulation of wealth. The posho mill [etinga] was not placed or located anywhere, but in special areas or regions where it was viable and strategic for its operation. The prerequisites for its location included steep gradient to enable the water directed to the turbine run faster and with high pressure; a river nearby with required volume of water to run the turbine; the stones from special rock [marble] used for grinding and installation. Because of the factors, people could come from very far for grinding purposes, and led entrepreneur purposes. The people who came for grinding paid through money currency method and others who could have used commodity [barter] method. Some of the items of commodity used were some of the quantity of stuff was scooped from the cereal to be grinded or eggs and so on.

RESEARCH FINDINGS
The preparation and installation of posho mill [Etinga] takes different steps sequential for its operation. The installation took seven phases or stages or steps as: preparation of the grinding stones; digging of the trench for installing the turbines and grinding stones and the channel diverted from the main river directed to the turbines; The preparation of turbines; the construction of the building where the grinding stones to be placed for operation or grinding; the preparation of the gear to control the speed of grinding stone during grinding or production process; the preparation of the trough [Orotuba] for directing water to the turbine and finally preparation of funnel shaped trough [Orotuba] for placement of food stuff to be grinded directed to the grinding stone. There was a stick suspended to the trough, as the grinding stone was rotating, shaking the funnel shaped trough for cereal and dropping slowly to nozzle of grinding stone and as being regulated by the rectangular trough. Findings are vital to Kenyans because it’s one of our own innovations as Kenyans and Africans at large and make Kenya proud of its own innovation as it would be ‘branded’ kenyan, not Chinese or Japanese nor American and England made.

Preparation of the grinding stones: In this first phase preparing of the two stones was very significant, because it was the starting point of the posho mill after surveying the appropriate area of the location. The two stones were made from a special rock, marble type, which does not break or crack easily, sculptured in a circular shape. Stone A was placed on the constructed floor of timber inside a constructed house/building where etinga was placed. Stone A had a hole/nozzle wide which could allow rotation of the piston [wood] fixed into the turbine (Figure 2).
The second stone B of a light surface and weight to enable the turbines rotate it, is designed to be fixed to the turbines to make it rotate anticlockwise as the turbines rotate by the force of water as illustrated in figure 3. The stones A and B, stone A is fixed permanently on the floor of timber and not to rotate and stone B which is fixed to the turbine rotates on the surface of stone A. The cereals were dropped from above placed trough in small quantities. This was the one rotating and grinding the cereals and dropped the flour in the circumference of the stone. The flour was accumulated and collected by a broom and put into the bag, sack or any container.

**Digging of the trench and channel:**
A deep trench is dug on the gradient of the slope which confirmed viable for installing posho mill. The dimensions of the trench are at least 7 feet deep, 5 feet width and 7 feet length decreasing with decreasing gradient of the slope as illustrated in Figure 4a. The trench is where the turbine is installed and the water from the trough [Orotuba] is directed under the floor of timber where the two stones grinding attached to the turbine are installed. The digging of the channel is for the purpose of diverting water from the main river towards the direction where the posho mill is installed. It is important to note that there are three channels dug for controlling and regulating water to the posho mill; channel 1 from the main river to the trough direct to the turbine. Channel 2, from control A [door] opened to allow flow of water directing to the main river when etinga [posho mill] is not operating, in other words closed, and control B [door] is closed to allow flow to channel 2. It is vital to note that the two control A and B were the “keys” for closing and opening Etinga. The last channel three is dug from the trench to allow water used from the turbine flow to the main river. The three channels MUST be in place for the posho mill [etinga] to operate. As illustrated in Figure 4b.

![Figure 3: Stone B fixed to the turbine, rotates to grind. Source: Researcher 2014](image1)

![Figure 4A: Construction of the trench. Researcher 2014](image2)

**The construction of the building:** a house is designed and constructed on the sides of trench so that to cover the grinding stones and the cereals for shelter and security purposes. The house is constructed one meter [3 feet] along the sides of the trench. As illustrated in figure 5.

**The gear attached to the turbine**
The gear was fixed connecting the tip of the turbine, which was a metal rid where the turbine rotates and since the turbine was attached to the grinding stone, when the gear is changed by raising it upwards, the grinding stone become lighter and rotates faster and grinds faster but the flour would not be “very fine”. When the gear is changed downwards the grinding stone becomes heavy as it’s in contact with fixed stone not rotating. The speed is slow and grinds fine flour.
The preparation of the turbine

The turbine was prepared from a special tree [Omotembe] which does not break or crack once the turbines are fixed. They could have a minimum of 4 propellers and maximum 8 propellers depending on the weight of the rotating stone. The “lighter the grinding stone, the less the propellers and vice versa”.

Preparation of the trough [Orotuba]

The trough directing water to the turbine was prepared from timber. It is designed to have a wide space from the side of approaching water reducing to the side of water approaching the turbine. It is so designed deliberately to allow large volume of water at top to fall and compressed to narrowing opening to the turbine to make it rotate. The water ran in high speed as in “water fall” of river, because of the steep gradient and facilitated the turbine to rotate as illustrated in figure 6.

The preparation of the funnel trough

The funnel was prepared by use of timber had four sides and fixed to the wall to hold the cereal to be grinded. It was designed to be wider at the surface to accommodate enough food stuff to be grinded at least five kilograms. It was decreasing downwards to the tip in the bottom, to allow sequential quantity to be grinded. At the bottom of the funnel trough, there is a flexible rectangular trough with a nozzle dropping the quantity of cereals to the nozzle of the grinding stone. The rectangular trough fixed to the funnel trough could be raised up not allowing too much quantity depending on the type of cereal for example maize, it is adjusted downwards and for finger millet, it adjusted upwards by the string attached to it. As illustrated in figure 7.
DISCUSSION AND CONCLUSION

In conclusion the posho mill is advantageous, first it uses water as a source of energy in turning the turbine, second does not pollute the environment; third, water is readily available in rivers and some quantity diverted and channelled to be used in the posho mill and fourth, there is minimal maintenance once installed.


In the first dimension of awareness-among the abagusii and the rest of Africans, for achievement of innovation, the usefulness of every member of the group was of paramount importance; in the second dimension of search-was done in practical nature, the learning-by-doing as was a value of innovation techniques among the Africans; the third dimension of core competence was demonstrated by talents and gifts of people displayed by people in performance in any aspect in that particular community; the fourth dimension of strategy, is emphasized and encouraged by almost static and general knowledge of the people; the fifth dimension of assess and select in relation to the posho mill [ettinga] viable place was assessed and selected for installation; the sixth dimension of acquire-the materials for the preparation posho mill were acquired for the installation purposes; the seventh dimension of implement-the indigenous education can borrow literacy, numeracy and formalism from western education the latter could borrow functionalism, environment-centredness and practicalism from the former [Bogonko, 1994;4], for implementation; the eighth dimension, learn-there was no specialized training to operate the posho mill [ettinga], it was practical approach for the purpose of general knowledge and education; and the ninth dimension of linkage-since that education was largely conservative, there was little room for innovation and therefore, the scope for experimentation with ideas and techniques was extremely limited [Bogonko, 1994;4], and there was linkages of knowledge and dissemination of skills.

Recommendation

It is recommended etinga should be modified and used in modern society, following the nine dimensions of technological capability of:

(i) **Awareness** dimension of traditional posho millm[ettinga] to be modified through scientific techniques and improve the speed;
(ii) **In search** for relevant skills and knowledge in science and technological universities for modifications;
(iii) **Core competences** of experts of the indigenous knowledge and know-how are important for modification;
(iv) **In strategy** dimension, of making etinga[posho mill] permanent in use as a source of business enterprise in Kenya; **assess and select** dimension the excellent and effective modality of modification by use of electricity and metal material where wood material is used;
(v) **Acquire** dimension, the relevant knowledge from the surving experts and use for modifications;
(vi) **In implementation** dimension-the introduction of technology is often cited as one of the justifications for the development of interactions between education and productive work. These justifications are based on the increasing interest taken in the study of the impact of technology on the levels of the government, on the appearance of new concepts such as those of alternative, intermediate, soft, appropriate and other technologies, and on the problems raised by the transfer of technology [Carton, 1984;15];
In learn dimension, a scientific instrument is only developed at the meeting-point between some device and a scientific need-such a measure movements with precision. As soon as Galileo learned of the existence of the telescope invented by Lippershey and Janssen, he could calculate the grinding and the strength of lenses. The technical result was therefore maximum accuracy in prescribing-and therefore manufacturing-lenses, hence the need for accurate and mathematical grinding tools[Carton,1984;15];

In linkage dimension-this presupposes the ability to theorize certain technical problems on the basis of scientific concepts, thus creating an organic link between science and technology[Gille,1978],and link to the indigenous African technical knowledge[IATK] as displayed by the etinga[posho mill] among the abagusii of Western Kenya.

REFERENCES

LINKING ENTREPRENEURIAL INNOVATIONS FROM KENYAN UNIVERSITIES TO KENYAN MARKET THROUGH PRIVATE VENTURE CAPITAL FINANCING

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ABSTRACT
Innovation is the process of Entrepreneurship. It involves opening new markets, which the particular branch of manufacturer has not previously entered. It involves conquest of a new source of supply of raw materials or half manufactured goods. Companies cannot grow through cost reduction and re-engineering alone. Innovation is the key element in providing aggressive top-line growth and bottom line results. Innovation is the successful introduction of a new thing or method. It is the embodiment, combination of synthesis of knowledge into original, relevant, valued new products, processes or services. Universities play an important role as sources of fundamental knowledge and industrially relevant technology in modern economies. Financial inaccessibility has been cited as a major challenge in growth of small enterprises. Many innovations go down the drain as the young innovators are unable to take their innovations to the market due to lack of funding. This study investigated private venture capitalists that are willing to risk with the young entrepreneurs to facilitate market entry of their innovations. Many university students get stuck after developing great innovations due to lack of venture capitalists, willing to come in as active investors to risk with the young entrepreneurs and fund young innovations, normally consider risk averse, lacking collateral required for traditional financial institution lending. It is important to embrace private venture capitalists as alternatives of funding young innovators in pursuit of mitigating this deep rooted challenge.

INTRODUCTION
There’s no universal definition of Entrepreneurship and the scholars view of the topic has considerably changed since Schumpeter (1934) defined it for the first time. Drucker (1985) viewed Entrepreneurship as an innovative act, which includes endowing existing resource for new wealth producing capacity. Gartner (1985), attempted to find different personality and background that are fundamentally different from those of non-entrepreneurs, that each Entrepreneur has His or Her unique motivation, goals, and talents for venture creation according to His or Her unique background. Gartner (1989) suggested job satisfaction, previous work experiences, Entrepreneurial parents, age and Education as factors which differentiate Entrepreneurs from non-Entrepreneurs. Cho (1998) maintained that if Entrepreneurial talents were innate and could not be build up postnatally, Entrepreneurship Education would loss its significance and that Entrepreneurial talent should not be perceived as innate. Cho’s study reveals that Entrepreneurship Education promotes the intention of venture creation because Entrepreneurship related knowledge and skills stimulates an individual’s motivation to create a new venture. Timmon (1999), stated that team based venture creation is more common than individual venture creation. Since it is difficult for even entrepreneurs to have all required managerial knowledge, individuals with complimentary backgrounds make effective teams for creating new venture companies.
THE CONCEPT OF INNOVATION

There are numerous definitions of innovation (Fagerberg et al 2005) that emphasize that innovations are not only new products and technological production processes, but also new organizational forms and creation of new markets. Innovation literature defines an innovation as something that is new to the firm adopting it, rather than new to the whole market or the whole world (Van de Ven et al 1989). Basic research plays a major role in many types of innovations.

This model however has been criticized by many researchers (Kline and Rosenberg, 1986). He argues that the linear innovation model portrays research as the driver of innovation while in most cases the key driver of innovation is a need found among certain users in the market or within a company. The argument is that it underestimates the many reverse processes and feedback loops inherent in technological change. Other critiques say that the linear model underestimates the importance of incremental changes, particularly those related to the production processes.

These resulted to the development of a more up-to-date and most commonly used model of technological innovation referred to as the chain-linked model. (Kline and Rosenberge 1986) argues that the key process of innovation is to create a design based on needs and demands. Although the process can be sequential, it has several feedback loops. When a problem arises, participants turn to existing scientific and technical knowledge to look for solution.
Implicit in this view of innovation is that the knowledge and skills of the involved firms and individual matter when it comes to being able to utilise relevant scientific and technical knowledge, an aspect often referred to as absorptive capacity (Cohen and Levinthal, 1990), hence exploiting basic research requires certain types of knowledge and experience that may be a more important bottleneck to the use of science in innovation than the quality of the research. Innovation is a key driver of economic growth. Research and innovation are key components in developing knowledge-based economies. In many African Countries, research has not been accorded the priority it deserves.

**VENTURE CAPITAL DEFINED**

Venture capital is business financing provided by individual investors or organizations in exchange for a high return on investment in privately owned business ventures. Venture capitalists are not passive investors. They play an active role in the strategic planning phase of business and seek continuing involvement. They also expect to be fully informed about operations problems and whether or not joint goals are being met. VC can be a solution to young innovations that have high potential rapid growth and considerable profits. It addresses the funding needed by local entrepreneurs that generally do not meet the necessary requirements to obtain capital from more traditional sources of finance, which in Kenya has been mainly commercial Banks.

Besides venture capitalists being financiers, are usually involved in management, marketing and strategic planning for the businesses selected for financing. Venture capital growth or development provides the financial market with an avenue for long term capital. Venture capital financing requires a detailed exit mechanisms worked out with the business that has been financed. This is because venture capitalist leaves the business after the stipulated investment period. Venture capitalists can be segmented into two: private venture capitalists and public venture capitalists. Private venture capitalist refers to professionals’ investors who managers funds and looks for suitable investments. Private venture capitalists are out to invest in business ventures whose rate of return has a range of 25% to and75%.

A venture capitalist may have no business experience applicable to the industry that the business is involved and is focused on the potential rate of return that the company can provide. On the other hand, public venture capital is apart of the venture capital industry which is relatively distinguished from private equity. Public venture capital is a segment of venture capital where a Government or a Government Agency or Public sector entity is the source of capital. Thus, the Government as public venture capitalists is involved in investment of high technology cluster Industries in order to implement their macro-economic strategies. It is this public venture capital definition that the researcher will use throughout the research.

Venture capital is one of the sources of non bank financing which is quiet prevalent in the developed financial markets for small and start up firms. (Keuschnigg 1998). They are organized providers of financing for winning but risky business proposals by small and medium firms that have a promising but unproven idea. If a venture capitalist is convinced that a business idea is promising, they will take an ownership stake in the business and provide the needed fund while sharing the risk. It is expected that many of the Country’s small business whose growth has been constrained by shortage of capital or increased cost of borrowing will have another source of finance.

Venture capitalists (VCS) are different from other financial intermediaries in that they provide governance and value addition to the companies they invest in. (Gompers and Lerner, 1998; Cumming et al; 2004). The interaction of many plus value added is supposed to create value in the investee companies. As a result, it is assumed that there is a positive impact on venture capital funding and as Gompers and Lerner (2001) argue, this is one of the pending issues in Research.
Challenges of Venture Capital Industry in Developing Countries

Venture capital is a risky business because it is difficult to judge the worth of early stage companies as well as correctly predict their future growth. Venture capital firms therefore set rigorous policies for venture proposal size, maturity of the seeking company requirements and evaluation procedures to reduce risks since their investments are unprotected to the event of failure (LaRue Jone Hosmer, 2004).

According to Fox (1996), USAID venture capital projects in the developing Countries have almost uniformly failed. It examined 13 of USAID’s venture capital investments and found that ten had failed to meet the desired outcome and that three were not even implemented. There were two problems established from the report, first is that the USAID often promoted venture capital projects in unpromising nations where the business climate was uncertain or the prospects for expanding firms were poor. Secondly, that the agency treated an activity requiring great flexibility and initiative as straight forward and simple. The projects were also considered to be overly designed. Some venture funds performed relatively well, but others incurred significant losses. The report suggested a fundamental reason for failure, that the allure of equity investment in emerging companies in developing countries is a mirage that conceptually it appears likely to pay high returns but in practise it does poorly. The conclusion was derived from the notion that a huge difference exists between financial market conditions in developed Countries where venture capital companies have thrived than in developing countries.

The USAID had made two major assumptions in their venture capital projects:

a) That the US experience can be transferred directly to developing Countries by professionals using techniques learnt in the USA

b) Venture capital development is a vehicle for capital market development

Economic and market conditions in developing Countries are significantly different from those in developed Countries. Information about the companies’ finances, market conditions and relevant government policies is likely to be much scarcer in developing Countries. Legal systems are frequently less transparent and the Government policy may change more quickly and dramatically than in developed Countries making the prospects for any company less predictable. Developing Countries are far smaller economies. A typical developing Country has a gross national product (GNP) the size of one city in America. Prospects for profits from such transactions are therefore likely to be much smaller. Consequently risks are likely to be much larger and profit prospects much smaller than in the United States.

In United States, Venture capital was not a vehicle for stock market development; vibrant equities markets long preceded the development of venture capital industry. Emerging Companies are unlikely to be an important of any Country’s stock markets. The backbone of such markets has to be equity and debt of very large and stable companies with large track records and a need for additional capital. Every County has such blue-chip enterprises, ranging from banks breweries and cement plants to public utility debt would seem an important factor even if such enterprises are Government owned. A well established market for equity and debt in large enterprises would seem to indicate the possibility of developing trading in smaller companies. Where no such market exists, it seems unlikely that promotion of equities in small Companies would produce one. (Fox, USAID 1996).

Contrary to the USAID report that painted a bleak picture of venture capital as an instrument applied to poor economies, the implementation of the venture funds did not conform to traditional fund disbursement guidelines. According to Athar Osama (2006) the USAID funded projects revealed serious design flaws that were more likely responsible for premature failure. He sighted the following flaws:

1. USAID provided the money for a venture fund and then began looking for an appropriate person to manage it. This process was carried out in the reverse order to the traditional venture capital setting has inherent problems that could easily cripple the operations of the funds.

2. Less-experienced fund managers were recruited in a rush to get the project off the ground. Their ability to perform was not matched to the size of the fund. In the traditional venture setting, the fund is raised by the fund managers to the size proportional to their ability

3. USAID should utter disregard to the local socio-economic environment as it attempted to literally replicate a US institution in the host Country with unfeasible and unsustainable Organizational structures.

Failure by USAID to successfully establish its venture capital investment has been attributed to its inability to understand the instrument than the failure of the instrument itself to deliverer in developing Country and emerging market environments. (Osama, 2006)
What Venture Capitalists look for Before Lending

The different ways in which financial Institutions such as Banks and venture firms would evaluate local business seeking financing is that banks look at the immediate future, and dwell their assessment of a company on its past. Venture capitalists on the other hand focus more at the future potential of a business organization.

According to LaRue Tone Hosmer (2004), venture capitalists are interested in many of the factors that influence bankers in their analysis of loan applications from local businesses. All types of financial institutions are interested in the results and ratios of past operations the amount and the intended use of the needed funds, and the earnings and financial conditions of future projections. On the other hand, venture capitalists look much more closely at the features of the product and the size of the market than do commercial banks in their evaluation.

Financial Banks such as Banks and creditors have interest on product/ market position only to the extent that this service or product can provide steady sales and generate sufficient cash flow to repay the loan. They look at projections to be certain that the owner managers have done their homework.

Venture capitalists on the other hand are shareholders or part owners of a business they have invested in. They hold stock in the company, adding their invested capital to its equity base. They are therefore careful to examine the planned products or services and their existing potential markets with extreme care. They invest in firms they believe can rapidly increase sales and generate substantial profits for the simple reason that they invest for long term capital gain, not for interest income. A common estimate is that they look for 3 to 5 times their investment in 5 or 7 years. It is important to note that venture capitalists do not always realize capital gain on their investment.

There are a number of conditions required for venture capital participation (Spies and Agnew, 2003)
1. Existence of product or service that has a potential for growth.
2. The willingness of business owners to give up part of their share holding to venture capitalists
3. The availability of correct information to assess profitability and potential growth of a business in question.
4. A large established market for the product or service
5. The availability of high return business to justify venture capital
6. The business owner should clearly understand the business they are in.
7. The availability of a successful exit strategy of the investment put in by the venture capital.

Venture Capital in Africa

Venture capital is a relatively new concept in Africa, with most projects starting in the early 80s. According to USAID reports, most previous attempt of donor agencies to launch venture capital projects in Africa had mixed though predominately relatively poor results. A good example is Kenya private Enterprises Development Project of 1980. USAID found that there was little interest in the provision of venture capital and most of the owners of small and medium sized organizations that were targeted by the project had no desire to reduce their debts in exchange for potential ownership in their companies. Many of these organizations either were unwilling or did not have financial documentation needed by venture capitalists to assess realistically the potential for investment. According to the report, (Fox, USAID 1996), 17 of 18 firms asked if they would submit proposals for possible venture capital investments showed no interest.

Another International organization that aimed at developing venture capital in Africa was the Commonwealth Development Corporation (CDC) of the United Kingdom. The first venture capital project by the CDC was in Zimbabwe (VCCZ) IN 1991. It injected a total capital of USD 18 million. Other International financial organizations like the International Finance Corporations provided 20% of the share capital. The initial years were difficult with only 2% of over 500 applications resulting in successful deals. By 1996, VCCZ had affected over 20 investments, two of which failed eventually. From VCCZS findings, starts up companies were considered to be riskier than existing ones.

Venture Capital Financing in Kenya

Kenya is slowly but surely warming up to the venture capital concept. However like many other developing Countries, not a lot has been written about venture capital in Kenya nevertheless, its importance and existence cannot be ignored. Although many would still be sceptical about partnership and venture capitalist involvement in their businesses, there is need to emphasises on other benefits that a venture capitalist brings along in the business besides finances.
The Business environment in Kenya can be described as vibrant. Kenya is the largest economy in the East African region with business opportunities ranging from Agriculture to Telecommunication which has demonstrated exponential growth over the years.

The Government has made considerable effort to create a favourable environment for domestic and foreign investors to do business in Kenya across any sector of the economy. Kenya boasts of an equally vibrant human resource capital, comprising of well educated young professionals with immense talents to scale businesses to success.

Kenya envisions being industrialized by the year 2030 besides becoming a middle income Country providing high quality life for all its citizens (vision 2030). The economic pillar aims at providing prosperity to all Kenyan through an economic development programme aimed at achieving an average Gross Domestic Product (GDP) growth rate of 10% per annum. The viability of this vision can only be ascertained with a focus on growth of up coming innovations in Kenya. Finances, which are life-blood of any business does not only need to be made available but accessible as well.

Public Venture Capitalist
Besides the private venture capital, public venture capital is also part of the venture capital Industry which is relatively distinguished from private equity. Public venture is a segment of venture where a Government or Government agency or Public sector entity is the source of capital. As public venture capitalists, the Government is involved in investments of high technology cluster industries in order to implement their macro-economic strategies. The Government endeavours to grow venture capital through direct measures such as incentivising the creation of public venture capital and through indirect measures such as improving the regulatory framework and providing tax incentives for venture capital investment. Many Countries have set up public venture capital programmes. Public venture has become an important part of the venture capital industry (OECD, 1997).

Public Venture Capital Projects Established in Various Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Enterprise</th>
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</thead>
<tbody>
<tr>
<td>USA</td>
<td>1958</td>
<td>Small business investment company</td>
</tr>
<tr>
<td>Japan</td>
<td>1963</td>
<td>Small and medium business investment and consultation companies (SBICS)</td>
</tr>
<tr>
<td>Singapore</td>
<td>1983</td>
<td>South East Asia venture investment</td>
</tr>
<tr>
<td>Korea</td>
<td>1974</td>
<td>Korea Hi-Tech company</td>
</tr>
<tr>
<td>China</td>
<td>1985</td>
<td>China New Technology venture investment corporate</td>
</tr>
</tbody>
</table>

Yong et al. 2006: Small Business Administrators (2009)

Venture Capital, Successful Cases
Different evidence from different economic environments across the world show how carefully designed venture capital programmes that adapt the important features of instrument to their unique socio-economic settings stand a fair chance of success. The international Finance Corporation (IFC) invested US$ 196 million in 49 venture capital funds in developing Countries and emerging markets between 1977 and 1995. Over the years, funding increased considerably and from 1990 -1995, it was 12 times higher than during the previous 13 years. Another example of successful public venture capital initiative is Israel’s Yozma programme (which means initiative in Hebrew) launched in 1997, the Israel Government provided venture capital funds to match private investment. YOZMA was hugely successfully within a short time and after four years successfully privatized, the Israel venture capital Industry grew from US$ 30 Million in 1986 to US$ to US$ 6 million in 2000.

The Indian venture capital Industry showed a much slower but sustained growth pattern. Indian benefited from four venture capital programmes founded by the World Bank in the 1980s. While these programmes were only moderately successful, they created the expertise for an entire cadre of individuals who had learnt the art of venture investment through trial and error. These people created a second series of successful venture capital funds. Today, India boosts a vibrant venture capital sector that ably supports the growth of its IT and Biotechnology industries. While attempts to literally transplant US –style venture capital may still be doomed to failure, evidence from across the developing world paints a more optimistic picture and calls for a re-examination of traditional venture capital guidelines. (www.scidev.net).
### Examples of Private Venture Capital Firms in Kenya

Some examples of Private venture capital firms in Kenya include:

<table>
<thead>
<tr>
<th>i. Fusion capital</th>
<th>vi. Jacana fund</th>
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<tbody>
<tr>
<td>ii. Fanisi capital</td>
<td>vii. Acacia fund</td>
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<tr>
<td>iii. Savannah fund</td>
<td>viii. Gold venture capital</td>
</tr>
<tr>
<td>iv. Maris capital fund</td>
<td>ix. Aureous capital</td>
</tr>
<tr>
<td>v. DVGrencap (By Heshan de Silva-Kenyan)</td>
<td>x. Norfund venture capital</td>
</tr>
</tbody>
</table>

### Examples of Public Venture Capital in Kenya

- ICDC (Industrial Corporation Development Council)
- KIE (Kenya Industrial Estate)
- Women Enterprise fund
- Youth Enterprise Fund

### Integration of Entrepreneurship Education in Kenyan Universities

Entrepreneurship Education and training was identified by the World Bank as a catalyst that could stimulate innovation and generate jobs among University graduates especially in sub-saharan Africa where graduates unemployment rates are high. Jomo Kenyatta University of Agriculture for example has integrated entrepreneurship concepts in most of their academic programme. Mount Kenya University and Kenya Methodist University which are private Universities have integrated Entrepreneurship in all there Faculties to teach Entrepreneurship and Management. Besides incorporating Entrepreneurship and innovation concepts across its academic programmes, Strathmore University offers full academic programmes in Entrepreneurship in their school of Commerce and Management. Jomo Kenyatta University, Kenya University, and Strathmore University have linked their academic Entrepreneurship agendas to incubator programmes that offer a range of service from networking, mentorship connection to accessing potential funding from the private sector. Dedan Kimathi University, Chuka University among others have Entrepreneurship courses at different levels. This is a clear indication of how Universities have positively embraced Entrepreneurship as a potential solution to the high unemployment rate and as a way of facilitating the attainment of Vision 2030.

### Linking Kenyan University Innovations to Kenyan Markets

The fact that Entrepreneurship courses have been widely embraced by Kenyan Universities can not be overemphasised. However there is a big gap between the innovations taking place in the Universities and the reality in Kenyan market. This is mainly because the students cannot access fund from the traditional financing Institutions as they lack what the Banks consider for lending popularly referred to as the four Cs of lending, that is:

<table>
<thead>
<tr>
<th>i) Capacity</th>
<th>ii) Collateral</th>
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</thead>
<tbody>
<tr>
<td>iii) Capital</td>
<td>iv) Character</td>
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The truth on the ground is that many colleges and Universities are investing heavily in the development of their students entrepreneurial skills. By the end of the day, many of them can dream of starting the next Face book or twitter which was actually started by students but without financial support, this can only remain a dream. Since many Financial Institutions would be unwilling to fund such innovations as their future is uncertain, there’s need to embrace venture capital concept where professionals would be willing to risk with the young innovators.

A perfect example of innovation and funding partnership is when Jomo Kenyatta introduced to the Kenyan market a brand of instant noodles, a fate made possible courtesy of a partnership with Japanese Noodles manufacturer, Nissin Food Holdings. The joint venture, Jkuat Nissin Food Limited was the first of Japanese firm’s investment in Africa and also promised to manufacture two flavoured brands of chicken and Nyama Choma flavours.

The partnership between Jomo Kenyatta and Japanese Company to manufacture the noodles not only facilitated knowledge on value addition and proper usage of the available raw materials but also created employment for the graduates to work in the joint Company and even other opportunities in the firm. The noodles have steadily gained popularity in the Country fuelled by urbanites whose lifestyle relies more on convenient foods that are tasty and quick to prepare.
In response to a call for competitive grant research proposals by the Kenya Agricultural productivity and Agribusiness project (KAPAP) in 2010, Mount Kenya University, University of Nairobi, Chuka University, Bondo University College, Egerton University, Kenya Industrial Research and Development Institute (KIRDI) and National Museums of Kenya (NMK) prepared a joint research project proposal which was approved for financial support. The title of the research was ‘Enhancing production, value addition and marketing of Indigenous vegetables among small scale holder farmers in Kenya.’ Until the concept of venture financing is fully embraced, great innovative ideas will continue gathering dust on Kenyan university libraries which would otherwise be utilized in the Kenyan market.

CONCLUSION
Entrepreneurship Education is very important to Economic Development of any Nation in the world. Kenya has underscored this in the National Development goals and plans. Like many African Countries, Kenya faces the challenge of providing employment especially for the many youth who graduate every year. With the job market shrinking globally, a new strategy of exploring available self-employment opportunities is of paramount importance. Every University has a responsibility towards the attainment of the National strategy on Economic growth as outlined in vision 2030. Entrepreneurial skills empower graduates to identify competitive and viable business ideas and opportunities. With proper funding, a reasonable number of creative and innovative students will be able to start and manage profitable business enterprises. Creative and innovative students should therefore be exposed to both private and public venture capitalist that would be willing to partner with them in order to accelerate their innovations in Kenyan market.

REFERENCES

APPLICATION OF OPEN SOURCE TOOLS AND CLOUD COMPUTING TECHNOLOGIES IN REAL-TIME DATA COLLECTION AND ANALYSIS

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ABSTRACT
Cloud Computing technology is a new phenomenon that though fully utilized and implemented in developed countries, its power is yet to be tapped in a number of developing countries. There are different kinds of data that can be entrusted to cloud computing providers that would reduce operating costs and save on time and financial resources. This paper sheds light on a number of cloud computing services such as Google App Engine and Open Source tools.
such as Open Data Kit and how the two can be used in effective data collection and analysis for organizations both
governmental and non-governmental as well as business organizations. Google App Engine offers a combination
Infrastructure as a Service (IaaS) and Software as a Service (SaaS) to be able to provide both a mobile application and
web application that can be used to receive data for analysis from field research; every instance of the application can
be fully customized to meet the specific data collection needs

**Key words:** Google App Engine, Open Data Kit, Real-time, Mobile Application, Web Application.

INTRODUCTION

The crucial steps of every research process are the collection of data and its analysis to formulate accurate and timely
information that can be used to make critical decisions. Data collection needs to be conducted prudently to ensure that
respondents provide credible data for statistical analysis. Considering all these facts this means that proper care needs
to be taken from data collection through to the formulation of a thesis from the research undertaken. A researcher can
now easily tap into the extensive power provided by the combination of cloud computing technologies and open source
tools.

This paper aims to explain the concept of open source and cloud computing as one of the indomitable technological
phenomenon that have been combined can help develop solution prototypes that have been tried and tested and has
worked for the good of the end user. Open Source is the term that is used to denote software whose source code is
freely available and accessible to anyone for assessment, enhancement and/or modification. Source code is the section
of software that is normally available only to the persons who developed the software. It is the part that programmers
manipulate in order to change how part or whole of the program works. [10]. Cloud Computing is a concept whereby
instead of services being provided through a direct connection to a conventional server, services are provided via the
internet through web-based tools and applications [1].

The tools employed in my case study are:

- **Open Data Kit Suite [8]** - an extensible, open-source suite of tools designed to build information services for
developing regions. [2]
  - **ODK Collect** – A smart phone client application that runs on smart devices that run on Android an
    open source operating system for mobile devices.
  - **ODK Build** – An open source form designer that is used as a tool to design and create Xform that are
    later downloaded to ODK Collect from ODK Aggregate.
  - **ODK Aggregate** - Aggregate provides a server repository to manage collected data, provide standard
    interfaces to extract data, integrate with existing systems and is designed to be a generic data storage
    service that will run on the user’s choice of computing platform. It can receive data from smart
    devices through the ODK Collect.
- **Google App Engine** – A cloud service that enables users to upload and run applications as well as giving real
time statistical information on bandwidth usage and application access.

MOTIVATION

Having tried and tested these tools in my undergraduate final year project it became vivid that these tools are cost-
effective and essential in any kind of data collection process that is intended to produce concise and timely information.
A researcher without any programming expertise is able to re-design, customize and deploy these tools as perfect
agents to enable him/her to have real-time data collected and input into an aggregate system ready for statistical
analysis using statistical software such as SPSS.

The strong belief and closed mindset of researchers in data collection through filling out paper forms and gathering
responses through rigidly designed questionnaires delimits the power of research, creativity and hence innovation.
The inception of Huduma Kenya by the Kenyan Government to provide its citizens access to public services through
integrated technology platforms from One Stop Shop citizen service centres called Huduma Centres located at Postal
Offices of major towns, has shown the commitment of the government in embracing Information Technologies. The
Government also intends to come up with an online services portal [3].

Automation of data collection processes will surely ensure that the government delivers its services much faster
since paperless and cashless technologies are fast becoming a phenomenon in the country. The innovation of cashless
payment services in buses and matatus [5] and even payment of parking fees within Nairobi City [7] has shown clearly
that computing facilities are being employed to ease the burden of revenue collection as well as inhibiting cases of corruption.

With all these innovations there is surely the need to gather feedback from citizens on their take on the use of Information technology as well as having a forum where users can suggest improvements. A respondent can therefore download a customized version of the ODK Collect and retrieve the Feedback form and post his/her feedback which can be analyzed in real time.

**SYSTEM DESIGN**

**A. Case Scenario**

To demonstrate the use of the ODK Suite and the Google App Engine, consider the following case scenario. Uwezo Fund which is a government loan for Youth and Women Groups needs to collect information about Groups applying for the loan and the composition of the group in terms of membership and what they intend to do with the loan if awarded. In the present scenario:

1) Applicant representing the group downloads form for printing or picks it at respective constituency offices.
2) She/he fills the form in triplicate.
3) Mails the form to the constituency offices or travels there to personally submit it.
4) Uwezo Fund Constituency Committee goes through all the forms (some being illegible) to check for relevant and qualified groups.
5) The committee submits the forms of qualified applicants to a National Committee for approval.
6) Upon approval the committee generates a list for qualified applicants to undertake the Capacity Building Programme.
7) After successful completion of the training program the loan is disbursed to the bank account of the group.

If Uwezo Fund employed open source tolls such as ODK Suite and Google App engine the steps would be:

1. Applicant downloads ODK Collect, retrieves the form and starts filling it right from his/her smart device. OR Authorized Uwezo Fund Agents would move around collecting applicant information of interested groups to the designated Smart device that has ODK Collect installed and with the form retrieved.
2. Complete forms are uploaded to the already deployed ODK Aggregate and the forms can be Analyzed by the committee in real time for eligibility.
3. The committee can submit a list of approved eligible applicants on a daily or weekly basis to the National Committee for approval which can be done as soon as the list is e-mailed.
4. Upon approval the committee generates a list for qualified applicants to undertake the Capacity Building Program.
5. After successful completion of the training program the loan is disbursed to the bank account of the group.

**B. Tool Design**

The ODK Suite need to be designed, tested and re-designed before using it in a real scenario, there are various tools and cloud providers that can help in achieving this namely:

- **ODK Build** - a web-based graphical designer that allows non-programmers to build applications with complex logic and interactions, we designed that allows users to create applications using a drag-and-drop metaphor. [2]
- **Google App Engine** – a cloud computing service upon which the ODK Aggregate is deployed for submission of filled forms and retrieval of blank forms.

Figure 1 shows a data collection form for Uwezo Fund Loan Application [9] being designed using ODK Build in drag-and-drop fashion, the final form will later be saved as an XML form that will be uploaded to ODK Aggregate for later unlimited retrieval by the smartphone clients ODK Collect. This is similar to the process of formulating a questionnaire for use to interview respondents.
Fig. 1: In ODK Build, prompts appear on the left of the screen while properties appear on the right. Users rearrange prompts using a drag and drop interaction in the web browser.

Figure 2 shows a deployed instance of the ODK Aggregate that accepts form submissions and blank form retrieval for the Uwezo Fund Loan Application Form. [9]

Fig. 2: An instance of ODK Aggregate on Google App Engine’s Cloud Service

SYSTEM IMPLEMENTATION
For implementation of the system, ODK Collect which is a smart phone client is installed on a device running an Android Operating System. Figure 3 a-f shows a series of screen shots of ODK Collect in operation. [6]

Fig 3.a ODK Collect’s First Screen with command options
Fill Blank Form – Start filling out an already retrieved form.
Edit Saved Form – Continue filling a form from where you left.
Send Finalized Form – Submit a duly filled form.
Get Blank Form – Retrieve a blank form from ODK Aggregate

Fig 3.b The Settings Menu: URL Configuration. On the settings Menu configure the URL of ODK Collect to point to the URL of where the ODK Aggregate is deployed for retrieval of blank forms and submission of finalized forms to take place
A Summary of ODK Collect

In just six simple steps you are able to understand a simple concept which you can easily use without any additional costs apart from having a smart device with internet connection. The forms can also be filled multiple times before submission such that a researcher can perform a field study where there is no internet connection as long as he/she has already retrieved the blank form. This shows that one does not need any programming expertise in order to make use of the open source tools for data collection.

Fig 3.c After successful connection with ODK Aggregate one is able to retrieve a list of blank forms hosted on the server and select the ones to download. In this case the server has a blank form named Sample. After selecting the for, tap on Get Selected in order to download the selected form.

Fig 3.d Once downloaded the form will appear in the list of blank forms when you tap on Fill Blank Form indicated in figure 3.a above. After you tap on Sample(indicated in red) you will have a begin prompt telling you to swipe across either to the left or to the right to start filling the blank form.

Fig 3.e After all the fields in the form are filled with the required data, as a researcher you can review the details, before marking the form as finalized to make it ready for submission.

Fig 3.f Tap on “Send Finalized Form” as indicated in figure 3.a above and a listing will appear with all the finalized form that have not been submitted to the ODK Aggregate. Select the Sample Form and tap on “Send Selected”. A notification will appear to confirm that the form has been successfully uploaded.

Fig 3.b You are at the end of “Sample”. Youtube tutorial on this concept also available. You can name your blank form. Sample

A Summary of ODK Collect

In just six simple steps you are able to understand a simple concept which you can easily use without any additional costs apart from having a smart device with internet connection. The forms can also be filled multiple times before submission such that a researcher can perform a field study where there is no internet connection as long as he/she has already retrieved the blank form. This shows that one does not need any programming expertise in order to make use of the open source tools for data collection.
**ODK Aggregate**

Without proper deployment of the ODK Aggregate onto the Google App Engine all the functionality and efficiency provided through ODK Collect is impossible to achieve. Figure 4 a-d shows a series of screenshots reflecting on fundamental aspects of the ODK Aggregate. [4]

Figure 4 a shows the process of uploading blank form (to be retrieved by ODK Collect) to the Aggregate server

This is the first step after successful deployment which is just a step-by-step wizard using an installer as long as you have a Google ID which is just a Google/Gmail Account. The form is uploaded as a Form definition which is an XML file; one may add any other kind of media that he/she would like an agent to retrieve through ODK Collect that would be relevant to the research being undertaken.

Figure 4 b shows a successful submission of a form to the ODK Aggregate.
Figure 4 c shows the page to configure access to the ODK Aggregate.

Figure 4 d shows the process of exporting form submission as a CSV file.

CONCLUSION
The concepts of cloud computing and open source are here to stay even beyond the 21st Century. The need to save on financial costs and to make efficient use of limited computing resources has driven cloud computing and open source software to the enormous technological phenomenon in this century. Their adoption by both governmental and non-governmental organizations would see a tremendous impact in donor funding which relies heavily on information gathered and the need for more funding evidenced by the positive feedback gained from the initial funding. The fact that there are tools that have simplified these concepts to the point where no programming expertise is needed has opened their power to all kinds of researchers other than those in the Information Technology field. There are also unlimited online support resources as well as forums and discussions boards on Open Data Kit tools.

RECOMMENDATIONS
Adoption of seamless Information Technology innovations for research and data collection has evidently transformed the way we make decisions that require processing the data into information within the shortest time possible to the point of making real-time decisions that have immediate positive impacts from the prompt feedback collected. This results in a continuous and sustainable development especially when this information that comes from the ground in real time is used in making appropriate budgetary allocation in red-flag areas. With the inception of devolution and
with every county having an Information Technology docket, these dockets can be of critical importance in assisting the county leadership in the collection of feedback from citizens and in making significant improvement that would result in a more effective and efficient service delivery. Real-time data can also enable sectors such as security be able to gather evidence from crime scenes by capturing images and collecting statements from witnesses about the happenings before, during and after an accident or a crime. Respondents can also provide intelligence about an impending terror attack which would trickle to the relevant authority so as to make appropriate counteractions.

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INNOVATIVE RADIO BASED EXTENSION FOR AGRICULTURE AND LIVESTOCK PRODUCERS IN KENYA

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ABSTRACT
This is a case study report based on a pilot innovative approach to extension that targeted the dairy farmers in high rainfall areas and subsequently up scaled in a pastoral setting in twelve (12) Arid and Semi-Arid Land (ASAL) counties of Kenya. This innovative radio based training approach was a culmination of a study that showed that 70% of dairy farmers in the high potential areas of Kenya had no access to education or extension messages on dairy production. The objective of the radio programme is to increase extension training and ultimately improve incomes for the dairy farmers as well as the livestock producers in high rainfall and pastoral areas, respectively. The approach involves a collaborative effort between broadcasting radio station that airs interactive discussions by subject matter specialists in the studio and most importantly, field support by government technical officers who create awareness, mobilize and organize farmers and pastoralists into radio listening groups, recap the aired topics with the listeners and carry out practical demonstrations for the farmers. The listeners register by paying KS 100 via Mpesa. Followership is monitored through asking a simple question at the end of each session and listeners answers via the provided cell phone number of registration or through a dedicated number provided by the radio station. The pilot and upscaling have resulted to over 25,000 benefiting while immediate impacts like reduction of milk rejection by a cooperative from 30% down to 8%; stimulating demand for extension (demand for services increased from 59%-68%); pastoralists seeking information about livestock prices increased from 28.1-35.1%, among others. This approach is a useful and penetrative tool of extension, contents, educative, applicable and increase participation of women and youth in agriculture. The county governments and private sector should adopt this innovative approach to reach many agricultural producers.

Key words: Interactive, Registration, Extension, Dairy, Pastoralists, Upscale
1. INTRODUCTION

1.1 Background
The livestock sub-sector is one of the several subsectors of the agricultural sector. The latter also comprises of the development of arid and semi-arid lands among others like the crops, land, water and environment. Agriculture is the mainstay of the Kenyan economy directly contributing 26% of the GDP annually, and another 25% indirectly. The sector accounts for 65 per cent of Kenya’s total exports and provides more than 70 per cent of informal employment in the rural areas. Therefore, the agricultural sector is not only the driver of Kenya’s economy but also the means of livelihood for the majority of Kenyan people (ASDS, 2010-2020). With Funding from the European Union, the Food and Agriculture Organization of the United Nations (FAO) has been implementing a unique radio based extension approach since 2010. The radio based training approach was conceived as a result of a survey results that indicated that over 70% of dairy farmers were not receiving adequate extension. The first pilot dubbed ‘Maziwa ni Mali’ programme that targeted the dairy farmers was quite successful with an enrolment of over 6,000 farmers. It stimulated demand and a scale up to cover areas that had not been covered by the pilot registered further success with over 10,000 registered farmers and over 50,000 more received the messages via radio. A further upscaling of the radio based training to 12 pastoral counties registered even more success with over 8,000 pastoral livestock producers registering to follow the programme with astonishingly high adoption rates of the training.

1.2 Rationale for use of radio for extension
A study was commissioned by FAO Kenya that aimed at assessing the performance of smallholder dairy assessment within the former Rift Valley and Western regions of Kenya. The target districts included: Rift Valley - Nakuru, Molo, Kipkelion, Uasin Gishu, Trans Nzoia, Koibatek, Kericho, Keiyo, Nandi, Lugari, and Marakwet within Rift Valley and Western Kenya.

The study undertook to assess the current status, constraints, and opportunities within the smallholder dairy sector in key target areas, as a basis for recommending the way forward in regards to enhancing livestock production in support of vulnerable populations in Kenya affected by volatile food prices.

The result on the gaps in extension services indicated that over 70% of the sampled farmers did not have access to adequate extension information and the report recommended use of ‘community radio’ to reach more farmers. It is on the basis of this finding that FAO Kenya undertook to pilot the use of radio based extension approach with an aim of reaching many farmers within a timely and cost effective way.

1.3 Objectives
To contribute towards improved household incomes and living standards

Specific objectives
i) To increase the number of producers with access to extension information including women with children and the youth.
ii) To provide an alternative mode of extension information delivery through interactive call-in and short messaging (sms) sessions.
iii) To enhance group leadership and dynamics through establishment of farmer cluster study groups.
iv) To enhance synergy between channels of information delivery to dairy and livestock producers
v) To inform the youth about the business opportunities existing in the dairy value chain.

1.4 Extension Methods
Agriculture Extension lacks a single universally agreed upon definition. One of the myriad definitions of extension purport that it is a service or system which assists farm people, through educational procedures, in improving farming methods and techniques, increasing production efficiency and income, bettering their standard of living and lifting their social standards. This involves the conscious use of communication of information to help people form sound opinions and make good decisions. The radio based training programme has been designed with the objective of increasing the resilience of the target communities to drought.

For the purpose of this publication, extension is defined as “a service of information, knowledge and skills development to enhance adoption of improved agricultural technologies and facilitation on linkages with other institutional support services (input supply, output marketing and credit)”. The services are majorly focused on facilitation of linkages of farmers with other institutional support services and aims at “facilitating farmers to improve technologies and adopt them in order to improve their efficiency, income and welfare (Purchell and Anderson, 1997).
In Kenya, agricultural extension was established after the Second World War. The extension services were provided by the government. Over the years, variations in the system have included: a) the integrated approach under the special rural integrated development project, 1970s, b) training and visit system, 1982, c) district focus for rural development, 1984 and d) national agricultural and livestock extension programme, 2000. The government is implementing the National Extension policy which advocates demand-driven extension and participation of other players. Agriculture training is provided in farmer’s colleges and tertiary institutions. Shifts in extension policy in Kenya have been due to perceived low impact of agricultural extension. The extension system has been characterized by weak operational framework and poor linkages between research, extension and the farmer.

2. METHODOLOGY/APPROACH
The radio based training approach involves a process of activities with intense involvement of various types of stakeholders. It can also be viewed as a classic case of a synergized public private partnership. The approach was initially conceived by FAO Kenya as a pilot within the dairy sub-sector in the former Rift Valley where the dairy farming is the main source of livelihood for the inhabitants of those areas. The pilot was carried out in 14 districts (currently sub-counties) with astonishing good success and unprecedented positive results that will be enumerated later in this publication. As a result of the good lessons, the radio based training approach was up scaled to extend the same to the Arid and Semi-Arid areas that harbour about 60% of Kenyan livestock. Suffice to say that the livestock in Kenya contribute about 40% of the agricultural GDP (approx. 13%) and it is the main source of livelihood for over 30% of population living in ASALs and the subsector contributes over 50% of the agricultural sector labour force.

2.1 Module/Curriculum development
The initial pilot that targeted purely the dairy sector was premised on an existing curriculum of the Dairy Training Institute (DTI). The adapted module is normally a residential training delivered to farmers for a whole week of 35 hours at a cost of twenty five thousand Kenya shillings (300 US dollar) per participant.

The Dairy Training Institute is a government institution located in Naivasha and was established in 1963. The institute has a wide reach of clientele, being the only dairy training institution within the eastern and central Africa region. The institutional mandate is to impart knowledge and skills in livestock production, hygienic milk handling, processing/value addition, appropriate technologies and entrepreneurship to stakeholders in the dairy sub-sector. It strives to meet this mandate by provision of both theoretical and practical training to dairy farmers and frontline livestock extension staff in the areas of animal breeding, dairy production systems, feeding regimes, quality control/assurance, processing, technology validation and marketing.

The institute offers 4 types of programmes comprised of Certificate and Diploma courses: Certificate in Rural Dairy Management: Certificate in Dairy Science and Technology: Diploma in Dairy Technology which is done in collaboration with Egerton University and a short Tailor-made Course designed to address specific needs of the participants. The short course feature topics like Clean milk production, Quality control/assurance, Value addition, appropriate technologies and Marketing of milk and milk products. For the radio based training approach, the latter module was tailor made and adapted to the needs of the radio extension.

2.2 Module preparation and delivery
It is imperative that preparation determines success and this was very evident in the delivery of the ‘maziwa ni mali’ radio based training programme. The following steps were taken in preparations for the delivery of the radio based training programme targeting the dairy farmers and subsequently upscalling to pastoral areas:

2.2.1 Module for Dairy farmers (‘Maziwa ni mali’)
Several consultative meetings were carried out between FAO and the Ministry of Agriculture, Livestock and Fisheries (Ministry of Livestock at the time) involving the two departments of Livestock Production and the Veterinary Services. Dairy Training Institute also falls under the ministry of Agriculture, Livestock and Fisheries and it was key to the consultations. Figure 1 depicts the conceptual or institutional arrangement in the delivery of the radio programme.

2.2.2. ASAL Radio Based Training module development (Mifugo ni Mali)
Upscaling of the radio based training approach to the pastoral areas did not enjoy the privilege of having an existing module. Developing a tailor made module relevant to the pastoral system was the first hurdle to overcome. However,
there were a lot of lessons to draw from the module meant for the dairy farmers. The process kicked off with first identifying the relevant middle level college to partner with and this happened to be the Animal Health and Industry Training Institutes (AHITI). There are three such colleges in Kenya (AHITI Kabete, AHITI Ndomba and AHITI Nyahururu). Choice of AHITI, rather than continuing with DTI was as due to consideration of the different mandates. The DTI mainly deals with the dairy technology while the AHITI train Technicians with an emphasis on animal health. However, DTI was quite instrumental in sharing the lessons having participated in both the pilot and the upscaling of the same in wider coverage.

Wide consultations were made between the three AHITI and a small technical group was composed with representation from the three colleges as well as relevant departments in the livestock production and veterinary services with a special emphasis on inclusion of range department. Collaboration with animal welfare organisation was also sought and this was provided by the World Society for the Protection Animals (WSPA). The technical working group embarked on developing a module relevant to the pastoral system. The results of the technical group were presented to a wider stakeholder meeting with a wide representation from the pastoral areas of North Eastern (Mandera, Wajir, Garissa, Isiolo, Marsabit, and Tana River) among others.

2.2.2.3 Pre-testing of the module
The comments from wider stakeholder presentation were taken on board and a field pretesting of the module was undertaken in three pastoral representative counties namely Marsabit, Isiolo and Samburu. The field pretesting of the draft module involved participation from FAO and the colleges. The involvement of the colleges was to ensure early exposure of the potential subject matter specialists to ASAL environment in preparation for the delivery.

The module was then finalized by taking into account the comments from the field pretesting. The latter mainly involved conducting Focused Group Discussions (FGD) with pastoralists, interviews as well as keen field observations. Field pretesting also helped to assess the likely radio to be used by getting information of the radios that reach in those areas and gauging their signal strength. Having structured the broad topics, the technical group embarked on preparing detailed notes to ensure harmony and consistency in the delivery of the messages.

2.3 Implementation of the Radio Based Training Programme
The implementation of the radio based training programme involves a careful, dedicated and trustworthy execution of the stakeholder mandates. The stakeholders in this case, as depicted in figure 1 include the potential radio listeners, the government field technical officers and their superiors at the HQ, the radio broadcasting station and the technical institution. Each one of them had a specific role, but intertwined and coordinated by FAO. The Monitoring and evaluation team of FAO played a very crucial role in putting in place an MandE system which included a careful Baseline and Endline surveys to monitor the impacts created by the programme.

2.3.1 Government Field Technical Officers
The success of the radio based training programme is hinged on the support provided by the technical field officers. These are based at the field level and are in direct contact with the dairy farmers or livestock producers. Among the activities that were carried out included the following:
- Carrying out mobilization, create awareness, sensitization and registration of radio listening groups be they dairy farmers or pastoralists. They also organize the potential listener groups into radio listening groups.
- In each geographical area of jurisdiction, the field technical teams would organize themselves into Project Implementing Team (PIT) comprising of all the relevant departments from veterinary, livestock production, cooperative to gender
- Maintain active link with the technical institution secretariat and assist in reconciling the registration of the listeners
- Actively participate in the baseline survey and Endline evaluation of the programme
- Monitor listenership and help the listeners to recap/revise the aired topics
- Carry out practical demonstrations with the listening groups after every one or two of aired topics including organizing field days for target livestock producers
- Reporting progress during mid-review and closure meetings
- Continuously documenting success stories
- Organizing and facilitating farmer/pastoralist exchange visits
- Feedback on challenges encountered (signal strength etc.)
There are innumerable advantages of working with the government technical officers, key among them being sustainability considerations. The extension function is a government responsibility and thus given a tested model, it should be easy for the government to take it up. Another advantage of working with the government is cost implications. As the government personnel are already employed by the government, the project only required to provide funds for logistics (fuel, car maintenance and out of duty station subsistence).

2.3.2 Identifying the radio station
Organizations have procedures for procurement that must be strictly followed. However, a simple profile of the available radio stations covering the target areas is very crucial to help in the launch of procurement for the radio services. In this particular case, the government technical officers in the target areas were quite instrumental in in providing information regarding the available radio stations, their coverage, signal strength and estimated popularity in listenership. It is debatable if popularity of a radio is crucial to the choice of the radio. Reports from independent surveys by organizations like Synovate would help in narrowing down to the radio stations to be invited for bidding.

The timing of the day and best hour for broadcasting is a very crucial element in the success of the radio based training programme. During the pilot phase, broadcasting was done every Thursday from 9.30-10.30 PM. The evaluation found that this was a bit too late for the dairy farmers and there was challenge of other competing programmes from the local fm stations. The upscale in dairy areas adjusted time to 8.00 – 9.00 PM and this was received very well. The broadcasting of the radio based training targeting the pastoral areas was done between 8.00-9.00 PM every Friday. Issues about clashing with Muslim prayer time featured in the evaluation. Understanding the daily calendar of the target community greatly helps to negotiate the hour with the radio station. It is one of the critical factors in choosing the radio to award the contract besides coverage of the radio frequency.

The broadcasting station provides the air waves and a lead presenter. The role of the lead presenter is very important and the popular the presenter is the better for the programme. It is imperative that listeners follow presenters and some can easily migrate with entire audience from station to station. In the radio based training approach, the role of the presenter is to lead the subject matter specialists to deliver to the listeners the topic of the day. The presenter also moderates the timings and presents the questions from the listeners to the subject matter specialists in the studio. In case the interactive sessions involve call-ins, it is the work of the presenter to regulate and moderate all these. The radio station provides a dedicated number through which listeners interact with the subject matter specialists during the interactive session and even after. It is normally very important to let the listeners know if the number is toll free or if there is a cost when they send a message through it. The radio station must provide recordings after interactive sessions as these are useful during the recap sessions in the field between the technical officers and the listeners.

2.3.3 Technical Institution or middle level training college
The middle level training institutes involved in these programmes include the DTI and the AHITI, so far. The institutes provide the subject matter specialists for the various topics in the module. The latter deliver the topics within their area of expertise in an interactive session with the guidance of the radio presenter. In this particular approach, two lectures (subject matter specialists) were involved in each one hour interactive topics. The subject matter specialists attend studio sessions where they are led in the discussions by the presenter in a very systematic way. Besides discussions, they answer questions posed by the presenter on the behalf of listeners. The listeners pose questions through short message mobile system (sms).

At the end of the topic of the day, a question is posed to listeners which they are supposed to answer through the same sms system. The question plays two crucial roles of monitoring the listenership and motivating the listeners to stay tuned. The answers are analysed at the end of the programme and the top performers rewarded in a pompous ceremony (if funds allow). The closure ceremony should happen in the location or county that produced the best performers. This closure can also serve as a final monitoring and evaluation where the donor can also be involved as well as the top government decision makers. Such a meeting can serve as a handover to government and crucial decisions regarding future support by the government can be made.

Rewarding immediately at the end of the topic where the winner was announced in the following interactive programme ensured that the listeners paid keen interest to get the answer right. The technical institution takes lead in developing the curriculum jointly with the FAO technical personnel, pre-tests the curriculum, where feasible and provides the subject matter specialists. Further to the provision of subject matter specialists, the technical institution sets up a
secretariat with dedicated customer lines to register the potential listener farmers or pastoralists, receive farmers calls and SMS’s, offer timely responses to farmer questions and monitor the followership by the farmers through sms feedback and calls. The secretariat also analysis the answers to the question posed to the listeners at the end of every topic. In the programme targeting the pastoralists, a motivation concept was hatched whereby, the first correct answer was announced during the following programme and awarded Kenya shilling 1000/= via M-Pesa to his or her phone. This greatly enhanced listenership and keenness to get the message.

The secretariat was mandated to maintain linkage between the institute and the field (officers and producers) during the project period. Dairy Training Institute provided the needed technical services to the radio based extension for the dairy farmers while the Animal Health Training Institute provide the service for the radio based extension targeting the pastoral areas. The European Union has been funding right from the pilot that was funded through the EU Food Facility programme up to the upscaling that has been funded through the ‘Improved CommunityDrought Response and Resilience’ project component of the Kenya Rural Development Programme. Overall coordination was carried out by FAO personnel in charge of the programme. FAO also provided technical backstopping to field technical officers and technical institutions.

2.3.4 Certification and Awarding good performers

Ensure certification and recognition of farmers who showed exemplary performance in answering questions during the interactive sessions. Registered farmers and livestock producers that followed the radio based training programme were awarded DTI and AHITI certificates, respectively. The awarding is normally done in a closing ceremony that involves participation of donors, local government and FAO and most importantly by the listeners who have been following the programme. The participants use the occasion to show case what they learnt over the radio programme period. The closing ceremony also serves as an evaluation as well as a handing over ceremony. Successful radio listeners receiving their awards for good performance during the radio based training programme (photo courtesy of Kamande Njuguna)

3.0 Upscale to dairy areas

After the successful pilot of the radio based training programme in 14 districts of the former Rift Valley, the news about a new way of reaching farmers spread and the demand to extend the programme to the neighbouring districts grew. In essence, with more funding from the EU, an upscaling of the radio programme was carried out in ten (10) more districts both in former Rift Valley province and Central Kenya. This first upscaling of the radio based training programme registered 10,164 dairy farmers and 3000 from the East African Dairy (EAAP).

3.1 Synergy with other programmes

The collaboration with EAAP with a resultant registration of 3000 listeners was a very good example of synergy building between programmes where the EU programme provided the air waves while the EAAP supported the dairy farmers in five districts (Emuhaya, Murang’a South, Rongo, Taita Taveta and Imenti South). The dairy module was reviewed based on the lessons of the pilot programme and the recommendations made by the participating farmers during evaluation, ensuring that the gaps identified during the pilot were addressed.

The module was then presented at a workshop where the field officers from target districts were in attendance. These districts included Bomet, Bureti, Nandi North, Eldoret East, Subukia and Nyahururu in the Rift Valley province and Nyandarua North, Milangine, Nyeri South and Tetu districts in Central province. Inputs from the Provincial Directors of Livestock Production from the former Rift Valley and Central Provinces were also included.
The following topics were identified by farmers as key and needed to be addressed in the future programmes.

- Feeding and Nutrition including on farm feed formulation
- Diseases (Diagnosis, prevention and control)
- Dairy breeding including use of A.I services
- Pastures and Fodder (Establishment and management)
- Milk Marketing and group dynamics
- Dairy Hygiene including prevention of mastitis
- Value addition and related statutory requirements

Based on the analysis of the above challenges raised by the farmers and also based on the number and frequency of questions asked the following topics were added to the revised module: Biogas production, requirement for cottage milk processing, milk testing, role of milk in human nutrition, farm structures, farm planning and Stocking rate, leguminous plant establishment, pasture conservation for dry season feeding.

**Figure 1: Institutional arrangement of the radio based training programme**

**4.0 Monitoring and Evaluation**

**4.1 Baseline Survey**

During the pilot programme and subsequent upscaling within the dairy sector, the baseline survey was carried out by the DTI to determine the status of the participating farmers at the beginning of the radio training. However, during the upscaling to the ASAL or pastoral areas, FAO carried out the baseline survey in the target 12 counties. This was meant to ensure a comprehensive baseline study as well as build the capacity of the government technical officers to carry out baselines. By FAO being in-charge of the baseline directly, it meant that the integrity of the data was impeccable. The overall objective of the baseline survey was expected to contribute to the improvement of the planning, monitoring and evaluation of the radio based training programme for the ASAL based training on the analysis of knowledge, attitude and practices of pastoralists in the target 12 ASAL Counties.

The government technical officers were quite instrumental in arranging ground field logistics including mobilizing the potential respondents who were actually registered pastoralists for the radio programme. The survey instrument had been developed in a participatory manner between the FAO Monitoring and Evaluation office, FAO livestock technical experts and the government technical officers including the AHITI personnel. The baseline parameters included the personal and demographic characteristics, data on livestock production, economic characteristics as well as access to...
markets, livestock diseases and access to extension information, training needs as well as social information issues among others.

4.0.1 Challenges during baseline
The ASAL counties are normally very vast and the programme had targeted these counties for the radio based training programme. Illiteracy rates in most of these counties average over 80% and thus during interviews and FGD, translation is normally required. This does not only consume time but one may not be sure about the accuracy of the translation.

4.0.2 Broadcasting language
The language of broadcasting language was Kiswahili which is supposed to be the national language in Kenya. However, despite it being the national language, it is still difficult for the ASAL pastoralists to communicate in Kiswahili. This was one of the challenges to the radio programme in ASAL. One of the recommendations picked by the endline evaluation and the official radio programme closure was to have the messages translated to the local dialect for effective impacts.

1.1.2 Air waves
The signal strength was weak in some areas and thus quite frustrating to the listeners. Measures to rectify this involved constant discussion with the radio station to boost their transmission in the respective areas.

4.2 Endline evaluation Results (sample)
A total of 12 counties were covered at baseline. This was to ensure county specific information on animal health and production was collected for use by the counties. End line however was done in a sample of 6 counties (Samburu, Wajir, Makueni, Kajiado, west Pokot and Tana river) representing the livelihood zones of the 12 counties. A total of 1204 livestock producers were interviewed at baseline and a total of 333 at end line. In addition, at the end line, focus group discussions were held with at least 5 producer groups in each of the 6 counties. The sample size for both assessments was calculated using 95% confidence level, a confidence interval of 10 and a maximum of 3,000 registered livestock producers per county. Sampling was done to cover at least 80% of the groups formed and from each sampled group, producers were randomly selected from the register and questionnaire administered.

4.2.1 Endline evaluation sample Results
The following are a few examples of immediate impacts as a result of the radio based extension that was carried out for only six months in pastoral and dairy areas respectively. The pilot programme ran for one interactive hour per week for twenty three weeks, the upscale to dairy areas ran for thirty weeks while the ASAL radio based programme ran for 23 weeks.

Pasture and Grazing Management System
On pasture management system, there was notable increase in the % of producers who adopted reseeding from 7.3% at baseline to 26% following the training.

Grazing Management System
On grazing management system, there was increase in the % of producers practicing dry/wet season grazing areas (From 51.5-56.2%) and deferred grazing system (20.6-36.3%)

Animal Identification
There was increase in the % of producers who are practicing branding, ear notching and decrease in the % practicing traditional brands.

Increase in pasture production and conservation
Majority of producers are now establishing and conserving pasture. There was increase in the % of producers engaged in fodder production (22.3%-39.3%) and fodder conservation (32.1-49.2%). There was also increase in the acreage put under fodder from an average of 2.1 to 3.2 acres per household.
Livestock production and health messages were provided through Chief’s Barazas before the radio programmes. There were limited extension services for the farmers, most of who did not even know the qualified service providers to consult when in need for service. This has changed. Focus group findings from 6 counties showed that producers now know where to go or who to call for animal health services. They now know the government extension officers and have their cell phone contacts. “We are not strangers with the government extension officers anymore, we can call them because we know them”, said assistant chief of kongelai division who is a member of pokea mali listening group West Pokot.

Table 1 shows a sample of immediate impacts due to the radio based training programme in Dairy areas.

### Table 1: Changes as a result of the radio programme

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Baseline</th>
<th>End line</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application of ideas gained</td>
<td>Less</td>
<td>98% of the participating farmers applying the training.</td>
<td></td>
</tr>
<tr>
<td>Clean Milk production</td>
<td>30% of the milk rejected at the reception platforms</td>
<td>Post-harvest losses decreased from 30% to a low of 8%. Saving an average of 900 lts per day which translates to at least Kshs. 11 million in the 14 districts per month.</td>
<td></td>
</tr>
<tr>
<td>Milk production</td>
<td>66% of the Farmers producing &lt; 10 litres per day</td>
<td>On average milk production increased by 25% after adoption.</td>
<td></td>
</tr>
<tr>
<td>Milk marketing</td>
<td>15% in marketing groups</td>
<td>45% of the field school clusters converted to milk marketing groups.</td>
<td></td>
</tr>
</tbody>
</table>

4.2.2 Beneficiary testimonies/success stories

- **Improved production and income**: Kanaani group in Makueni has a total of 22 farmers. Members have an average of 2 dairy cows. Following the training, and adoption of practices taught, they have been able to increase the amount of milk they sell from 25 to 200 liters a day. Initially, only 4 of the farmers were taking milk to the dairy, now 15 out of the 22 take milk to the dairy. Due to increased milk production and need to deliver the milk daily, the farmers have employed someone to deliver their milk for a total of Kshs 15,000 per month. The group has ventured into poultry production too. As at the end of the training, a total of 14 of them had / or were in the process of constructing a conventional poultry house and the goal was to have all 22 with poultry houses, and in poultry production by the end of the year.

- **The training was a refresher course for extension government workers**: “This is refresher training. I last...”
saw some of the animal husbandry equipment provided by the project in college” said a Government extension worker in West Pokot district.

- **Collective Marketing** by Ona Mbee group in Makueni: “This training got us from somewhere and has taken us elsewhere” said Grace Mongoyo, chairperson of the group. The group of 64 members composed of over 96% women, now does collective marketing of their chicken and eggs. They used to sell one chicken (Despite the weight) at Kshs 150 but now sell at 500kshs per kg.

- **Boiling milk:** A whole village, Karapker in Sigor west Pokot, now is boiling milk to avoid getting milk borne diseases as reported by chairman of Kiprui listening group in west Pokot.

- **Informed participation in county budgeting process:** the group are now empowered to question the rationale behind the county budget.

- **Uptake of the innovation by Counties:** Makueni and West Pokot counties have planned to replicate this extension model using the local language. Use of local radio stations was one of the key recommendations across the counties.

**CONCLUSIONS**

Radio based extension is feasible and a viable venture that can be used to reach many farmers and producers in a cost effective way. It is an extension method that has the potential to spur the economy and contribute to the alleviation of poverty. Majority of the farmers are interested with information which translates to increased and sustained productivity throughout the year. Market access for small holder producers remain a major challenge. Radio based training plays an integral role in delivery of extension messages. Farmers demand for extension service is stimulated through radio training. Radio messages have been found to carry more weight. Radio also reaches a wide range of clientele within a short time.

**RECOMMENDATIONS**

With the advent of devolution, Collaboration between Development Partners and County governments to upscale the radio based training approach using local dialects will give extension the required impetus for development. Radio gives youth an opportunity to get extension messages and they can be easily targeted using the radio. In the design of the radio based extension, the involvement of field based technical officers is a great contributor to the success and effectiveness of the programme and greatly enhances adoption by the livestock producers and dairy farmers. Next steps should involve carrying out the radio based training through the local dialects. This should be feasible as there is virtually an fm station broadcasting in a local language. To be cost effective, the cluster approach should be adopted where counties with people speaking in the same language are aggregated and targeted. An elaborate study to determine the true impacts and the success factors contributing to the success of the radio based training approach is imperative.

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**MOBILE AGENT BASED SYSTEM FOR LISTING FUNDAMENTAL WI-FI PEER-TO-PEER NETWORK**

**DETAILS**

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**ABSTRACT**

In our everyday operations there is need to engage agents to perform some duties on our behalf, hence they are gaining acceptance as a technology and are being used. Most of the networked offices, networked homes, cyber cafe’s, learning institutions and other arenas where computers are interconnected on a Wi-Fi network, have peer-to-peer networks. In Wi-Fi peer-to-peer networks, it is difficult to identify the network details of all the network devices connected such as the IP addresses, mac addresses and computer names of all computers connected on Wi-Fi peer-to-peer network at one
go, hereby referred to as fundamental network details. This is possible in a client-server based architecture where the server monitors all the computers on the network. From the above gap, we developed a mobile agent that could be run in any computer on the Wi-Fi peer-to-peer network and it lists these fundamental details of all the computers connected to the Wi-Fi peer-to-peer network. In developing this mobile agent, we used the MaSE agent methodology. The mobile agent was coded, implemented and tested and subjected to various controls which it overcame and managed to return desired fundamental details with 80% accuracy. The agent had the capacity to classify every computer on the network as either intruder or non-intruder based on the list of authorised computers supplied by the user. The agent suffered major limitation such as taking long to learn and return the results, not communicating to the intruders or shutting them down. In future, the agent could be improved to reduce processing time, communicate and shut down intruding computers or deny them network access.

**Keywords:** Wi-Fi, Agents, Network, Peer network

### 1.0 INTRODUCTION

On our everyday operations there is need to engage agents to perform some duties on our behalf, hence they are gaining acceptance as a technology and are being used. There is a growing need for practical methods for developing agent applications to ease some of our duties. Wooldridge M. (2004) suggests that agents in multi-agents systems setup are concurrent autonomous entities that coordinate and cooperate so as to perform their various tasks, these coordination and cooperation tasks might be achieved through communication, interaction etc.

Mobile agent based system for listing fundamental Wi-Fi peer-to-peer network details is an agent that is responsible for listing details of the computers found on the Wi-Fi P2P network or workgroup. It lists IP addresses, mac addresses and computer names of the computers. There being various categories of computer networks, this agent is best used in a small Wi-Fi WLAN environments such as in the small cybercafes, schools, networked offices, wireless home networks and other small Wi-Fi P2P computer networks. This agent will be useful to the computer users and the network administrators as it will be able to monitor who are the Wi-Fi P2P network users, hence discouraging the illegal network users who do piggybacking on an authorised Wi-Fi networks. This could be further attributed to the fact that most home computer networks today are Wi-Fi P2P networks.

**1.1 Statement of the Problem**

The primary goal of this study is to design and build a fundamental network details listing agent using jade platform, then implement, test and evaluate the agent, with a view to return the fundamental Wi-Fi peer-to-peer network details of the devices connected to that network. The agent also classifies the devices connected on the Wi-Fi P2P network as either intruders or non-intruders to the LAN, based on their IP addresses and could be run on any computer on the Wi-Fi P2P network.

**1.2 Research objectives**

The research objectives of this project are as follows:

- To design and build a fundamental network details listing agent for Wi-Fi P2P network using the java platform
- To implement, test, evaluate network details listing agent on existing Wi-Fi P2P network configuration

### 2.0 RELATED TECHNOLOGIES AND LITERATURE REVIEW

#### 2.1 Related technologies

There are quite a number of related technologies in line with our system in the field of computing. Some of the related technologies and solutions include:

**2.1.1 Network management protocols:** Yang et al. (2004) argues that a set of automated network management tools usually deals with the multi-vendor environment of the typical installation; a network-management system is based on standardized network management protocols and applications which they are designed to achieve. Due to advanced technology, a large number of network management protocols exist to support network and network device management, although majority of them are not readily available to be used as a package on Wi-Fi peer to peer networks for network details listings. Some of these network management protocols which are highly in line with this project include and not limited to:

- Simple Network Management Protocol (SNMP)
- Common Management Information Protocol (CMIP)
- XML-based network management.
1.1.2 **Microsoft Windows Management Instrumentation (WMI).** The WMI technology is the Microsoft implementation of the Distributed Management Task Force (DMTF) Web-Based Enterprise Management (WBEM) initiative that extends the Common Information Model (CIM) to represent management objects in Windows-based management environments. The Common Information Model, also a DMTF standard, is an extensible data model for logically organizing management objects in a consistent, unified manner in a managed environment (Microsoft 2006). Based on the Common Information Model, WBEM is a DMTF initiative and technology that establishes management infrastructure standards and provides a standardized way to access information from various hardware and software management systems in an enterprise environment. WBEM provides a point of integration through which data from management sources can be accessed.

1.1.3 **Peer to peer File sharing software systems,** some of these file sharing software like Kazaa and Napster rank amongst the most popular software applications enable the exchange of some network information across the network, as well as the music and video files across the networks. Although majority of these file sharing software do not disclose the fundamental network details of the all the devices connected on a Wi-Fi peer to peer networks.

1.1 Literature review

2.2.1 **Computer networks and the IP addresses**

Opiyo, E. et al. (2006) suggest that computer network speeds have also increased, which has made it possible to exchange information around the world in a much more feasible manner; in view of this we now hear and read about globalization where the world is tending to become one global village. For the computers on the network to communicate to each other there has to be some set of rules which have to be followed to effect communication, these rules are referred to as the Internet Protocol (IP). There are various computer networks namely:- Local area networks (LAN), Metropolitan area networks (MAN), wide area networks (WAN), virtual area networks (VAN), and personal area network (PAN).

El-Rewini H., Abd-El-Barr M. (2005) maintains that IP address is an exclusive number that all information technology devices (printers, routers, modems, etc) use which identifies and allows them the ability to communicate with each other on a computer network. The IP address could be either Static IP or a dynamic IP. The IP addresses are moving from IP version 4 (IPv4) currently used by most network devices to IP version 6 (IPv6), the move is due to more and more computers accessing the internet.

2.2.2 **Peer-to-peer / adhoc networks**

Odell J., et al. (2000) view that Peer-to-peer connection is a connection where any computer on the network can be a client or a server or both at the same time, i.e. there is no dedicated server to control the clients. P2P networking type is most commonly used computer networks. This network type is very cost effective but supports lesser number of computers in network, about ten to fifteen computers can be connected to each other using P2P networking model without problem, more number of computers often create problems.

2.2.3 **Wi-Fi networks**

Michiardi, P. and Molva, R. (2003) explains that Wi-Fi is a communication technology that uses the ‘Direct-sequence spread spectrum radio technology’ and the ‘Orthogonal Frequency Division Multiplexing radio technology’. Wi-Fi is the trademark used by a trade group known as Wi-Fi Alliance. Wi-Fi networks Operating in peer-to-peer mode allows all wireless devices within range of each other to discover and communicate in ad-hoc fashion without involving central access points including those built in to broadband wireless routers. Below is a figure 1 showing Wi-Fi peer-to-peer network.

![Figure 1: Wi-Fi peer-to-peer network. Source <http://www.wifinotes.com>](http://www.wifinotes.com)
2.2.4 Agents
Nwana H.S. (1996), claims that agents are autonomous programs that can perform services on behalf of the user. Agent designing is task-oriented. Instead of looking at what actors are involved in an operation, you look at what tasks and subtasks the operation consists of. Agents are then created to solve these tasks. Whereas object orientation does not say anything about the actual tasks but rather expects the objects to solve them implicitly, agent orientation concentrates on the tasks at hand and creates actors that can help in solving these tasks. There are various categories of agents as illustrated below:

2.2.4.1 Network agents
There are a numerous network agents that have been designed and are in existence, but a majority of the agents are biased towards network security, client/server networks among others. Most of the network details listing agents are embedded within the operating systems, but this is merely to list only a few network details such as the IP address of the computer that the operating system is running within as illustrated by Odell J., et al (2000). Network features, such as Network card speed, Network switch speed, etc., does impact the network throughput of these agents.

2.2.4.2 Mobile Agents
Mobile Agents are programs that can migrate from host to host in a network. They should be able to execute on every machine in a network and the agent code should not have to be installed on every machine the agent could visit. Therefore Mobile Agents use mobile code systems like Java and the Java virtual machine where classes can be loaded at runtime over the network. Below is figure 2 showing a mobile agent movement. Michael W. (2002) suggests that mobile agents are seen as a potential threat to systems. If mobile agents were misused they could generate denial of service attacks or even steal data. Most mobile agents are heterogeneous so that they can travel around a heterogeneous network; hence they have all the characteristics of an agent. Mobile agents send not only data, but code, hence more network bandwidth is required. This is often offset or even reduced to lower level than without mobile agents by the fact that data can be processed at various locations in the network.

![Figure 2: Mobile agent illustration](http://www.limsi.fr/~jps/enseignement/examsma/2004/BHATTI/index.htm#Mobile%20Agents)

2.2.5 Mobile agents programming
As suggested by Tarau, P. et al (1997), there are various programming languages that can be used in implementing mobile agents, as long as the language has the following capabilities: - support for agent migration, support for agent-to-agent communication, support for interaction with local resources, security mechanisms, suitable execution efficiency, language implementation across multiple platforms, and Ease of programming of the tasks mobile agents perform. We used jade programming language in coding our agent, though there are other agent programming languages such as aglets, odyssey, Voyager, telescript, oblique and perl5 among others.

3.0 METHODOLOGY
3.1 Systems design
In system designs as advised by Chauhan (1997), we used MaSE (multi agent system engineering) methodology. This methodology advocates for two phases namely analysis phase and designing face. In analysis phase we captured the agent’s goals, applying use cases and refine agent’s roles. While in designing phase we created the agents classes, assemble agent’s classes then finally design the agent, as shown in table 1 below.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Models</th>
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</thead>
<tbody>
<tr>
<td>1) Analysis phase</td>
<td></td>
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<tr>
<td>a) Capturing goals</td>
<td>Goal Hierarchy</td>
</tr>
<tr>
<td>b) Applying use cases</td>
<td>Use Cases, Sequence Diagrams</td>
</tr>
<tr>
<td>c) Refining roles</td>
<td>Concurrent Tasks, Role Model</td>
</tr>
</tbody>
</table>
2) Design phase
   a) Creating agent classes
   b) Constructing conversations
   c) Assembling agent classes
   d) System design

<table>
<thead>
<tr>
<th>Agent class diagrams</th>
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<tbody>
<tr>
<td>Conversation diagrams</td>
</tr>
<tr>
<td>Agent Architecture Diagrams</td>
</tr>
<tr>
<td>Deployment Diagrams</td>
</tr>
</tbody>
</table>

Table 1: MaSE methodology steps

3.2 Experimental and data sources design
We began by setting up a Wi-Fi P2P network. In setting up this network we send the Wi-Fi signals from a wireless router or joined a P2P WLAN hotspot. We then ran our prototype in any randomly sampled computers forming the Wi-Fi P2P network and documented the results. We also added and removed other computers on the network and ran the prototype, then recorded the results obtained. The recorded results constituted the data which we used for the analysis of the mobile agent.

3.3 Data collections procedures, methods and tools
In data collections as argued by Kothari C.R. (2004), in our project we collected the data through experiments and observations methods. The data was recorded at source, immediately they were collected.

3.4 System implementation and testing
In the implementation of the fundamental network details listing agent, first we had to setup a Wi-Fi P2P network. In setting a P2P network, we either used Wi-Fi. Then we installed JAVA, this is because we are using java based framework. We then ran the system by invoking the agent.

3.5 Data analysis and Evaluation
In analysis we printed the screen shots of the results, graphs, tables and pie charts. We analyzed and evaluated the data with regard to real life experience and some sets of controls. The analysis and evaluations was done in a way such that we compared the data that the agent gave under various tests, and the actual information on the ground. Some of these comparisons were; how many fundamental computer network details does the agent return, while actually how many computers are connected to the Wi-Fi P2P network?

4.0 IMPLEMENTATION
4.1 Conceptual framework
4.2 Sample code for analysis agent
This is a sample code for the analysis agent, which analyses the IPs from the network scan agent and the allowed IPs file, and compares them to classify the computers as either intruding or non-intruding.

```
package agents;
import abstracts.AbstractAgent;
import behaviours.ReceiveMessages;

//@author gogo

public class AnalysisAgent extends AbstractAgent {
    @Override
    protected void setup() {
        register("Analysis Agent");
        addBehaviour(new ReceiveMessages(this));
    }
}
```

4.3 Sample code for network scanner
This is a sample code that scans the Wi-Fi P2P network and returns the network details that have been identified and forwards them to the analysis agent. Its in this code that one can change the range of IPs to be scanned.

```
package agents;
import abstracts.AbstractAgent;
import behaviours.GetAllIps;
//@author gogo

public class NetworkScanner extends AbstractAgent {
    @Override
    protected void setup() {
        register("Network Scanner");
        int range = 2;  //No of machines scanned by one behaviour
        for (int i = 1; i < 20; ) {
            int pass = ((i+range)-1);
            if(pass>254)
                pass=254;
            addBehaviour(new GetAllIps(this, i, pass));
            i += range;
        }
    }
}
```

5.0 TESTING AND RESULTS
5.1 Testing the system when connected to a network and no allowed IPs entered
When the system was connected to a Wi-Fi network connecting 4 computers without computer names, it returned the details of the 3 computers connected to the Wi-Fi network, missing one computer. It managed to classify all the IPs of the detected computers as INTRUDING, this is because we did not entered any computer IP address on the allowed IP file and so any detected IP will be classified as INTRUDING. Figure 3 below shows the systems interactive GUI with the results.
5.2 Testing the system when connected to a network with allowed IPs entered
The system was made to run again this time with allowed IP (41.89.64.60), it categorized the computer with the given IP as allowed as shown in the figure 4 below.

Figure 4: Systems GUI showing results when there is network with allowed IPs entered

5.3 Testing the system when connected to a network with both static and dynamic IPs
The agent was run on one network with 9 computers with some computers having static IP address it identified all the 9 computers and classified them accordingly. It also managed to classify the IPs that are in the allowed file (192.168.1.100) as allowed IPs, as shown in the figure 5 below:-

Figure 5 - System GUI showing results when networks changed as system runs
6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The main objective of the mobile agents that we have developed was to relay the fundamental details of all the computers connected on the Wi-Fi P2P network. These computer network details are: computers IP addresses, computer names and the Mac addresses. The agent was developed and tested on various Wi-Fi P2P networks as well as the cabled networks. The mobile agent successfully achieved its intended objectives, but with some slight challenges in others. It worked well on networks which consisted of a few computers, especially with IP addresses following each other sequentially. The mobile agent also classified the computers found as either allowed or intruding, which will help the network provider or user to know who is piggybacking on his/her network.

The main challenge that the mobile agent is facing is time consuming. In essence to scan a single IP address the agent takes about 2 second, which implies that if the IP range is from IP 192.168.1.1 to 192.168.1.20, then the system will take about 2 minute 30 seconds inclusive of time for learning its path which is on average 1.75 minutes. In some occasions, especially when the Wi-Fi network was weak, the agent returned a few IP addresses with an accuracy of about 80%.

6.2 Recommendations

The system managed to solve a greater part of the problem which was at hand. We hereby recommend the following further developments on the systems: -.

• Reducing the time it takes the multiagent to go through a P2P WiFi network and return a substantive network detail without a miss
• Detects your internal and external IP addresses.
• Retrieves currently logged-on users, configured user accounts and uptime.
• Supports Wake-On-LAN, remote shutdown and sending network messages.

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DEVELOPMENT OF INTERACTIVE WEB PORTAL FOR KENyan TEA

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ABSTRACT
In Kenya the tea sector’s growth is dependent on tea production, marketing and research. For better performance of these key areas, information flow is critical. However the information flow is still poor due to lack of an effective information delivery system. Although development of web sites and other cross platform tea information systems have made information sharing easier and faster than ever, their dynamic, unstructured nature and lack of necessary level of interaction limit their potential in the information delivery. The exponential growth of these resource platforms has also resulted to scattering of the information widely which makes it difficult for users to obtain the desired information efficiently. Marketing is also ineffective due to lack of an online marketing tool for the Kenyan tea, and with the increased global market competition posed by the major tea producers in the world including China, India and Sri Lanka, Kenya is faced with major threats in maintaining its tea market share. In this project an interactive web portal was developed as a resource platform for tea, that would bring together the tea information into an integrated “one-stop shop” for improved efficiency in information access and retrieval, and to provide a marketing platform for the Kenyan tea. The development process involved; designing of web portal architecture, development of the system components, system testing and hosting the program on World Wide Web. The following utilities with outstanding features were used to develop the portal; Joomla! 3.2, XAMPP, PHP5.3.1, MySQL 5.1.41, PhpMyAdmin, Adobe Dreamweaver CS6 and site extensions including; PixSearch, Joom!Fish, VirtueMart and JomSocial. The web portal was then evaluated in JKUAT based on organization of information, friendliness of the user interface and efficiency in information access and retrieval.

Key words: Kenya’s tea sector, information flow, web portal, Vision 2030.

1.0 INTRODUCTION
1.1 Background information
In Kenya tea is an important commodity and is ranked as the third major foreign exchange earner, behind tourism and horticulture, contributing to about 26% of all foreign exchange earnings and 4% of the gross domestic product (TBK, 2010). Tea production, marketing and research are the key factors that determine growth of the tea sector in Kenya. Performance of these key areas is dependent on availability and access to information. However the information flow within the tea industry is poor due to lack of an effective information delivery system. Marketing which is also an essential integral element of the tea sector development in Kenya is ineffective due to lack of a reliable marketing platform for the Kenyan tea, and with the increased global market competition posed by the major tea producers in the world including China, India and Sri Lanka, Kenya is faced with major threats in maintaining its tea market share.

Although web-based tea information systems have, in a great deal, improved the information flow within the tea sector, these resource platforms are limited in terms of their efficiency in the information delivery due to their unstructured nature. The difficulties to access information are due to multiple application presentation of content from disparate sources and different interfaces which leads to user dissatisfaction. This project was therefore aimed at developing an interactive web portal as a resource platform for tea that would consolidate the scattered information into a single place, with an integrated access to variety of tea resources and services in a secure, consistent and customized manner, and which would provide a marketing platform for the Kenyan tea.

A web portal is an online service that brings information together from diverse sources in a uniform and organized format, owing to its design (Davidson et al., 1995). It provides a personalized, single point access to resources and has features that offer services such as forums, e-mail, entertainments, news, search functions and links to other web resources. There are many different definitions of portal, however in IT context the term “portal” is developed gradually as an entry point to relevant information on the Internet. The key features of a portal emphasized in most of the definitions are the interactive nature, dynamic and goal oriented aspects, and the ability of users to exchange information with other users on the web portal. The portal was developed following waterfall model which involves following steps; requirement analysis, design, implementation, testing and system maintenance (Royce, 1970).
1.2 Review on the tea industry in Kenya and the need for a tea web portal

Tea was first introduced in Kenya from India in 1903 by G.W.L. Caine, a European settler who planted the seedlings in Limuru, near Nairobi (TBK, 2010). Since its commercialization in 1924, the tea industry has experienced significant growth and today tea plantations cover over 157,720 hectares, with production of about 345,817 metric tonnes of made tea, most of which is black tea. However green tea, Oolong, yellow tea and white tea are produced on order (TBK, 2010).

The tea industry operates under the auspices of Ministry of Agriculture that bears responsibility to the government. There are several institutions that play different roles ensuring excellence of the industry including; Tea Board of Kenya (TBK), The Tea Research Foundation of Kenya (TRFK), Kenya Tea Development Agency Ltd (KTDA), Kenya Tea Growers Association (KTGA), Nyayo Tea Zones Development Corporation (NTZDC) and the East African Tea Trade Association (EATTA)(TBK, 2010).

There has been demand in the tea sector to promote information exchange and access which is still poor due to lack of an effective information delivery system. For example, the Tea Research Foundation of Kenya has developed forty five varieties of tea (TBK, 2013), of which farmers are yet to adopt due to lack of information about their availability and potential. There is need to improve the information delivery through adoption of Information technology (IT) which in Agriculture increases the effectiveness and efficiency of information flow and use in the sector (Thompson et al., 1997).

The rapid development of web based information resources and accessibility of internet at a worldwide level has resulted to establishment of web portals as one of the paradigms which are implemented to provide integrated access to a huge number of heterogeneous and autonomous information resources. Global research conducted by Accenture (Englert, 2003) reflects the growing importance of portals in institutions around the world. The potential of web portals in information delivery is incredible, therefore development of the web portal for the Kenyan tea would, in a great deal, benefit the tea industry in Kenya.

1.3 Statement of the problem

Access, efficiency and affordability of information in the tea industry in Kenya continue to be the major impediment for improving its performance. While the tea web resources have improved information sharing, their unreliability, dynamic and unstructured nature limit their potential in the information delivery. With the increasing number of these resource platforms, users have to manually browse through several web pages in order to obtain the desired information which is quite tedious, time consuming and costly hence negatively affecting the information flow. Marketing is also ineffective due to lack of an online marketing platform for the Kenyan tea which is still traded as an agricultural commodity making it vulnerable to supply and demand pressure (Kilele et al., 2013). The main challenge is to organize the available large amount of information on tea to suit different end-users, to improve efficiency in information access and retrieval, to provide a marketing platform for the Kenyan tea and the necessary level of interaction.

1.3 Justification

Kenya depends on Agriculture for its sustainability and good Agricultural performance translates into measurable improvements in the quality of life (Kimenyi, 2002). The tea sector in Kenya provides employment and livelihood to many people across the value chain (TBK, 2010). To facilitate coordination between the supply chain partners, information sharing is essential (Elias et al., 2012). Information technology (IT) offers the ability to increase the amount of information provided to all participants in the agricultural sector and to decrease the cost of disseminating the information (Lancioni et al., 2000).

In dealing with the said problems of ineffective information flow, it was necessary to develop the tea web portal that would consolidate data from multiple sources into a local warehouse, enhance capability to effectively store, process, provide uniform access to the information thus limiting redundancy, increasing efficiency in dissemination of information and facilitating a dynamic exchange of the information. The portal would also facilitate marketing of the Kenyan tea which would ensure increased sales and achievement of a sustainable competitive advantage giving Kenya a firm footing in the world tea market. Information promotes competition and improves market performance (Thompson et al., 1997).
The web portal would greatly benefit the tea industry in Kenya which the government of Kenya lists as one of the pillars of realizing the government’s Vision 2030 (GoK, 2007).

1.5 Objectives
1.5.1 General objective
To develop an interactive web portal as a resource platform for Kenyan tea

1.5.2 Specific objectives
1. To design the system architecture
2. To develop the system components
3. To test the system; functionality testing, usability testing, interface testing, compatibility testing and performance testing.
4. To validate the requirements of the portal based on organization of information, friendliness of the user interface and efficiency in information access and retrieval.

2.0 MATERIAL AND METHODS
2.1 Study area and materials
A web portal was developed as a resource platform for the Kenyan tea using the following utilities; Joomla! 3.2, XAMPP, PHP 5.3.1, MySQL 5.1.41, PhpMyAdmin, Adobe Dreamweaver CS6 and site extensions for improving the portal functionalities, including: PixSearch, Joom!Fish and JomSocial.

2.1.1 Joomla!
Joomla! is an open source content management system (CMS) that was used to handle the content of a web site because it provides multiple functionalities with capability to organize and manage the contents of a site rather than developing the site contents from the scratch. Joomla! 3.2 was obtained from its main site http://www.joomla.org.

2.1.2 XAMPP
XAMPP (A cross platform Apache Mysql Php Processor) is an open source cross-platform web server package including the Apache HTTP Server, Mysql (My Structure Query Language) database and interpreters for scripts written in PHP (PHP: Hypertext Processor) and Perl programming languages. It was used as a development environment that allowed the web portal to be tested on the computer without any access to the internet. XAMPP was downloaded from www.apachefriends.org.

2.1.3 PHP
PHP (PHP: Hypertext Preprocessor) is a server-side scripting language designed for web development but also used as a general-purpose programming language. It was used because of its text processing features that enable outputting of HTML, image, PDF files and even any text such as XHTML and XML. It also works well with Mysql databases and can be deployed on most web servers and operating systems.

2.1.4 HTML
HTML (Hyper Text Markup Language) is the standard markup language for web pages that web browsers use to interpret and compose text, images and other materials into visual or audible web pages. HTML elements were used as the building blocks together with CSS (Cascading Style Sheets) which is the recommended way to control the presentation layer in a web document of a site.

2.1.5 MYSQL
Mysql (My Structured Query Language) is an open source Relational Database Management System (RDBMS). Mysql was used because is a popular choice of database for use in web applications, has fast performance, high reliability and can run on virtually every platform.

2.1.6 PhpMyAdmin
PhpMyAdmin is an open source utility which is written in PHP. It was used because of its user friendly interface and the ability to connect the PHP script with the database by using the phpMyAdmin service.

2.1.7 Adobe Dreamweaver
Adobe Dreamweaver CS6 which is a proprietary web development tool developed by Adobe systems was used as an
editing environment for the HTML tags of templates. It was used because of its ability to facilitate rapid layout design and code generation, as it allows users to quickly create and manipulate the layout of HTML elements. It also provided transfer and synchronization features and a template feature that allowed single-source update of shared code and layout across entire sites without server-side scripting.

2.2 Development procedure

The methodology used to design and develop the web portal involved waterfall model (Royce, 1970). The steps involved are as outlined in figure 1 below.

![Waterfall Model](image)

**Fig. 1**: waterfall model (Royce, 1970)

2.2.1 Requirement analysis

The requirement analysis process involved a detailed study of the system requirements through feasibility study, elicitation and analysis. Information about the required system and existing systems were gathered in order to define the user requirements and system requirements. The user requirements included the services that the system was expected to provide to the users, the required system performance and the constraints under which it were to operate. On the other hand the system requirements included a more detailed description of the software system’s functions, services and operational constraints.

The requirements were based on two major categories: functional requirements and non-functional requirements. The functional requirements analysis involved determining what the program should do. Here the functions of the system were determined. The non-functional requirements on the other hand were those that were not directly concerned with the specific services delivered by the system to users. They were important but not related to the functions of the program and were basically constraints on the functions offered by the system.

The requirements were established through extensive literature review and interaction through interviews with some of the tea industry stakeholders including; Nyayo Tea Zones Development Corporation, Kenya Tea Development Agency and the Tea Board of Kenya.
2.2.2 System design
In the system design process the overall system architecture was established, this helped to identify the main structural components in the system and the relationships between them. The process focused on high level design and low-level design. The high level design involved defining what programs were needed and to determine how they would interact, while low-level design determined how the individual programs were going to work.

The four main activities that were part of the design process included:

1. Architectural design: Here the overall structure of the system was identified and the principle components and their relationships were determined. The design involved defining the content, site structure, application logic, graphic design, and navigation schemes.
2. Interface design: The interfaces between the system components were defined. All the Web pages in the application and how the content was to be distributed among them were also defined.
3. Component design: Each system components and their operations were designed.
4. Database design: The system data structures and how they were to be presented in the database were designed. Information design was also determined to ensure proper organization and storage of data in the database.

2.2.3 Implementation Process
After the design process the work was divided in units and the system components were then developed.

2.2.3.1 Database creation and management
Database was created using XAMPP. Under the localhost/PhpMyadmin upon running the XAMPP, a database named “kenyatea” was created using the system on the text field labeled ‘create new database’. The database was then automatically created using the MySQL.

The database management was done using Joomla! 3.2 which was also used to create and manage the contents of the portal. It was installed on a local server to allow creating and testing the site on the computer prior to deploying it on a live server. This was to avoid moving files back and forth from a remote web server when making changes to the site, making the development efforts easy.

2.2.3.2 Web page development
HTML tags were used as the basic building-blocks of the web pages that described how the web pages were displayed by the web browser. The PHP was responsible in creation of the dynamic web page content of the portal. To be able to create the web pages, the files were copied into a directory placed inside the htdocs directory. These files included: index.php, template.css, templateDetail.xml and template_thumbnail.png. The HTML elements contained in the template index.php file was used for the page layout and the statements that included the component and module output. CSS enabled the actual display of these pages.

The template’s HTML was edited using the Adobe Dreamweaver CS6. This package was used as a development environment in setting functionalities of the page such as the page layout. It was possible to access the site by opening the URL in the browser upon running XAMPP, as follows: http://localhost/kenyatea. XAMPP enabled running of programs on the web browser without access to the internet because it is unified software package that bundles the entire necessary server environment.

2.2.4 Integration and System testing
System testing was done to ensure that the system worked as expected and that the set requirements were met. The individual program units were tested separately and also integrated and tested as a complete system.

Testing activities were carried out at every stage of the development process. Fault injection was the verification activities while the fault removal was the testing activities; integration tests, unit tests and system tests. Any fault of the system was revealed by a failure. A failure is an incorrect result during execution that occurs when a software system does not behave as desired (Sommerville, 2001).

The following aspects were tested during the system testing activities: functionality testing, compatibility test, performance, usability testing, interface testing, accessibility, performance testing and security testing. The testing activities were as shown in table 1.
Table 1: System testing activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Aspect tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functionality testing</td>
<td>- Testing the system functionalities including; links to web pages, database connection, forms and Cookies.</td>
</tr>
<tr>
<td>Usability testing</td>
<td>- Testing navigation for users to surf.</td>
</tr>
<tr>
<td></td>
<td>- Content checking for ease of understanding, visibility, spelling errors and provisions for user instructions.</td>
</tr>
<tr>
<td>Interface testing</td>
<td>- Interactions between Web server and Application server interface, and the interaction between Application server and Database server interface.</td>
</tr>
<tr>
<td>Compatibility testing</td>
<td>- Testing web application on different browsers such as Internet explorer, Firefox, Netscape navigator, Internet Explorer, Google Chrome, AOL, Opera and mobile browsers with different versions for compatibility.</td>
</tr>
<tr>
<td></td>
<td>- Testing the system on different operating systems such as Windows, Unix, MAC and Linux for compatibility.</td>
</tr>
<tr>
<td>Performance testing</td>
<td>- Load testing; to determine the system’s behavior under both normal and anticipated peak load conditions to determine the system responsiveness and stability. Also to determine which element would cause degradation.</td>
</tr>
<tr>
<td></td>
<td>- Stress testing; checking how the system reacted to stress and how the system recovered from crashes. To determine safe usage limits and to confirm that the intended specifications were met.</td>
</tr>
</tbody>
</table>

3.0 DATA COLLECTION AND ANALYSIS

3.1 Research design
A qualitative research method was used to obtain information that would give a deeper understanding of the tea industry in Kenya and for the requirement analysis of the intended portal. The method was used because it is flexible in driving the research according to the scope of the study. There is also space to clarify ambiguities and confusion over concepts. The issues under study were; to generally understand the tea industry in Kenya, identifying challenges in information flow and marketing, evaluating the available tea resource platforms and to define the nature of the intended portal. Some of the key institutions in the tea industry were used as sources of the required information, including; KTDA, NYAYO TEA ZONES and TBK. These institutions play crucial roles in the tea industry and therefore informants from these institutions were appropriate to answer the specific questions under investigation.

3.1.1 Data collection technique
A semi-structured interview was used for data collection. Interview is a type of conversation with a people or group of people under a set of assumptions and understanding about the situation where raw data from the interviewing can be used for analysis at a later time (Wilkinson and Birngham 2003). By conducting the semi-structured interview, there was flexibility to vary the context and content of the interview. The method also enabled the respondents to give in-depth details relevant to the scope of the research rather than responding to closed questions. This enabled probing for more information and clarification of answers giving deeper understanding and insight.

3.2 Data analysis and presentation
The data collected were notes that were taken during the interviews. From these notes the original comment and observations were reconstructed. The data was then categorized into patterns as the primary basis for organizing and reporting the results. The data analysis was done in the following 3 steps:

1. Derivation of issues from the raw data: As the raw data contained detailed explanations, the data was summarized and reformulated by deriving issues from the raw data.
2. Grouping the issues: The issues were grouped based on their relation to each other.
3. Issue summary: The issues were summarized in the form of short statements. For instance the issues on the nature of the system and the services to be offered were categorized into functional requirements and non-functional requirements and the respective requirements clearly identified.

4.0 RESULTS AND DISCUSSION

4.1 Interview results
The interviews conducted yielded the following results;
(i) The result of the interview on the issue of information flow in the tea industry was consistent with that of the literature review; that the information flow was poor and there was need to improve it. Front the entire
respondents it was evident that development of a web portal for the Kenyan tea would be able to address most of the stated problems.

(ii) From the informants responses, the key areas to be captured in the portal were identified as Tea production, Tea marketing, Tea research, Tea Buying and Selling.

(iii) On the issue of requirement analysis of the system the identified system requirements were as shown in table 2.

<table>
<thead>
<tr>
<th>Functional requirements</th>
<th>Non-functional requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Information content management</td>
<td>- User friendly interface</td>
</tr>
<tr>
<td>- Search functions</td>
<td>- Ability to operate on different platforms</td>
</tr>
<tr>
<td>- Content single sign-on (SSO)</td>
<td>- Automated back-ups</td>
</tr>
<tr>
<td>- Provision for user registration</td>
<td>- Performance</td>
</tr>
<tr>
<td>- Security</td>
<td>- Accessibility</td>
</tr>
<tr>
<td>- News and updates</td>
<td>- Maintainability</td>
</tr>
<tr>
<td>- Interactions</td>
<td>- Web clipping</td>
</tr>
<tr>
<td></td>
<td>- Ability to react on requests in a short time</td>
</tr>
</tbody>
</table>

4.2 The developed system components
4.2.1 Template files structure
The template file structure of the system is as shown in figure 5 below.

Figure 2: Template files structure

The key files in this template file include: Index.php, Template.css, Template_thumbnail.png, and TemplateDetails.xml. These template files contain all the necessary elements for the functionalities of the portal. They control the general appearance of the site and are the container for all the output on the page and define the look and feel of the page. All of the text and the colors on the screen are controlled by these templates, via the template’s CSS files.

4.2.2 MySQL for the web portal
The following MySQL codes were created to be used as the relational database management system (RDBMS) for database of the portal. This contains the entire necessary query that is executed by the system.

MySQL codes:
-- phpMyAdmin SQL Dump
-- version 3.2.4
-- http://www.phpmyadmin.net
-- Host: localhost
-- Generation Time: Jan 19, 2014 at 04:37 PM
-- Server version: 5.1.41
-- PHP Version: 5.3.1

SET SQL_MODE="NO_AUTO_VALUE_ON_ZERO";
/*!40101 SET @OLD_CHARACTER_SET_CLIENT=@@CHARACTER_SET_CLIENT */;
/*!40101 SET @OLD_CHARACTER_SET_RESULTS=@@CHARACTER_SET_RESULTS */;
/*!40101 SET @OLD_COLLATION_CONNECTION=@@COLLATION_CONNECTION */;
/*!40101 SET NAMES utf8 */;
-- Database: 'kenyatea'
-- Table structure for table 'nkmsu_assets'
4.2.3 The database structure of the portal
The created database contains all the information of the portal including texts, images, username and passwords. The database structure of the portal is as shown in figure 3.

![Mysql database structure](image)

Figure 3: Mysql database structure

4.3 The system architecture
The developed system architecture followed the 3-tier architecture. The general architecture of the developed system is as shown in figure 4 below.

![The client server architecture](image)

Figure 4: The client server architecture
The component structure is as discussed in table 3 below.

<table>
<thead>
<tr>
<th>Application</th>
<th>Interfacing environment</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client side design</td>
<td>HTML,CSS</td>
<td>Web browser</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- This is the presentation tier and is the actual interface for users. The interface communicates with other tiers by which it puts out the results to the browser/client tier and all other tiers in the network.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- The web browser on the client machine sends service-request data to the web server running on the server machine. The server then sends an existing page to the client machine.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- The browser uses HTML tags to interpret the content of the page.</td>
</tr>
<tr>
<td>Server Side Design</td>
<td>HTML,CSS</td>
<td>Apache</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- This is the logical controlling part of the portal (application layer)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- This layer coordinates the application, processes commands, makes logical decisions and evaluations, and performs calculations. It also moves and processes data between the two surrounding layers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- The web container (Apache) running under the server machine handles the client request, validates with the server side program (PHP) and then generates an appropriate page or locates an existing appropriate page and sends the page to the client side.</td>
</tr>
<tr>
<td>Database Design</td>
<td>MySQL</td>
<td>Database management systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- It is in this layer that information is stored and retrieved from the database, the information is then passed back to the logic tier for processing, and then eventually to the user. The web server pulls up data with the help of database server (MySQL), fit it into a web page and sends it to the client machine.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- The DBMS allows users to insert, update, delete and retrieve data from the database. It has a central repository for all data and data description.</td>
</tr>
</tbody>
</table>

### 4.4 The Front-end/User interface

This is the target for output and the place where the visitors access the site’s content and functionality. The front-end contains menu items, search box and the social place. The user interface contains the home page which is the page that is displayed when user visits the site. The Home page/landing page is as shown in figure 5 below. Visitors to the site are able to see and use the front-end content and functionality with any of a wide range of browsers, both current and older editions.

#### 4.4.1 Menu items

Menu items were created to provide principal navigation links on the pages of the portal. These menu items include; Home, Stakeholders, Marketing, Production, Research, Shop, Login and Contacts. The menu items appear in two parts of the page; one is at the top of the page and the second is at the left side of the page situated vertical which have the same content but with one more item featuring beneath it which is ‘Other related links’.
4.5 The Back-End/Admin Interface

The back end is the administration interface where the majority of the site management activities occur. Access to the admin system is controlled by a login form and is restricted to only those users who are assigned to user groups higher than publishers.

REFERENCES


Management, 29:45-56.

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COMPUTER ERGONOMIC ISSUES IN LEARNING INSTITUTIONS IN KENYA: CASE STUDY OF KIRINYAGA COUNTY

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ABSTRACT
Learning institutions are emphasizing computer hardware and software, while neglecting computer hardware compliance with ergonomics. Since non-compliance to good ergonomic practices is not a onetime effect, users are not usually aware of the negative impact on their being until too late. The question of ergonomics is very sensitive during this era when the government is championing use of ICT in all learning institutions. The health-risks that come with non-compliance cannot be underestimated. This study investigated computer ergonomic issues and problems that face students when using computers as tools of learning in selected primary, secondary and university institutions in Kirinyaga County. Purposive sampling was used to select the institutions. Stratified sampling was used to pick the sample size. In each stratum, random sampling was adopted. Total sample size was 350. Closed ended questionnaire was constructed and self-administered to collect information about computer related ergonomic issues and habits of students. Data were analyzed and presented using SPSS V20. Most of the institutions don’t have ergonomic furniture. Laboratories and computer screens were poorly lit. Most institutions used older machines that produced noise and emitted a lot of heat. Laboratories were poorly ventilated and respondents were not aware of ergonomic practices and habits and the risks that come as a result of non-compliance. Learning institutions lack knowledge on the importance of computer ergonomics. Thus stakeholders need to intensify campaigns on computer ergonomics in learning institutions.

Key words: ICT, Laboratories, Learning institutions, Health-risks, Habits

1. INTRODUCTION
The foundations of the science of ergonomics appear to have been laid within the context of the culture of Ancient Greece. A good deal of evidence indicates that Hellenic civilization in the 5th century BC used ergonomic principles in the design of their tools, jobs, and workplaces. One outstanding example of this can be found in the description Hippocrates gave of how a surgeon’s workplace should be designed and how the tools he uses should be arranged (Marmaras, et al., 1999). It is also true that archaeological records of the early Egyptians Dynasties made tools, household equipment, among others that illustrated ergonomic principles. Ergonomics is the science of designing user interaction with equipment and workplaces to fit the user. Proper ergonomic design is necessary to prevent repetitive strain injuries, which can develop over time and can lead to long-term disability. According to the International Ergonomics Association (IEA) ergonomics is employed to fulfill the two goals of health and productivity. It is relevant in the design of such things as safe furniture and easy-to-use interfaces to machines.

Ergonomics emerged as a scientific discipline in the 1940s as a consequence of the growing realization that, as technical equipment became increasingly complex, not all of the expected benefits would be delivered if people were unable to understand and use the equipment to its full potential. In 1949, at a meeting of distinguished physiologists and psychologists at the Admiralty, the term ergonomics was coined from the Greek roots (ergon [work] and nomos [shape/measure]).
natural laws]. Later that year this same body of scientists, together with some like-minded colleagues formed the Ergonomics Research Society which became the first such professional body in the world.

According to Occupational Safety and Health Act (2007), ergonomics at workplace is paramount and must be put in considerations when designing buildings, fixtures, machinery, equipments, tools and workstations. In Kenya the Act is circulated in all governmental and non-governmental agencies and department to ensure adherence. The concern is that most of the institutions ignore this Act in their day to day operations and they end up compromising human health safety. Learning institutions in Kenya are keeping pace with the technological advancements; putting more emphasis on the acquisition of hardware and software while ignoring the aspect of ergonomics. This paper is an investigation of computer ergonomic issues and problems that face students when using computers as a tool of learning in selected primary schools, secondary schools and universities in Kirinyaga County.

2. LITERATURE REVIEW

Ergonomic Computer Workstation Considerations for Library Staff

Rodrigues (2010) addresses work place ergonomics for library employees with an aim of promoting and protecting health through ergonomically sound practices. Adeyemi (2010) observed that library staff sit for long hours carrying out their daily routines, and as such every workstation should be designed with both the worker and the task in mind so that work can be performed comfortably, smoothly and efficiently. She emphasized the need for general workstation ergonomic instructions to be taught in library schools and that University Commissions should include ergonomic measures, plans and education as parameters for measuring quality of academic libraries; this would engender competitiveness and compliance with the resultant effect in the promotion of staff health and welfare. The paper addresses ergonomic computer workstation furniture; highlighting issues on: correct work station height, top, leg room, thickness of work surface among other issues. This paper does not address ergonomics in computer laboratories in learning institutions considering that in some, like in primary schools, the size of pupils is small and therefore the measurements given in this paper cannot best suit the small children.

![Figure 1: Source: http://www.opraxmedical.com/Accessories/Digital/Furniture/ (Mayo, 2010)](http://www.opraxmedical.com/Accessories/Digital/Furniture/)

Ergonomic Aspects of Implementing Computer Technology into School

This paper addresses the issue of implementing computer technology into educational settings from an ergonomic point of view. Effective ergonomic implementation of computer technology should address the following five phases in Figure 2.
The paper emphasizes on education of teachers and school leadership in connection with ergonomic implementation of computer technology into educational settings which include: ergonomic aspects of quality computer hardware, elements of ergonomically constructed computer software, work with computer from an ergonomic point of view, information about ergonomically shaped workspace and understanding of ergonomic burdening on children’s school work (Samo and Uros, 2009). The research generally proposed a Model of ergonomic implementation of computer technology into school environment but did not specify how this knowledge will reach a wide range of students. Also the paper does not have a mechanism of ensuring the information disseminated is followed to the latter. This paper will recommend ways of how the knowledge should be disseminated in Kenyan learning institutions.

**Improving Products’ Ergonomic Value Using Intelligent Decision Support System**

The paper presents a knowledge base, containing ergonomic design knowledge specific for hand tools design. A pneumatic hammer handle design was used as a case study to show how ergonomic design knowledge built in the system was used to improve the ergonomic value of the product (Fain, 2010). Product ergonomics applies theory, principles, data and methods to optimize human well-being and overall system performance. The ergonomic quality of a product can be defined by a match between anthropometric data and formal attributes. However, the quality of ergonomics is not only based on anthropometrics, as the field of human factors has been realizing over the past thirty years (Kroemer, 2001) Cognitive and experiential processes play a major role in deciding whether a design is usable, efficient, satisfying, easy to use, or comfortable.

The researcher developed a prototype of an intelligent advisory system Oscar, based on expert design knowledge management. Du et al. (2009) proposed logical frame on ergonomic knowledge management at Computer-Aided Industrial Design and Conceptual Design conference which was used with improvement in aesthetic appearance of the product. The knowledge built in the prototype of the intelligent system named Oscar was structured in the form of different classes interconnected with various attributes and their values at the input side, the output of the system allowed (re)design recommendations leading to achievement of certain design goals that can improve the ergonomic value of the product (hand tool) being developed. The intelligent decision support to the ergonomic design process represented added value to the existing ergonomic CAD tools that enable various ergonomic analyses, but failed to provide engineering advice on how to improve the ergonomic value of a design candidate that is the subject of ergonomic evaluation. The paper emphasizes on intelligent CAD tools for designing ergonomic products which are not affordable in Kenya, since most schools depend on government funding.

**Principles for the wise use of computers by children**

Children tend to use computers more at home than at school (Moseley et al. 2001, Kerawalla and Crook 2002, Kent and Facer 2004). The paper reviewed the current exposure data and the evidence for positive and negative effects of computer use by children. The case for child specific evidence-based guidelines for wise use of computers was
presented based on children using computers differently to adults, being physically, cognitively and socially different to adults, being in a state of change and development and the potential to impact on later adult risk. The paper broadly addresses effects of use of computer by children from home to school and the duration of exposure. The case under study is more relevant to developed countries where children are exposed to computers from a young age to maturity.

In developing countries, interaction with computers is mostly experienced in middle ages when most students join high school and colleges. Many studies in addition to the above, including Sawyer and Penman (2011) on ergonomic and computer use in rural secondary schools students and Castellucci, Goncalves and Arezes (2010) on ergonomic design of school furniture: Challenges for the Portuguese schools; have been conducted but none of them have addressed the issues of computer ergonomics in Kenyan learning institutions.

3. METHODOLOGY

The study targeted five primary schools, ten secondary schools and one university (Kirinyaga University College) in Kirinyaga County. Purposive sampling was used to select the institutions that use computers in teaching and learning. Stratified sampling was used. In primary schools only class eight students were considered, in secondary schools only form four computer students were considered and in the university, computer science and information technology second year undergraduate students were considered. In each stratum, random sampling was adopted. The sample size was picked as follows: 10 respondents from among class eight pupils in every primary school totaling to 50, 20 from among form four students in every secondary school totaling to 200 and a 100 students from Kirinyaga University college. Total sample size was 350. Closed ended questionnaire was constructed and self administered to collect information about computer related ergonomic issues and habits of students. Copies of questionnaire entitled “Questionnaire to Capture Information on Computer Ergonomic Practices” were administered to selected sample sizes. Observation schedule was used to complement the questionnaire. Data was analyzed using IBM SPSS statistics V20 and results presented.

4. DATA ANALYSIS RESULTS AND DISCUSSIONS

From the 350 questionnaires that were distributed, 305 were returned which is 87.14% which is a sufficient percentage for analysis (William et al, 2012). The questionnaire addressed the following objectives: to determine whether learning institutions’ fraternity is aware of computer ergonomic issues, to assess the extent to which ergonomics practices are being followed in our learning institutions and to identify problems that learners face for not adhering to ergonomic practices while using computers; under the following headings:

1.1 MACHINES

1.1.1 Anti-glare screen

The study sought to establish whether monitors of computers being used were fitted with anti-glare screens. 2.4% of the respondents agreed that their computers had anti-glare screens while 87.8% disagreed. 9.8% did not respond. From observation, the study established that all the institutions chosen had no anti-glare screens fitted on the student machines. The 2.4% who agreed could be as a result of not understanding what anti-glare screens are.

1.1.2 Adjustable brightness

The study sought to find out whether the computer screens brightness and contrast could be adjusted. A total of 82.9% of the respondents agreed with the item, while 14.7% differed. 2.4% did not respond. Most of the machines both CRT and TFT monitors have mechanisms for adjusting brightness and contrast and most of the students had been taught and shown how to perform this. The study observed that even with this feature, most of the students had put very bright coloured screen savers on the monitor screen and the screens were too bright combined with the artificial lighting in the computer laboratories.

1.1.3 Noise

The item sought to establish whether computer and accessories produce disturbing noise while functioning. 47.1% of the respondents concurred, while 50.5% were of the contrary opinion. 2.4% did not register their responses. From observation, and also data analysis, most of the responses on this item came from primary schools which get free computer donations from people who dumb e-waste in Kenya in the name of helping digitize education.

1.1.4 Keyboard and mouse design

The respondents were to give their views on whether the keyboard and mouse design allowed appropriate arm postures. Majority of the respondents did not have problems with the keyboard and mouse designs. 50.7% agreed, 44.4 disagreed.
while 4.9 did not respond. The results could be attributed to the fact that all keyboards and mouses are standard and the designs do not take into consideration the various needs of users.

1.1.5 Adjustable computer screen
The study wanted to find out the respondents opinions on whether computer screens were adjustable at a comfortable eye height level. 17.1% of the respondents were in agreement while 73.1% did not agree. 9.8% did not respond. The 17.1% responses could be because of respondents inability to distinguish between tilting with adjusting. These results were backed up by the study observation results that none of the institutions under study had acquired adjustable computer screens.

1.2 FURNITURE
1.2.1 Adjustable chair height to table
The study required the respondent to give views on whether the height of chair was adjustable to match with the height of the table. 2.4% of the respondent were in agreement while 97.6% did not. The few that agreed to this item could be the technicians in the only university college who had chairs adjustable to the height of the table. The majority of the respondents were sitting on wooden chairs which were not even comfortable with studying.

1.2.2 Adjustable chair for feet and back rest.
Using this item, the study looked for views of respondents on whether height of chair was adjustable to allow feet and back rest. 19.5% concurred while 80.5% had different opinion. This is due to the fact that all the primary and secondary schools had very poorly done furniture which were not even suitable for normal sitting. The 19.5% respondents could have come from the only university in Kirinyaga where the study observed that some slightly decent comfortable chairs had been procured specifically for the two computer laboratories though the chairs were not adjustable.

1.3 WORK ENVIRONMENT
1.3.1 Shielded computer screen
On whether computer screens were shielded away from direct sunlight, respondents gave the following responses. 34.1% agreed while 65.9% disagreed. These results indicate that most laboratories in the institutions under study were not initially designed to host computers and therefore the positioning of furniture and computer accessories versus the direction of the sun becomes a challenge. Also, a few of the institutions had gone an extra mile to put translucent glasses and curtains.

1.3.2 Artificial lighting in Laboratories
The item sought to establish if the respondents were comfortable with artificial lighting in computer laboratories. 73.2% agreed while 24.4% disagreed. 2.4% did not respond. Majority of the respondents agreed that they were comfortable with the artificial lighting in the laboratories because most of the institutions under study had installed only one bulb or fluorescent tube per laboratory which is not much light while using computers. Although the lighting was as per majority of responses it was evident that the lighting wasn’t enough as per the expected computer laboratory standards.

1.3.3 Heat generated by computers
The study sought opinions of respondents about heat generated by computers in the laboratories. 34.1% reported being uncomfortable with the heat generated while 65.9% were comfortable. The 34.1% are those institutions that had been given donations by some non-governmental organizations and computer for schools Kenya. These computers are old versions with inferior circuitry systems and components hence emitting a lot of heat. Most of the laboratories were congested, with some housing over 30 machines in small rooms hence poor circulation of air.

1.4 KNOWLEDGE
1.4.1 Frequent Breaks
The study sought to establish whether the respondents were encouraged to take break offs from computer use. 31.1% agreed while 68.9% did not agree. Primary and secondary school lessons take a maximum of 80 minutes. The students automatically break before they are fatigued. In the university, lessons can go up to 5 hours. This is the reason for the 68.9% of the respondents who felt that they are not encouraged to take breaks. Some of them were just not aware that they needed frequent breaks depending on the level and age of the students. Due to the nature of curriculum both at secondary and university level, it is difficult to incorporate breaks after every 30 minutes which translated to a higher number of respondents’ disagreeing.
1.4.2 Health issues awareness
The item sought to establish if the respondents were aware of the health issues associated with poor computer usage. 53.7% of respondents agreed while 46.3% were of the contrary opinion. The results indicated that majority of the respondents were aware that there are health risks associated with use of computers and accessories.

1.4.3 Ergonomic best health practices
The study required the respondents to disclose on presence of health practices guides in the computer laboratories. 19.5% admitted presence while 75.6% were of the contrary opinion. 4.9% did not respond. The results of the study indicate that majority of the institutions had not displayed computer health practices guides and guidelines in the computer laboratories and therefore many of the responses did not know how to conduct themselves while interacting with computers and accessories. The study observations also indicated that majority of the students were not keen on reading and/or adhering to the health practices put in place.

1.5 HEALTH SYMPTOMS
Table 1: Health symptoms associated with continuous use of computers and accessories

<table>
<thead>
<tr>
<th>No.</th>
<th>Symptoms</th>
<th>% Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Backache</td>
<td>79.4%</td>
</tr>
<tr>
<td>2</td>
<td>Shoulder ache</td>
<td>49.3%</td>
</tr>
<tr>
<td>3</td>
<td>Arm pain</td>
<td>46.8%</td>
</tr>
<tr>
<td>4</td>
<td>Neck pain</td>
<td>63.1%</td>
</tr>
<tr>
<td>5</td>
<td>Wrist pain</td>
<td>24.3%</td>
</tr>
<tr>
<td>6</td>
<td>Headache</td>
<td>41.5%</td>
</tr>
<tr>
<td>7</td>
<td>Eye strain</td>
<td>75.4%</td>
</tr>
<tr>
<td>8</td>
<td>Weakness</td>
<td>14.3%</td>
</tr>
<tr>
<td>9</td>
<td>Tension</td>
<td>17.1%</td>
</tr>
</tbody>
</table>

The above results indicate that eye strain and backache are highest health symptoms associated with bad computer ergonomic practices at 75.4% and 79.4% respectively, followed by neck pain at 63.1%. Backache could have been caused by poorly designed chairs and tables. Eye strain could be attributed to the fact that most of computer screens do not have anti glare screens thus direct radiations from computer screens affecting user vision causing headache (41.5%) at the end of the day. Neck pains and shoulder pains were as a result of students straining due to poor anthropometric designs of laboratory furniture.

4. CONCLUSION
The aim of the study was to assess computer ergonomic issues in learning institutions in Kenya: case study of Kirinyaga County. Objectives of the study were to determine whether learning institutions’ fraternity is aware of computer ergonomic issues; to assess the extent to which ergonomics practices are being followed in our learning institutions; to identify problems that learners face for not adhering to ergonomic practices while using computers and to propose best ergonomic practices to be adopted in learning institutions. The study found out that majority of respondents were aware of computer ergonomic issues surrounding usage of computers and associated devices in a computer laboratory but were not keen to adopt better ergonomic practices. The most visible causes of ergonomic problem as indicated by the respondents are poorly designed seats, awkward posture, exposure to computer screens on a regular basis without screen protectors, sitting in the same position for continuous long hours, frequent repetitive motion tasks and lack of break offs. To ensure best ergonomic practices are adhered to in learning institutions, the study proposed a framework of ICT ergonomic implementation in education sector.

5. RECOMMENDATIONS
Ergonomics is the science and practice of designing jobs, tools, equipment and environments to match the capabilities and limitations of the human body. Ergonomics studies emphasize on how to best make the work environment fit the worker.
Ergonomics help prevent injury and increase comfort and productivity. When ergonomic principles are applied in the computer laboratories, visual and musculoskeletal discomfort and fatigue can be significantly reduced. Peter et al., 2014 in the study on benefits of laptop computer ergonomics education to graduate students concluded that still after a sensitization on computer ergonomics and a series of follow ups, some graduate students still made no changes to how they interacted with machines and laptops. This means that ergonomics is not a one day lesson to warrant change. That is why this study took the initiative of choosing study subjects from primary to university to be able to establish the levels and impact of ergonomic education. The study made the following recommendations:

i) The government should fund educational institutions to ensure that besides acquiring computers for teaching and learning, institutions are also in a position to lay ergonomic infrastructure for the acquired computing devices. Most schools in Kenya are public schools and therefore funded by the government and partly by the parents. Kenya being a developing country, the GDP is below the international standards (average earning less than a dollar a day). Meaning that matters of computing in education are given second priority after basic necessities have been catered for.

ii) When institutions are acquiring computing devices, sizes that conform to age and size of user should be considered. For instance, computing devices for primary school pupils should be smaller in size compared to the ones for university students. In addition, furniture acquired should also be designed to match the size of acquired devices.

iii) Ergonomic education should be introduced at early stages of education (primary level) to inculcate a culture of good health practices in future while interacting with computer technology. Studies show that effects of continuous unhealthy use of computers and accessories manifest later in life.

iv) Government should consider researches that inform policies and decisions concerning ICT implementation in education sector. This will enable well informed strategies on how to roll out sustainable ICT programmes in education sector.

v) Management of institutions and stakeholders should be discouraged from receiving donations in form of ICT devices that do not meet ergonomic standards. The study found out that most of the primary and secondary schools under study had acquired computers through donations of which most of them were e-waste from other countries. Most of these computers are of lower versions with ever malfunctioning parts, producing hazardous emissions which are harmful to human health.

vi) Considering the environment at home, students should be encouraged to work with computing devices only while at school. This is because majority of Kenyan households do not have furniture that are computer ergonomically fit.

vii) Education institutions are encouraged to adhere to a computer to student ratio of 1:3; this will ease congestion in most of the schools which has translated to ergonomic problems. The study found out that in majority of schools under study, one computer was being shared by ten students.

viii) The recommends that all learning institutions adopt the framework of ICT ergonomic implementation in education sector in figure 3 below.
Figure 4: Framework of ICT ergonomic implementation in education sector (Researchers, 2014)

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ABSTRACT

Over 56% of Kenyan women deliver at home under traditional birth attendants and herbal remedies due to poor services, health workers’ negative attitude, cost, inaccessible health facilities and cultural preferences. Complications resulting from reproductive health (14.1%) account for second disease burden in Kenya after malaria (19.7%). National maternal mortality rates have remained high at 488 deaths per 100,000 live births, due to giving birth under the care of unskilled health care providers and preventable conditions such as haemorrhage, obstructed labour, unsafe abortion and high blood pressure. Thus medicines and indigenous knowledge used by traditional birth attendants deserve documentation and proper scientific validation under conditions mimicking indigenous methods of use. This study evaluated phytochemistry and ethnomedicinal use of Uvariodendron anisatum (Annonaceae) used ethnomedically to ease labour or if the after-birth is late or retained, calf is rejected, and root infusion for impotent men. It analysed phytochemical compounds and effects of extracts of U. anisatum root on uterus of Wistar rats. Phytochemical screening was done using accepted standard procedures and extracts were prepared by maceration and drying in vacuo using a rotary evaporator for methanol extract and freeze-dryer for aqueous extract. In-vitro pharmacological assay on a piece of isolated rat uterus previously pretreated with stilbestrol and suspended in De jalons solution at 37°C were performed using 5, 20, 40, 80 and 160 mg/ml. Alkaloids, glycosides, tannins, phenols, anthraquinones, steroids, carotenoids, coumarins, flavonoids and volatile oils were present, while saponins were absent. The extracts showed weak rat uterine motility, depending on dosage and displayed similar motility as oxytocin at high dosage (800 mg/ml). The uterotonic effects suggest the reason for use to ease labour or if the after-birth is late or retained. Uterine stimulating agents used frequently to induce or argument labour in selected pregnant women is common in hospitals, as plants used by traditional birth attendants to hasten child birth. Pharmacological assays to determine effective dose, active fractions and isolation of pure compounds warrant safety of U. anisatum Verdec use by traditional birth attendants.

Key words: Oxytocic-like activity, Maceration, Phytochemical screening, Oxytocin

INTRODUCTION

Over 56 % of pregnant women in Kenya deliver at home with the assistance of mainly traditional birth attendants who use herbal remedies to complete the processes of child bearing in both urban and rural communities (Kenya National bureau of statistics, 2011). The expectant mothers choose home deliveries for reasons including poor maternity services, negative attitudes of the health workers, cost, accessibility of the health facilities and cultural preferences (USAID-Kenya, 2014). In Kenya complications resulting from reproductive health related conditions such as maternal mortality and morbidity (14.1%) account for second in number of the disease burden in Kenya following malaria (19.7%). The national maternal mortality rates have unacceptably remained high with 488 deaths per 100,000 live births, largely because women do not give birth under the care of skilled health care providers and they die due to preventable conditions including, haemorrhage, obstructed labour, complications of unsafe abortion and high blood pressure (Health policy project, 2014).

In the efforts to meet the Millenium Development Goal number five of reducing maternal mortalities by 75% by the year 2015 and Kenya Vision 2030 (The Millenium Development Goals, 2013), the traditional medicines and indigenous knowledge used by traditional birth attendants deserve to be documented and the claims properly validated through scientific scrutiny under conditions mimicking the indigenous methods of use (GOK, 2014). This work evaluated the phytochemistry and ethnomedicinal use of Uvariodendron anisatum (Annonaceae) shrub which is used ethnomedically in the management of a variety of conditions including root decoction to ease labor or if the after birth is late or retained. The objective of this study is to investigate the phytochemical group of compounds and effects of Uvariodendron anisatum aqueous root extract on the uterus of Wistar rats with an aim of scientific validation of the ethnomedicinal use of this particular plant in the management of child bearing process. Uvariodendron anisatum belong to the genus Uvariodendron which is among the seventeen well known genera of...

The species *Uvariodendron anisatum* is used ethnomedically in Kenya in management of a variety of conditions including root decoction to easy labour or if the after birth is late and also root infusion for impotence in men (Gachathi, 2007). The Embu and Mbeere people of Kenya also use the root tuber concoction for the management of breast cancer, diabetes, snake-bite and calf-rejection in traditional veterinary medicine (Kareu 2007). The wood is used for walking sticks and axe handles (Beentje, 1994).

**MATERIAL AND METHODS**

The plant parts (roots, leaves and fruits of *Uvariodendron anisatum*) were collected from Kiangombe forest (Mbeere district) and a voucher specimen of the plant was authenticated at the Herbarium section of the National Museums of Kenya in Nairobi where a voucher specimen was deposited and its duplicate was deposited in the Herbarium at the department of Pharmacognosy, School of Pharmacy of Mount Kenya University with voucher specimen number “UAO-2014”. The roots of *U. anisatum* were air-dried, ground and 100 g were extracted by maceration for 48 hours using distilled water in a 2000 ml conical flask. The extract was filtered and then freeze-dried to afford the dry powders that was weighed and stored in a freezer at -20 °C until further use.

**Preliminary phytochemical screening**

The powders of roots and leaves were tested for the presence of bioactive compounds using standard methods as illustrated in table 2 (Harbone, 1976; Houghton, 1998; Trease and Evans, 2008).

**Table 2: Phytochemical tests of various parts of *Uvariodendron anisatum***.

<table>
<thead>
<tr>
<th>Phytochemicals</th>
<th>Test</th>
<th>Procedure</th>
<th>Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gums and Mucilages</td>
<td>Gums and Mucilages Test</td>
<td>0.5ml of extract + 5 ml distilled water + 25 ml of absolute alcohol were prepared</td>
<td>Cloudy or white ppt</td>
</tr>
<tr>
<td>Alkaloids</td>
<td>Mayer’s test</td>
<td>To a 1 ml filtrate, few drops of Mayer’s reagent were added</td>
<td>White ppt</td>
</tr>
<tr>
<td>Dragendorff’s test</td>
<td>To a 2 ml of filtrate, 2 ml of dragendorff reagent were added</td>
<td>White ppt</td>
<td></td>
</tr>
<tr>
<td>Glycosides</td>
<td>Kedde test – Unsaturated lactone rind</td>
<td>To 0.5 ml of extract + 2 drops of Kedde reagent were added</td>
<td>Purple ppt</td>
</tr>
<tr>
<td>Borntrager’s test - test for anthraquinone glycoside</td>
<td>About 5 g (Powder) + in 5ml of H₂SO₄ was boiled for 5 min. Filtered and cooled and then to the extract equal vol. of carbon tetrachloride was added and shaken. The organic layer was separated and shaken with a few drops of dilute ammonia.</td>
<td>A rose pink to red colour in the ammoniacal layer</td>
<td></td>
</tr>
<tr>
<td>Modified Borntrager’s test- anthraquinone glycoside</td>
<td>Extraction as above except 5 % FeCl₃, were added during extraction with dilute ammonia.</td>
<td>As a bove</td>
<td></td>
</tr>
<tr>
<td>Froth test - Saponins</td>
<td>A bout 0.5 g (powdered) + 5 ml water. The mixture was shaken and left to stand.</td>
<td>Persistent frothing</td>
<td></td>
</tr>
<tr>
<td>Tannins/ Phenols</td>
<td>Ferric chloride test</td>
<td>About 1 g (powder) was boiled in 10 ml of water for 5 min in a water bath, extract was filtered to 2 portions and cooled. To one portion 3 drops of ferric chloride solution were added and to the other portion 1 ml of lead subacetate was added.</td>
<td>brown-green ppt with FeCl₃ and a creamy-brown ppt with lead subacetate</td>
</tr>
<tr>
<td>Phytosteroids</td>
<td>Salkowski test</td>
<td>0.5 ml of extract + 1 ml of Conc. H₂SO₄</td>
<td>Wine red colour</td>
</tr>
<tr>
<td>Triterpenes</td>
<td>Liberman- Burchard’s test</td>
<td>0.5 ml of extract, few drops of acetic anhydride + 1 ml of Conc. H₂SO₄</td>
<td>Red ring at the junction</td>
</tr>
<tr>
<td>Coumarins</td>
<td>Ferric chloride test</td>
<td>About 1 g (Powder) + in 10 ml of ethanol was boiled for 5 min in a waterbath, extract was filtered and then cooled. To 2 ml of extracts a few drops of alcoholic Ferric chloride sol added</td>
<td>Deep green ppt turns yellow on + conc. nitric acid</td>
</tr>
<tr>
<td>Volatile oils</td>
<td>Smell test</td>
<td>5 mg of drug powder crushed between thumb and forefinger</td>
<td>Strong odour</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>Test with Ammonia vapour</td>
<td>A bout 1 g (powdered) was boiled in 10 ml 70% ethanol for 5 min, extract was filtered and cooled. A filter paper was dipped in alcoholic solution and then exposed to ammonia vapour.</td>
<td>Yellow spot on the filter paper</td>
</tr>
</tbody>
</table>
Preparing and Mounting of the rat uterus for uterotonic activity

A young non-pregnant virgin wistar rat weighing between 220 grams was pretreated with 0.2 mg/kg of stiboestrol 24 hours prior to the actual experiment. The rat was sacrificed humanely by spinal dislocation. The abdomen was opened and then the uterus was carefully dissected in a petri dish containing De jalons ringer solution. The horns of the uterus were carefully separated from the animal just below the ovaries and were cleaned and any extraneous fat and connective tissues were removed. The horns were then separated at the bifurcation and yielded two uterus preparations (Maud Kamatenesi et al., 2005). About 3 cm piece of the uterus was mounted in an organ bath containing De-jalons physiological salt solution composed of NaCl (9 g/l), NaHCO3 (0.5 g/l), D. Glucose (0.5 g/l), KCL (0.402 g/l), CaCl2 x 2H2O (0.08 g/l) (Catherine et al., 2012).

The tissue was aerated with 95% oxygen and 5% carbon dioxide and the temperature was maintained at 37°C and the solution PH of 7.4 for a period for 30 to 40 minutes to normalize before adding the plant crude extracts and the standard drug (oxytocin 0.1 IU) so that spontaneous activity could be deduced (Maud Kamatenesi et al., 2005; Falodun et al., 2006).

Preparation of aqueous extract

The stock solution of the extract was prepared by making 100 mg/ml and 1000 mg/ml. The syringe was used to administer 0.5 ml of the 100 mg/ml and 0.2 ml, 0.4 ml and 0.8 ml of the 1000 mg/ml into the organ bath with the tissue. These administrations represented concentrations of 50 mg/ml, 200 mg/ml, 400 mg/ml, and 800 mg/ml respectively. The microdynamometer recording machine was connected to the transducer machine and the writing lever that was put in place to translate the tissue contractions on the microdynamometer recording graph paper was used to produce printed graphs as shown in graph 1. The tissue was always washed with De Jalons ringer solution after every injected drug concentration or standard of drugs and recording was done before another drug or dose was introduced. The time of tissue washing varied based on the behavior of the drug on the tissue. The washed tissue in the organ bath was left to normalize before addition of another drug and each dose was administered three times.

RESULTS AND DISCUSSION

Phytochemical composition of Uvariodendron anisatum

The aqueous extraction of U. anisatum roots yielded 5.6%, implying that organic solvent extracts for the secondary metabolites may be explored for better yields, though it is well known that in traditional healing the water extract is the primary source of the U. anisatum for medicinal use. Table 2 shows the phytochemicals identified in the plant’s roots and leaves extracts as alkaloids, glycosides, tannins, phenols, anthraquinones, Phytosteroids, carotenoids, coumarins, flavonoids, saponis and volatile oils. The tannins and flavonoids have been reported to affect calcium availability for the contraction of uterine smooth muscle and cardiac muscle and also cardiac glycosides have been shown to affect the uterus of various animal species (Catherine et al., 2012; Omodamiro et al., 2012).

Table 2. A table showing the phytochemicals screening results of the root and leave powders

<table>
<thead>
<tr>
<th>Phytochemicals</th>
<th>Part of the plant</th>
<th>Root</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Leaves</td>
<td>Root</td>
</tr>
<tr>
<td>Alkaloids</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Glycosides</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Saponins</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Tannins</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Phenols</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Anthraquinones</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Steroids</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Carotenoids</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Coumarins</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Volatile oils</td>
<td>++</td>
<td>++</td>
</tr>
</tbody>
</table>

+ - Present in relatively small amounts, ++ - Present in relatively moderate amounts, +++ - Present in relatively high amounts

4.3 Uterotonic activity of Uvariodendron anisatum root extract on the rat uterus

The aqueous extracts of of U. anisatum roots dissolved completely in the De jalons solution. Uvariodendron anisatum
at 200 mg/ml, 400 mg/ml and 800 mg/ml showed rat uterine contraction activity (Graph 1). The rat uterus tissue was used in the ethnopharmacological screening because *U. anisatum* herbal remedies are used in stimulating child birth traditionally. The smooth muscle of the rat uterus was the point of contact for this herbal drugs experimentation because of its high sensitivity among other laboratory animals. The aqueous extracts of *U. anisatum* contracted and increased the uterine motility. In the interpretation of the results, normal motility is the baseline for that particular tissue. Standard drugs (Oxytocin) was used as the controls of the set up.

![Graph 1. The effects of *Uvariodendron anisatum* on the Rat uterine contractions](image)

From graph 1, injection of 50 mg/ml and 100 ml of aqueous plant extracts to the organ bath showed no uterotonic activity. The 200 mg/ml of the plant extracts produced contractions to the rat uterus. The 400 mg/ml of the plant extract showed uterotonic activity which was twice powerful as that produced by 200 mg/mL of the plant extract. Injection of 800 mg/ml of the aqueous plant extracts produced uterotonic activity almost equivalent to that produced by Oxytocin (Standard drug). Though the contraction of the extract were not as intense as those of the standard they indicate dose dependent activity and exhibit comparable results with the extracts of a plant of similar family, *Xylopia aethiopica* (annonaceae).

**CONCLUSION AND RECOMMENDATION**
The preliminary phytochemical screening results of this study indicates this plant (*Uvariodendron anisatum*) contain more than one group of secondary metabolites and this may suggestively be the reason for its elaborate usage in ethnomedicine. The observation of the uterotonic activity of the root aqueous extract on the isolated rat uterus justify the traditional use of the plant by traditional birth attendants for removing the afterbirth if it get retained when assisting women who are giving birth. It is recommended that further work be explored to isolate compounds responsible for the uterotonic activity that may be leads for the development of more save drugs to be used during delivery. These findings also warrant studies on mechanisms of action and toxicity of the plant extracts, fractions and isolated compounds.

**REFERENCES**


NUTRIENT AND ANTI-NUTRIENT CONTENT OF SELECTED WILD FOOD PLANTS FROM ITHANGA DIVISION, KENYA

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ABSTRACT

Wild food plants play an important role in the diet of inhabitants of Ithanga Division as famine foods during lean seasons. The area is ASAL, receives unreliable rainfall and frequent drought followed by food insecurity, malnutrition, especially in children less than 5-years-old. Locals use wild food plants to meet nutritional requirements. However, there is lack of data on nutrients in these plants. This study determined nutritional potential of selected wild food plants to enhance utilization and management of moderate malnutrition and food insecurity. Ten samples were collected through random sampling, washed, dried in oven at 60°C, ground into powder and analyzed for proximate composition, nutrient, mineral and tannin contents. Proximate composition varied with moisture content, ranging from 48.33-90.77%, with Cyperus rotundus having lower value of 48.33±0.54 and Oxygonium sinuatum highest value of 90.77% ± 0.54. The crude fibre content on dry weight basis was moderately low, ranging from 6.29-20.73 mg/100 g. The crude protein ranged from 1.68-11.6 mg/100 g, with highest in O. sinuatum and lowest in Lantana camara. Vitamin C and betacarotene were higher in Cumis dipsaceus (50.24±5.13) and Amaranthus dubius (5.24±1.89), while lower in Commelina africana (7.60±0.84) and Lantana camara (0.02±0.01) mg/100g, respectively. Zn content on dwb in Oxygonium sinuatum was 28.15mg/100g) and comparable with or higher than cultivated counterparts. Tannin content ranged from 3169-678mg/100g and was higher in Grewia bicolor and lower in C. dipsaceus, respectively. Thus, the wild food plants are good sources of nutrients and can be utilized to mitigate micro and macronutrient malnutrition to improve food security.

Key words: Nutrient content, Ithanga Division, Malnutrition

INTRODUCTION

Wild food edible plant refers to plant species that are neither cultivated nor domesticated but are available in their natural habitat and used as source of food (Beluhan and Ranogajec, 2010). Ethno-botanical studies have shown that, many wild food plant species are consumed alongside other food sources in developing countries (Getachew et al., 2013). According to Food Agriculture and Organization (FAO, 1999), at least one billion people around the world are

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thought to use wild food in the diet. They are an important source of vegetables, fruits, tubers, seed and nuts in balancing nutritional diet and curbing food insecurity throughout the world especially in developing countries (Heywood, 2011). In Africa, indigenous wild food plant have played crucial role in tradition diet of African people (Flueret, 1979). Numerous publications provides vast knowledge on wild plants species in various parts of Africa showing they are essential components of many African diet during the drought period (Campbell, 1986; Zemed, 1997; Agea, 2010). In South Africa, Fox and Young (1982) recorded more than one thousand wild indigenous food plant consumed by the locals.

Kenya has a diverse agro ecological zones that contribute to a wide diversity of neglected and underutilized wild food plant species. (Maundu, 1993). Maundu (1996) reported that, about 800 of Kenya total flora of 7000 species of vascular plant are used as food in the wild and out of these 50 % as fruits, 25 % as vegetables, 12.5% as tubers or roots 3-6 % as edible gums or resins with the rest in other kinds of food. About 200 species of plant species that grow naturally in Kenya are used as leafy vegetables. Some of the communities in Kenya that have a record of indigenous leafy vegetables species are the; Giriama (78 species), (Kamba 25 species), (Kikuyu 9 species), (Maasai 13 species), (Turkana 17 species) .These wild food plants play a major part in supplementing other foods especially in the rural communities. Wild foods plants have potential to provide sustainable and easily affordable solutions for micronutrient malnutrition and food security in Kenya. However they are limited research on nutritional value of these plants except for the indigenous ethnobotanical information of these plants (Bussman, 2006; Njoroge et al., (2006). These food plants play a significant role as famine food in food and nutritional security of the rural poor folk. They are gathered mostly for home consumption and others for sales. This study determined the nutritional value of some selected wild food plant species to enhance their utilization and encourage domestication.

MATERIAL AND METHODS
Sample collection and preparation: Ten wild plant species (i.e. Grewia tembensis, Ciumis dipsaceus, Commelina africana, Amaranthus dubius, Grewia bicolor, Lantana camara, Amaranthus hybridus, Cyperus rotundus, Commelina diffusa and Oxygonium sinuatum) were collected randomly from Ngelilia, Thungururu, Kwa Mukundi and Mavoloni locations in Ithanga Division. They were then put in cooler box and transported to the laboratory for analysis. The leaves, fruit and tuber were then prepared by washing and dried in oven at 60°C to moisture content below 12 percent. The dried materials were grounded separately using a mixer, sieved into powder and stored in airtight polythene bags.

Proximate analysis
Moisture content: Moisture, crude protein, fibre and ash were determined according to AOAC method 925.10-32, 20.87-37, 920-86.32 and 923.03-32, respectively (AOAC, 1995).

Determination of β-carotene: β-carotene was determined by method described by Imungi and Protter, (1983) Approximately 2 g of fresh material was weighed. It was placed in a mortar with about 10ml of acetone and ground thoroughly. The acetone extract was then transferred to a 100 ml volumetric flask and the residue extracted again with 10 ml acetone and transferred to the volumetric flask. The extraction with acetone was repeated until the residue no longer gives color to acetone. The combined extract was made to 100 ml. 25 millimeters of the extract was evaporated on a rotary vacuum evaporator (Bibby Sterlin Ltd, RE, 100B, UK) and the residue dissolved in about 1 ml petroleum ether and the solution introduced into a chromatographic column then eluted with petroleum ether. β-carotene eluted through as yellow pigment and collected to 25 ml volume in volumetric flask with petroleum ether. Five solutions of standards with concentration between 0.5 µg/ml and 2.5 µg/ml were prepared from a stock solution containing 2.5 µg/ml pure β carotene. The absorbance value of the solution was determined at 440 nm using UV-Vis spectrophotometer (UV mini 1240 model, Shimadzu Corp., Kyoto Japan) and plotted against corresponding concentration of the standard curve. The β-carotene content of the sample materials was calculated per 100 g of the material.

Determination of Ascorbic acid: About 10 g of sample was homogenized with 20 ml of 0.8 % metaphosphoric acid for 30 minutes and centrifuged at 10,000 r.p.m for 10 minutes using refrigerated centrifuge (model H-2000C Shimadzu, Corp., Kyoto, Japan).The supernatant was filtered using filter paper No. 42, microfiltered with µm 0.45 syringe filter and 20 µl injected into the HPLC (model 10A Shimadzu, Corp., Kyoto, Japan) fitted with PDA Waters 2996 detector. The column used was Supelco C 18 ODS of 150 ×4.6 mm with 5 µm particle size with mobile phase metaphosphoric acid at a flow rate of 0.5 ml/min. Detection was done by Waters PDA 2996 at 266nm.
**Determination of Zinc content:** 5g of samples were weighed in crucibles and transferred to hot plates in the fume hood chamber where they were charred to clear all the smoke from the carbonation materials before transferring them to the muffle furnace. The charred materials were incinerated at 550ºC until they were reduced to white ash. The ash was cooled; 20 ml of 1 N HCl was added to each of them in the crucibles before transferring them to 100 ml volumetric flasks and topped up with distilled water (AOAC, 1995). Atomic Absorption Spectrophotometer (Model A.6200, Shimadzu, Corp., Kyoto, Japan) was used for analysis of zinc which was subjected to flame emission.

**Tannins:** Samples of about 5 g each were put in a volumetric flask and 50 ml distilled water was added, shaken for 30 minutes and filtered. Exactly 2 ml of the filtrate was measured into 50 ml volumetric; similarly, 2 ml of standard tannic acid solution and 2 ml of distilled water were measured with separate flasks to serve as standard and blank respectively. 2 ml of Follins-Dennis reagent was added to each of the flask followed by 2.5 ml saturated sodium carbonate solution. The content of each flask was made up to 50 ml with distilled water and incubated for 90 minutes at room temperature. The absorbance of the developed colour was measured at 760 nm wavelength using Spectrophotometer (UV Mini, 1240 Model. Shimadzu, Corp., Kyoto, Japan). (Kirk and Sawyer, 1998)

**Statistical Analysis:** Analysis of the samples was done in triplicate. Data was analysed using one-way analysis of variance (ANOVA) with different plants species as a source of variance. Data was assessed using and Duncan’s Multiple Range Tests used to separate means. Significance was determined at \( P<0.05 \).

**RESULTS AND DISCUSSION**

**Proximate Analysis**

Ten different wild food plants (i.e. six leaves, three fruits and one tuber) were collected in Ithanga division and proximate analysis done. The moisture content ranged from 48.33 % in *Cyperus rotundus* to 90.77% in *Oxygonium sinuatum* (Table 1). Wild leaves of *Cucumis dipsaceus, Commelina africana, Amaranthus hybridus, Amaranthus dubius, Commelina diffusa* and *Oxygonium sinuatum* had the highest moisture content while *Grevia tembensis, Grewia bicolor, Lantana camara* and *Cyperus rotundus* had the lowest moisture content. Similar results have been reported in South Africa (Afolayan and Jimoh, 2009), where wild leafy vegetables moisture content in range of 57-89 %. The moisture content of fruits and vegetables are in the range of 60-68% (FAO, 1982) and most of the plants studied were within this range (Table 1).

The fruits of *Grevia bicolor, Lantana camara* and six wild leaves were analysed for crude protein as (table1). There was significance difference \( P<0.05 \) in crude protein among the food plants ranging between 1.68-11.60 % dmb with *Oxygonium sinuatum* having the highest value and *Lantana camara* the lowest value. The values of the plants were higher than (3.3%) recorded by USDA Nutrient Database for Standard Reference (Hall,1998).These values were comparable with similar studies done for wild plants (3.08-13.78%) as reported by Shad et al., (2013). Comparing the wild and cultivated counterparts (i.e. kales 3.3%, cabbage 1.7% and spinach 2.8%) as reported by (Maina and Mwangi, 2008), most of the selected plants investigated were superior in protein than domesticated ones thus suggesting that they are cheap source of proteins for the locals.

The crude fibre content was high in *Lantana camara* (20.73% dmb) followed by *Grevia bicolor* (19.66 % dmb) and *Amaranthus dubius* (6.29 % dmb) had the lowest fibre content (table 1). Six plant species which included two fruits and four leaves were analysed. There was no significance difference \( P>0.05 \) among the plants which ranged between 6.29-20.73 % dmb. The Fruits had high crude fibre content than the leaves. These finding are similar to studies done by Vishwakarma and Veenapani (2011) where they reported crude fibre content of wild edible plants in the range of 1.21-21.78% dmb.

The ash content ranged from 1.03-21.20 % dmb with fruits having the lowest ash content and wild leaves had the highest ash content (table 1). There was significance difference \( P<0.05 \) in ash content among the wild food plants studied. The ash content for wild leaves studied was higher than cultivated *C. nitidissima* leaves (10.7% dmb) as reported by (Zhongchen et al., 2010). High ash content is associated with the amount of mineral in wild food samples (Nielson, 2003) and this suggest that, leaves contained high levels of minerals than the fruits according to the study. Wild leaves have been shown to have relatively higher mineral content compared to exotic or cultivated vegetables. (Zhongchen et al., 2010)
Table 1: Proximate analysis results of selected wild food plants

<table>
<thead>
<tr>
<th>Botanical name</th>
<th>English/common name</th>
<th>Local name ('kamba')</th>
<th>Edible part used</th>
<th>Moisture %</th>
<th>*Crude protein %</th>
<th>*Crude fibre %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grevia tembensis</td>
<td>“Nduva” Fruit</td>
<td>62.29 ±0.29c</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Cucumis dipsaceus</td>
<td>Hedgehog Cucumber</td>
<td>81.24 ±0.11t</td>
<td>4.08 ±0.05a</td>
<td>7.41±0.75a</td>
<td>15.88±0.69b</td>
<td></td>
</tr>
<tr>
<td>Commelina africana</td>
<td>Yellow commelina</td>
<td>83.24 ±1.79p</td>
<td>3.66 ±0.15s</td>
<td>11.62±1.13s</td>
<td>16.44±0.58b</td>
<td></td>
</tr>
<tr>
<td>Amaranthus dubius</td>
<td>Spleen amaranthus</td>
<td>80.20 ±1.39p</td>
<td>9.82 ±1.39a</td>
<td>7.63±1.03s</td>
<td>17.37±0.48bc</td>
<td></td>
</tr>
<tr>
<td>Grevia bicolor</td>
<td>White leaved raisin</td>
<td>48.74 ±0.52a</td>
<td>8.17 ±1.07a</td>
<td>19.66±4.73a</td>
<td>1.03±0.04a</td>
<td></td>
</tr>
<tr>
<td>Lantana camara</td>
<td>Tick berry</td>
<td>51.72 ±0.23a</td>
<td>1.68 ±0.31l</td>
<td>20.73±6.35b</td>
<td>0.84±0.04a</td>
<td></td>
</tr>
<tr>
<td>Amaranthus dubius</td>
<td>Red amaranth</td>
<td>71.21 ±1.63hc</td>
<td>11.32±0.7a</td>
<td>6.29±0.77a</td>
<td>21.20±0.94d</td>
<td></td>
</tr>
<tr>
<td>Cyperus rotundus</td>
<td>Water grass</td>
<td>48.33 ±0.54a</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td></td>
</tr>
<tr>
<td>Commelina diffusa</td>
<td>Spreading dayflower</td>
<td>88.21 ±0.35e</td>
<td>6.88 ±0.09b</td>
<td>ND</td>
<td>18.66±0.60b</td>
<td></td>
</tr>
<tr>
<td>Oxygonium sinuatum</td>
<td>Double thorn</td>
<td>90.77 ±0.26c</td>
<td>11.60±1.15ac</td>
<td>ND</td>
<td>18.77±0.07bc</td>
<td></td>
</tr>
</tbody>
</table>

*Values are expressed as dry matter basis (dmb) except moisture content
Values are expressed as mean, ± standard deviation of triplicate results
Values in the same column with different superscripts letters are significantly different (P<0.05)
ND=Not determined

The levels of ascorbic acid for the six wild leaves (i.e. Cucumis dipsaceus, Commelina africana, Amaranthus dubius, Amaranthus hybridus, Commelina diffusa and Oxygonium sinuatum) (Table 2). There was significant difference (P>0.05) in vitamin C content among the wild leaves ranging from 7.60 mg/100g to 50.39 mg/100g highest in Cucumis dipsaceus and lowest in Commelina diffusa (Table 2).

Table 2: Ascorbic acid and β-carotene content of selected wild food plants on fresh weight basis (mg/100g)

<table>
<thead>
<tr>
<th>Botanical name</th>
<th>English/common name</th>
<th>Local name ‘Kamba’</th>
<th>Edible Part used</th>
<th>Vitamin C mg/100g</th>
<th>β-carotene µg/100g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grevia tembensis</td>
<td>“Nduva” Fruit</td>
<td>Fresh Fruit</td>
<td>ND</td>
<td>50.39 ± 5.13c</td>
<td>5110 ± 0.08b</td>
</tr>
<tr>
<td>Cucumis dipsaceus</td>
<td>Hedgehog Cucumber</td>
<td>Fresh leaves</td>
<td>37.15 ± 0.11c</td>
<td>4830 ± 0.38d</td>
<td></td>
</tr>
<tr>
<td>Commelina Africana</td>
<td>Yellow commelina</td>
<td>Fresh Leaves</td>
<td>11.87 ± 0.28a</td>
<td>3690 ± 0.56bc</td>
<td></td>
</tr>
<tr>
<td>Amaranthus dubius</td>
<td>Spleen amaranth</td>
<td>Fresh Leaves</td>
<td>11.16 ± 0.77a</td>
<td>5240± 1.89b</td>
<td></td>
</tr>
<tr>
<td>Lantana camara</td>
<td>Tick berry</td>
<td>Fresh Fruit</td>
<td>20 ± 0.01c</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amaranthus hybridus</td>
<td>Red amaranth</td>
<td>Fresh Leaves</td>
<td>7.60 ± 0.48a</td>
<td>3370 ± 0.10b</td>
<td></td>
</tr>
<tr>
<td>Commelina diffusa</td>
<td>Spreading dayflower</td>
<td>Fresh Leaves</td>
<td>18.79 ± 1.07b</td>
<td>3870 ± 0.29c</td>
<td></td>
</tr>
</tbody>
</table>

Values are expressed as mean, ± standard deviation of triplicate results
Values in the same column with different superscripts letters are significantly different (P<0.05)
ND=Not determined

These values of vitamin C content observed compares with those reported by Shad et al, 2013 who noted levels ranged between 1.6-52.8 mg/100g on fresh weight basis. The Recommended Daily Allowance (RDA ) of vitamin C for children below five years is between 15-25 mg/ day (Food and Nutrition Board, 2000) and wild leaves studied (Table 2) ranged between 18.73-50.39 mg/100g exceeding RDA required. This implies that consumption of these plants will meet the amount of vitamin C required by the children. Vitamin C is a highly effective antioxidant has been documented that it slows the aging process, reduce the risk of certain types of cancer, improve lung function, and reduce complications associated with diabetes (Sebastian et al., 2003).

Table 2 suggests that the investigated plants had reasonable source of β-carotene which ranged from 20 µg/100g to 5240 µg/100g and plants investigated included two wild fruits and six wild leaves. There was significance difference (P<0.05) in β-carotene among the wild food plants lowest in Lantana camara and highest in Amaranthus hybridus. These values were higher than cultivated cabbage (385 µg/100g) and spinach (3535 µg/100g) (Maina and Mwangi, 2008). The values observed were comparable with amaranth, African night shade and eggplant with value ranging between 40-7540 µg/100g as reported by (Weinberger and Musya, 2004). Higher β- carotene in green leaves could be attributed to close association of chlorophyll to beta carotene suggesting that, leaves were richer in beta carotene than the fruits.
Table 3 shows the results for zinc content in two fruits and six leaves of the edible plants parts on dry matter basis. The zinc content varied significantly (p<0.05) among the wild food plants with values ranging from 0.38 mg/100g to 28.15 mg/100g dmb. The highest source of zinc were found in leaves of *Oxygonium sinuatum* followed by *Amaranthus dubius* and least in *Grewia bicolor* (Table 3) and these show the plants investigated were rich source of zinc. The leaves had higher levels of zinc than the fruits. The value of zinc reported in the study was comparable with or higher than the commonly cultivated cabbage and kales in Kenya (Oyunga et al., 2010).

**Table 3: Zinc content of selected wild food plants**

<table>
<thead>
<tr>
<th>Botanical name</th>
<th>English/common name</th>
<th>Local name ‘Kamba’</th>
<th>Edible part used</th>
<th>Zn mg/100g(dmb)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cucumis dipsaceus</em></td>
<td>Hedgehog Cucumber</td>
<td>Kikungi</td>
<td>Leaves</td>
<td>4.17 ± 0.27b</td>
</tr>
<tr>
<td><em>Commelina africana</em></td>
<td>Yellow commelina</td>
<td>Kikowe</td>
<td>Leaves</td>
<td>2.21 ± 0.30a</td>
</tr>
<tr>
<td><em>Amaranthus dubius</em></td>
<td>Spleen amaranth</td>
<td>Telele green</td>
<td>Leaves</td>
<td>11.06 ± 1.32c</td>
</tr>
<tr>
<td><em>Grevia bicolor</em></td>
<td>White leaved raising</td>
<td>Ngalawa</td>
<td>Fruit</td>
<td>0.38 ± 0.12a</td>
</tr>
<tr>
<td><em>Lantana camara</em></td>
<td>Tick berry</td>
<td>Mukite</td>
<td>Fruit</td>
<td>1.12 ± 0.32a</td>
</tr>
<tr>
<td><em>Amaranthus dubius</em></td>
<td>Red berry</td>
<td>Telele Red</td>
<td>Leaves</td>
<td>17.66 ±2.42d</td>
</tr>
<tr>
<td><em>Commelina diffusa</em></td>
<td>Spreading dayflower</td>
<td>Gitula</td>
<td>Leaves</td>
<td>8.56 ±1.74c</td>
</tr>
<tr>
<td><em>Oxygonium sinuatum</em></td>
<td>Double thorn</td>
<td>Song’e</td>
<td>Leaves</td>
<td>28.15 ±4.71e</td>
</tr>
</tbody>
</table>

Values are expressed as mean, ± standard deviation of triplicate results

Dmb- dry matter basis

Values in the same column with different superscripts letters are significantly different (P<0.05)

The tannin content ranged from 677.81 to 3169.40 mg/100g dmb highest in *Grevia bicolor* and lowest in *Cucumis dipsaceus* (Table 4). There was significance difference (P<0.05) among the wild food plants studied. The values were lower or comparable wild and semi wild food plants than reported by (Getachew et al., 2013).

**Table 4: Tannin content of selected wild food plants**

<table>
<thead>
<tr>
<th>Botanical name</th>
<th>Common name</th>
<th>Local name ‘Kamba’</th>
<th>Edible Parts used</th>
<th>Tannin mg/100g</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cucumis dipsaceus</em></td>
<td>Hedgehog Cucumber</td>
<td>Kikungi</td>
<td>Leaves</td>
<td>677.81± 42.23a</td>
</tr>
<tr>
<td><em>Commelina Africana</em></td>
<td>Yellow commelina</td>
<td>Kikowe</td>
<td>leaves</td>
<td>698.80 ± 28.42a</td>
</tr>
<tr>
<td><em>Grevia bicolor</em></td>
<td>White leaved raising</td>
<td>Ngalawa</td>
<td>Fruit</td>
<td>3169.40 ± 83.65a</td>
</tr>
<tr>
<td><em>Lantana camara</em></td>
<td>Tick berry</td>
<td>Mukite</td>
<td>Fruit</td>
<td>788.52 ± 33.81a</td>
</tr>
<tr>
<td><em>Amaranthus hybridus</em></td>
<td>Red amaranth</td>
<td>Telele Red</td>
<td>Leaves</td>
<td>2466.46±40.68b</td>
</tr>
<tr>
<td><em>Commelina diffusa</em></td>
<td>Spreading dayflower</td>
<td>Gitula</td>
<td>Leaves</td>
<td>995.65 ± 25.90b</td>
</tr>
<tr>
<td><em>Oxygonium sinuatum</em></td>
<td>Double thorn</td>
<td>Song’e</td>
<td>Leaves</td>
<td>2390.73±502.3b</td>
</tr>
</tbody>
</table>

Dmb-dry matter basis

Values are expressed as mean, ± standard deviation of triplicate results

Values in the same column with different superscripts letters are significantly different (P<0.05)

**CONCLUSION**

The under-utilized wild food plants are good source of nutrients such as β- carotene, vitamin C proteins and zinc which are comparable or higher than the cultivated counter parts and they are available during different months/seasons of the year. These food plants can act as a cheap source of nutrients for the locals and consumption could help to combat malnutrition. Additionally wild foods studied contain tannin content comparable with other wild food plants species. The results provide useful information on nutritional properties of the wild food plants which can be integrated with indigenous knowledge of the plants by the locals to manage malnutrition. These under utilised plants can be further exploited to mitigate micro and macro nutrient malnutrition improving food security.

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YIELD MAXIMIZATION OF ETHANOL BY METABOLISM OF UNFERMENTED SUBSTRATE IN COCONUT PALM SAP WINE

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ABSTRACT
Palm wine (Mnazi) tapping is a socio-economic activity among the Mijikenda community at the Kenyan coast. It is prepared for economic, religious and cultural purposes. It contains lots of fermentable compounds. However, not all is fermented to generate ethanol as the end product by the natural occurring wild yeast. This study determined the level of fermentable compounds, unfermented substrates and ethanol yields of both natural and controlled fermentation. Fresh palm wine (Mnazi) samples tapped overnight were collected from Chumani, Rabai and Mtwapa in Kilifi County in sterile bottles and placed in a cool box with temperatures below 4°C. The samples were fermented under natural and controlled conditions using A. niger and S. cerevisiae for six days and substrate levels before and after fermentation quantified. The student’s t-test was utilized to compare differences between fermentable substrates, soluble solids, pH and ethanol content in fresh Mnazi and natural and controlled fermented Mnazi. Fresh Mnazi had high percentages of fermented substrates (10.087% sucrose, 2.29% glucose and 0.61% fructose), soluble solids (14.627%) and pH (6.0). Ethanol increased while percentages of unfermented substrates, pH and soluble solids in Mnazi decreased after both natural and controlled fermentation. The levels of fermentable substrates, total soluble solids and pH differed significantly (p<0.05) after both natural and controlled fermentation. Thus controlled fermentation using A. niger and S. cerevisiae generated higher ethanol levels than natural process and can be simultaneously used in industrial ethanol production from Mnazi.

Key words: Palm wine; Fermentation; Fermentable substrates; Ethanol

INTRODUCTION
Palm wine (Mnazi) tapping is a common socio-economic activity among the mijikenda community at the Kenyan coast (Kadere et al., 2009). The wine is prepared for economic, religious and cultural purposes. It contains lot of fermentable compounds such s sugars, proteins, vitamins, phytochemicals and other organic compounds (Kadere et al., 2004; Eze and Ogan, 1988). However, not all the sugars in the palm sap are fermented to generate ethanol s the end product by the natural occurring wild yeast. Unlike wine made from grape, the fermentation of palm wine is not controlled leading to wide variability in the ethanol produced. Further fermentation converts the ethanol to acetic cid, lactic cid and tartaric cid, a transition that makes it to have sour test (Kadere and Kutima, 2012). If the fermentation is allowed to continue further for 24 hours, vinegar is produced and Schizosaccharomyces cerevisiae, Sachioscchromyces probe, Lactobacillus plntunum, Leuconostoc Spp and Leuconostoc mesenteries are responsible for this fermentation (Kadere et al., 2008). Palm wine may also consist of pathogenic bacteria e.g. Serratia, Micrococcus and Klebsiella; and probiotic bacteria e.g. Lactobacillus and Pedioecoccus (Kadere et al., 2008). The theoretical alcohol yields lies in the range of 9-10% with natural fermentation process of the palm wine of bout 5-6% (Kumuthini et al., 1988).

It is therefore clear that most of the sugars in the palms sap are not converted to ethanol, a product which is of great industrial significance. The lower level of ethanol obtained by the traditional method could be associated with the natural process and the microbes involved. The method also account for 1.0-2.0% alcohol loss by injudicious handling (Kadere et al., 2009).

Most of the Mnazi prepared in the Kenyan coast is done by small scale tappers with the intention of making the local brew on a small scale level (Gachanja, et al., 2007), yet large mount of the sugars in the palm wine remain unfermented. Moreover, the wine goes bad few days after tapping thus cannot be prepared locally on large scale. Further, there is no preservation methods in place thus lot of the wine goes into waste.

With the current great demand for ethanol to meet the energy crisis as an alternative source of liquid fuel for automobiles and industrial use, generation of industrial ethanol from fresh tapped palm sap would therefore suitable alternative. Mnazi has been associated with irresponsible behaviors and poor health especially among men and youths in the Kenyan coast (Mwachiro and Gakure 2011; Kadere et al., 2009). Mechanism to ensure unfermented sugars are utilized to generate important products need to be put in place through metabolism of the unfermented substrates by microorganism such as A. niger and S. cerevisiae in controlled fermentation. This will lead to production of palm sap on large scale for commercialization activities such as generation of industrial ethanol. Generating other useful products from this important resource will be a major step in cubing the negative effects of
Mnazi brewers. This wills enhance economic growth and minimize the social and health problems associated with excessive Mnazi drinking. The study therefore was aimed to determine the level of total sugars, solid content of fresh palm sap, determine and quantify the unfermented substrates and quantify the ethanol yields of both natural and controlled fermentation.

**MATERIALS AND METHODS**

**Sample collection and storage**
Fresh tapped palm wine (Mnazi) samples tapped overnight were collected from Chumani, Rabai and Mtwapa (Kilifi County) and placed in a cool box with temperatures below 4°C to prevent natural fermentation by the naturally occurring yeasts and bacteria transported to the laboratory of Pure and Applied Science Department at the Technical University of Mombasa (TUM) where they were also stored below 4°C in a freezer to prevent any fermentation.

**Fermentation of the palm sap**
In natural fermentation samples of fresh palm wine obtained from tappers and were fermented under natural conditions for six days. No chemicals or substances were added into the samples and ethanol content, pH, sucrose and soluble solid content were quantified after fermentation. In controlled fermentation, strains of *S. cerevisiae* and *A. niger* were obtained from microbiology laboratory in Department of Pure and Applied sciences at the Technical University of Mombasa. The organisms were maintained on Potato Dextrose Agar slants at 37°C. The sap was pasteurized by boiling for 15 minutes in a boiling water bath and allowed to cool before inoculated with a 5ml of *S. cerevisiae* and *A. niger*. Fermentation processes were performed in 250 ml flasks where each fermentation media was inoculated with *A. niger* and incubated at 37°C for 3 days. The *S. cerevisiae* was added in the fermenting broth and fermentation continued for 4 days. PH of the medium was adjusted to 5.5 for each experiment using normal HCl or NaOH. Inorganic salts 0.5g/L NH₄Cl, 0.2g/L, MgSO₄ and 0.5g/L KH₂PO₄ were added to serve as the source of nitrogen, Mg²⁺ and Phosphorus respectively. The flasks were made air tight by a paraffin paper to maintain anaerobic conditions and incubation was done for six days.

**Quantification of substrate levels before and after fermentation**
Total content of sucrose, glucose, and fructose in both fresh and fermented samples was determined by use of dinitrosalicylic (DNS) method as described by (Wilson et and Walker, 2000) with slight modifications. 5 ml of both fresh sap and fermented wine was centrifuged for 10 minutes. 3ml of DNS was added to 3ml of sucrose, glucose, and fructose in capped test tubes, the mixture heated at 90°C to develop red brown colour with 1ml of 40% Rochelle salt (potassium sodium tartarate) solution added to stabilize the colour. After cooling at room temperature in a cold water bath, absorbance of the sugars was read from a spectrophotometer (Digital Model) at 340nm (sucrose), 590nm (glucose) and 490nm (fructose) and standard curve used to calculate the unknown concentrations. Ethanol level in both fresh sap and fermented sap was determined by use of spectrophotometric method as described by AOAC, (2000). 3ml of Mnazi test samples and 2ml of 0.1447M K₂Cr₂O₇ in presence of 6ml H₂SO₄ solution were allowed to react in test tube for 30 min. Absorbance was measured at 560nm and standard curve used to calculate the unknown concentrations. The total amount of soluble solids in the palm sap was determined by use of refractometer and the mass of 100ml of each sample measured and the density recorded by use of hydrometer.

**Data analysis**
Statistical software (Digital edition) and Microsoft Excel were used in analysis. T-test with confidence level of 95% was utilized to compare differences between the recorded means of ethanol content. ANOVA was employed to significance differences of sucrose, glucose, fructose and pH to ethanol content and total solid content in fresh palm sap and natural and controlled fermented sap.

**RESULTS**

**Standard Regression Graphs**
The standard solutions prepared were used to obtain regression graphs that were utilized in calculating the unknown concentrations of test solutions with the equation and R² value for each curve obtained using Microsoft Excel.
Analysis of substrates in Fresh palm sap samples

Analysis of ethanol, the highest concentration was 2.8% with the lowest concentration of 2.2% in a sample from Rabai. Sucrose was the main sugar in palm sap with highest percentage composition. Of the six samples, Rabai recorded the highest sucrose content (10.09%) while Mtwapa had the lowest content of sucrose (9.28%). Fresh sap had low levels of glucose compared to sucrose (Table 1). Sample from Mtwapa had glucose content of 2.2% as the highest while 1.9% as lowest in a sample from Chumani. Fructose levels were found to be very low in fresh Mnazi compared to the other sugars with the highest recorded from Mtwapa (1.2%), while the lowest (0.61%) from Rabai. Soluble solids were the highest components of palm sap (Table 1). Mtwapa fresh sap had lowest level (13.28%) while Rabai had highest content of (14.63%).

Table 1: Concentration of substrates in fresh palm sap

<table>
<thead>
<tr>
<th>Sample</th>
<th>Ethanol</th>
<th>Sucrose</th>
<th>Glucose</th>
<th>Fructose</th>
<th>Soluble solids</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>2.80 ±0.12</td>
<td>9.0807 ±0.12</td>
<td>1.93 ±0.132</td>
<td>1.067 ±0.067</td>
<td>14.307 ±0.098</td>
</tr>
<tr>
<td>C2</td>
<td>2.53 ±0.13</td>
<td>9.5967 ±0.22</td>
<td>2.07 ±0.075</td>
<td>1.343 ±0.346</td>
<td>14.023 ±0.054</td>
</tr>
<tr>
<td>R1</td>
<td>2.20 ±0.12</td>
<td>10.087 ±0.10</td>
<td>2.04 ±0.0367</td>
<td>0.61 ±0.148</td>
<td>13.58 ±0.197</td>
</tr>
<tr>
<td>R2</td>
<td>2.60 ±0.12</td>
<td>9.46 ±0.27</td>
<td>2.18 ±0.0367</td>
<td>0.943 ±0.057</td>
<td>14.627 ±0.056</td>
</tr>
<tr>
<td>M1</td>
<td>2.27 ±0.067</td>
<td>9.28 ±0.21</td>
<td>2.00 ±0.168</td>
<td>0.78 ±0.147</td>
<td>13.28 ±0.074</td>
</tr>
<tr>
<td>M2</td>
<td>2.47 ±0.134</td>
<td>9.913 ±0.037</td>
<td>2.29 ±0.132</td>
<td>1.23 ±0.243</td>
<td>14.457 ±0.046</td>
</tr>
</tbody>
</table>

Analysis of substrates in controlled fermentation

After of 6 days under controlled fermentation conditions increased the level of ethanol in the palm sap. Controlled fermentation generated higher ethanol level than the natural fermentation with the highest level (6.13%) from Rabai (Table 2) yielded the highest ethanol content while the lowest value obtained was 5.67%. Sucrose concentration in the fermented samples was low since it had been utilized by microorganisms in fermentation process. The concentration of glucose and fructose was below 1% after both controlled and natural fermentations (Table 2 and Table 3) that were almost insignificant.
Table 2: Concentration of substrates in palm sap after controlled fermentation

<table>
<thead>
<tr>
<th>Sample</th>
<th>Ethanol ±SEM</th>
<th>Sucrose ±SEM</th>
<th>Glucose ±SEM</th>
<th>Fructose ±SEM</th>
<th>Soluble Solid ±SEM</th>
<th>pH ±SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>5.8±0.23</td>
<td>2.067±0.1345</td>
<td>0.587±0.032</td>
<td>0.327±0.043</td>
<td>4.127±0.25</td>
<td>3.99</td>
</tr>
<tr>
<td>C2</td>
<td>5.73±0.067</td>
<td>1.87±0.24</td>
<td>0.48±0.02</td>
<td>0.23±0.049</td>
<td>4.717±0.055</td>
<td>3.76</td>
</tr>
<tr>
<td>R1</td>
<td>6.13±0.134</td>
<td>1.47±0.35</td>
<td>0.513±0.067</td>
<td>0.387±0.059</td>
<td>5.06±0.061</td>
<td>4.12</td>
</tr>
<tr>
<td>R2</td>
<td>5.93±0.241</td>
<td>1.867±0.067</td>
<td>0.557±0.067</td>
<td>0.423±0.059</td>
<td>4.913±0.464</td>
<td>3.97</td>
</tr>
<tr>
<td>M1</td>
<td>5.8±0.177</td>
<td>1.667±0.35</td>
<td>0.48±0.052</td>
<td>0.353±0.077</td>
<td>5.237±0.35</td>
<td>4.12</td>
</tr>
<tr>
<td>M2</td>
<td>5.67±0.35</td>
<td>1.667±0.24</td>
<td>0.62±0.064</td>
<td>0.387±0.069</td>
<td>5.29±0.25</td>
<td>4.35</td>
</tr>
</tbody>
</table>

Analysis of substrates in natural fermentation

After 6 days of natural fermentation the highest level of ethanol obtained was 5.6% while the lowest concentration recorded was 4.87% (Table 3). Most naturally fermented samples indicated higher glucose and fructose content than the controlled fermentation. The highest concentration of sucrose was in the sample fermented naturally (2.47%) while the lowest in sample under controlled fermentation (Table 3).

Table 3: Concentration of substrates in palm sap after natural fermentation

<table>
<thead>
<tr>
<th>Sample</th>
<th>Ethanol ±SEM</th>
<th>Sucrose ±SEM</th>
<th>Glucose ±SEM</th>
<th>Fructose ±SEM</th>
<th>Solid ±SEM</th>
<th>pH ±SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>4.87±0.291</td>
<td>2.47±0.07</td>
<td>0.44±0.029</td>
<td>0.38±0.059</td>
<td>5.323±0.091</td>
<td>2.98</td>
</tr>
<tr>
<td>C2</td>
<td>5.13±0.177</td>
<td>1.800±0.18</td>
<td>0.49±0.029</td>
<td>0.38±0.041</td>
<td>5.007±0.45</td>
<td>3.27</td>
</tr>
<tr>
<td>R1</td>
<td>5.21±0.116</td>
<td>2.27±0.291</td>
<td>0.47±0.04</td>
<td>0.223±0.017</td>
<td>6.83±0.203</td>
<td>3.08</td>
</tr>
<tr>
<td>R2</td>
<td>5.63±0.241</td>
<td>2.13±0.241</td>
<td>0.60±0.041</td>
<td>0.3±0.017</td>
<td>5.883±0.281</td>
<td>3.15</td>
</tr>
<tr>
<td>M1</td>
<td>5.33±0.116</td>
<td>2.07±0.35</td>
<td>0.60±0.077</td>
<td>0.41±0.076</td>
<td>4.877±0.25</td>
<td>3.03</td>
</tr>
<tr>
<td>M2</td>
<td>4.93±0.177</td>
<td>2.00±0.24</td>
<td>0.58±0.072</td>
<td>0.223±0.088</td>
<td>6.15±0.48</td>
<td>3.30</td>
</tr>
</tbody>
</table>

For the fresh palm sap, the lowest pH recorded was 6.24 in samples from Chumani while the highest 6.53 from Mtwapa (figure 1). The pH of palm sap drastically decreased during both controlled and natural fermentation processes. The highest pH level was recorded in naturally fermented samples after the six days. Putting in consideration Sodium hydroxide and other compounds were added in samples for controlled fermentation, the highest pH was 4.35. At 95% confidence, level of sucrose, glucose, fructose, total soluble solids and pH differed significantly (p<0.05) between fresh Mnazi and after both natural and controlled fermentation.

Figure 1: The pH of palm sap wine (Mnazi) before and after both natural and controlled fermentation

DISCUSSION

Fresh Mnazi contained ethanol in the range of 2.0-3.0%. Presence of ethanol in the fresh sap could have been contributed by the natural microflora of palm trees (Kalaiyarasi et al., 2013; Kadere et al., 2008), microorganisms in tapping implements the long period of tapping that was carried overnight, or during storage period (Kadere, 2004). Samples fermented by A. niger and S. cerevisiae yielded higher ethanol than naturally fermented samples. Lower ethanol obtained from samples fermented naturally could have been due to lactic acid fermentation or acetylation by the microbes in the sap (Kadere and Kutima, 2012), which even further resulted in lower pH.
Sucrose was recorded as the highest soluble solid in all fresh sap collected. Thus, it was the main sugar utilized in fermentation process in all samples. Consequently, after fermentation the samples recorded very low levels sucrose. Of the low sucrose levels, most samples fermented under controlled conditions recorded the lowest. This is because conditions employed promoted optimum metabolism of sucrose into ethanol by *A. niger* and *S. cerevisiae*. On the other hand, the higher sucrose level in naturally fermented samples could have been due to harsh conditions that hindered sucrose metabolism. Harsh conditions might have been caused by acidic pH resulting from acetic and lactic acid fermentation in the sample media (Kadere and Kutima, 2012).

Glucose and Fructose levels were very low in fresh *mnazi*. The two are sugar molecules readily used up by microbial enzymes in the broth media, and therefore their concentrations were minimum with that of fructose being lower than glucose. Similarly, after fermentation fructose and glucose levels were very low and almost negligible. From observation made on fresh *mnazi*, soluble solids contributed to the high turbidity, sweet fermentative smell and sweet taste. The turbidity of palm sap greatly depends on its protein content and the polyphenolic compounds (Balange, 2009). Soluble solids were the main component of *mnazi* that was used in fermentation. It is worth to note that, of the soluble solids some were fermentable while others unfermentable. The lower soluble solid content in samples fermented by *A. niger* and *S. cerevisiae* was because saccharification was enhanced by the *A. niger*. It produces enzymes involved in substrate breakdown to yield fermentable molecules that are easily fermented by *S. cerevisiae*.

Similar microorganisms in naturally fermented sap could have been out competed by other microbes in the sample broth. In addition, if similar microbes involved in saccharification were present in naturally fermented sap the species might have been different and inefficient. Other soluble solid content apart from sucrose, glucose and fructose that could have contributed to the total soluble solids are xylose, raffinose, celliobose, mannose, rhamnose, trehalose and dextrose (Eze and Ogan 1988; Okafor, 1978).

Microorganisms, mainly lactic acid bacteria produce organic acids e.g. lactic acid, these increase the total acidity and decreased pH (Kadere and Kutima, 2012). The pH levels in fresh palm sap wine samples were above 6.0. Fermentation in all samples caused a decrease in pH. Naturally fermented samples had a lower pH than those fermented under controlled conditions. The lower pH in naturally fermented media could have been due to acids generated from acetic and lactic acid fermentation. On the other hand controlled fermentation had slightly higher pH due to addition of NaOH and MgSO₄.

**CONCLUSION**

From results obtained, the suggested method of controlled fermentation generated higher ethanol levels than natural process. Larger amounts of soluble solids were used up in controlled method than the natural process, thus saccharification was accomplished. Most of the sugar substrates were utilized in the controlled process, thus their levels were minimal when measured in samples after the fermentation. Lactic and acetic acid fermentations are suggested as one of causes in PH decrease in the natural process. The ethanol yields were greatly affected by substrate contents and PH levels. Therefore, saccharification of unfermentable sugars in *mnazi*, the microbes and fermentation conditions employed are critical factors to consider in obtaining higher ethanol yields from *Mnazi*. *Aspergillus niger* can be utilized in metabolism of unfermentable substrates in palm wine to maximize industrial ethanol production. Pure ethanol for industrial use can then be recovered from *Mnazi* by process of distillation.

**RECOMMENDATION**

From findings of this study, *A. niger* and *S. cerevisiae* can be simultaneously used in industrial ethanol production from *Mnazi*. Further research can be done on these two microbes and their genomes improved to enable them carry out ethanol fermentation in *mnazi* at higher levels. This can be achieved through genetically improving the fermentative microbe’s ability to metabolize unfermentable substrates and its tolerance to ethanol. Production of alternative commercial products e.g. industrial ethanol, acetic acid, lactic acid or other significant chemicals from palm wine during the fermentation process should also be promoted. Further, tappers should be educated on importance of using clean implements in handling of *mnazi* since it affects ethanol yields.

**ACKNOWLEDGEMENTS**

The Department of Pure and Applied Sciences, Technical University Mombasa (TUM) is highly indebted to the funding on this study. We thank the general community of Kilifi County for their cooperation in the field during sample (Palm sap wine) collection period.
REFERENCES


REPELLENCE OF CATTLE ANAL ODOUR CONSTITUENTS AND SELECTED ANALOGUES AGAINST Rhipicephalus appendiculatus

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ABSTRACT

A study was conducted to determine repellence of anal odour constituents, blends and selected analogues against Rhipicephalus appendiculatus control. The odours were trapped, eluted and analyzed by gas chromatography-linked mass spectrometry. Constituents were identified by comparing their mass spectra with those in the National Institute of Standards and Technology libraries. Major constituents were o-xylene, 4-hydroxy-4-methyl-2-pentanone, 4-methyl-2-methoxyphenol, ethyl benzene, 2,6,6-trimethyl[1S(1α,β,5α)]bicycloheptanes, 5-ethoxydihydro-2(3H)-furanone, 3-methylene-2-pentanone, 5-methyl-2-phenyl-1H-indole, and 3-pentanone. Repellency of the odours, selected constituents and blends was evaluated using dual choice tick climbing assay. The 4-methyl-2-methoxyphenol was most repellent (RD75 =0.56) and 3-pentanone least active (RD75 = 622.7). Two blends that were more repellent than the anal odour were: made up of 4-methyl-2-methoxyphenol, 3-pentanone, 3-methyl-2-pentanone, and 4-hydroxy-4-methyl-2-pentanone, with RD75 of 0.032, and another without 3-pentanone, with RD75 = 0.019; p≤0.05, SNK. Bioassays of analogues of 4-methyl-2-methoxyphenol (4-Methylguaiacol) was done: guaiacol, eugenol, 3,4-methylenedioxytoluene and 2,4-dimethylphenol, where 3,4-Methylenedioxytoluene was inactive, while 2,4-dimethylphenol was most repellent (RD75 = 0.0089) compared to all compounds and blends tested. The 2,4-dimethylphenol analogue of 4-methylguaiacol
may represent a promising additional tool in the arsenal of techniques in East Coast Fever control.  

**Key words:** East Coast Fever, Repellence, 4-Methylguaiacol, 2,4-dimethylphenol

**INTRODUCTION**

Ticks transmit the widest variety of pathogens of any blood sucking arthropod including bacteria, rickettsiae, protozoa and viruses. Tick bites and tick-borne diseases continue to be a serious public health problem throughout the world (Carroll, 2005). Ticks are responsible for substantial losses to livestock industry (Willadsen *et al.*, 1988). Cattle tick borne infections are widespread in Africa and they present a great constraint (Walker *et al.*, 2003).

The tick *R. appendiculatus* Neumann 1901, *R. zambeziensis* (Walker *et al.*, 2003, Norval *et al.*, 1991) and to a lesser extent *R. duttoni* Neumann 1907, are the only known field vectors of *Theileria parva* Théler 1904, the causative agent of cattle disease, East Coast fever (ECF) (Lawrence, 1991). East Coast fever is one of the most devastating livestock diseases in east, central and southern Africa, and remains the major health hindrance to the development and improvement of the livestock industry (Norval *et al.*, 1992). East Coast fever causes economic losses to individual farmers and governments. Such losses can be classified into direct and indirect production losses, losses through costs incurred for controlling the disease and costs for providing research, training and extension services pertaining to the disease. Such economic losses vary widely within and among countries in both time and space, due to differences in livestock production systems, cattle types, level of disease risk, disease control policies and programmes cost and price structures (Mukhebi *et al.*, 1992).

The disease is prevalent across the eastern, central, and southern parts of Africa, and has been reported in 11 countries in the region: Kenya, Uganda, Tanzania, Burundi, Rwanda, Malawi, Mozambique, southern Sudan, Democratic Republic of Congo (DRC), Zambia and Zimbabwe (Lawrence *et al.*, 1992). About 28 million cattle in the region are at risk and the disease kills at least 1 million cattle per year. Economic losses are concentrated on small-scale resource-poor households (De Deken *et al.*, 2007). The disease further prevents the introduction of the ECF-susceptible but more productive exotic breeds of cattle, hampering the development of the livestock sector considerably. This loss is termed “lost potential (De Deken *et al.*, 2007).

ECF is thus a major limiting factor working against small-scale farmers attempting to climb out of poverty by moving from subsistence to market oriented enterprises as the demand for meat and milk in developing countries is expected to double by 2020, the majority which will be provided by small holders (VIE, 2002). This puts further pressure on the need to control ECF.

Ticks are commonly controlled using conventional acaricides which has been considered as the best method of controlling ticks, however it has certain shortcomings. Conventional acaricides are expensive or unaffordable to rural farmers. In some studies done by Garcia-Garcia *et al.* (2000) and Laffont *et al.* (2001), residues of conventional acaricides were noticed in meat and dairy products and also caused contamination of environment via the cattle dung. Some reports have shown that ticks have developed resistance against a range of conventional acaricides (George, 2000).

In most areas of the world, ticks have become resistant to arsenic and organophosphorus acaricides (Drummond, 1983). Chlorinated hydrocarbon acaricides have also been withdrawn from the market (Spickett, 1998), because of their high toxicity and long residual (lifespan). Carbonates are more toxic than organophosphates for mammals and are much more expensive (Spickett, 1998). Existence of alternative wild hosts increases the tick population and also the diseases, (Young *et al.*, 1988).

The limitation associated with the current methods of ECF control and the opportunities for reducing reliance on intensive acaricides use in region have prompted the search for new, safer, cheaper and more sustainable control strategies. The use of semiochemicals represents one such strategy.

**MATERIAL AND METHODS**

Stocks of *R. appendiculatus* ticks were obtained from colonies at International Centre of Insects Physiology and Ecology (ICIPE) Nairobi, Kenya. Rearing conditions were as described by Irvin and Brocklesby (1970).

The odour trapping was carried out on Friesian steers (Figure 6) at Kenyatta University cattle shed using adsorbent
sachets (4 x 4 cm) made of filter papers containing 0.2 g of either reversed-phase C18–bounded silica, Porapak Q or Super Q. Six such traps were be placed in an oven bag (An oven bag is a special plastic bag used for the roasting of meat or other food in an oven) and this bag was attached to the anal region of the cattle as shown in Figures 3.1 using metallic clips. Prior to use, traps were cleaned first by putting them into a 200 ml soxhlet extractor for 3 days, dried, and then flushed of any contaminant with a stream of dry nitrogen at 60 °C for 3 hours.

The oven bags were heated in the oven at a temperature of 100°C to remove any volatiles that may have been present. The sachets were held on the anal region for 6 hrs. The trappings were wrapped with clean aluminium foil, and in metallic tins. These tins were carried in a flask containing dry ice, Then transferred into a Pasteur pipette and eluted with distilled dichloromethane (4ml, > 99.9%). Elution was carried out under dry ice. Elution from trapping cycles was pooled, concentrated and stored at -20°C until required for analysis and bioassay. For bioassay, volumes of 100 µl, 200µl and 300µl were used.

A dual-choice tick climbing assay apparatus was used for screening the repellency of the odours, synthetic chemical compounds the blend, all at doses of 0.001, 0.01, 0.1, and 1 mg respectively. DEET which was a positive control was also screened in a similar manner. The bioassays were done using a tick climbing assay in a laboratory at ICIPE (Wanzala et al., 2004). The assay protocol exploited the behavior of the adult ticks, R. appendiculatus, which climb up grass stems to the stem tip to wait for any potential passing host (Chiera et al., 1985). An aluminum base of area 105 cm² with two stands of 26 cm in height and 7.0 cm apart was put in a basin of water 1.5 cm deep (to retain the ticks at the base) this was as describe by Wanzala et al., 2004. A strip of filter paper (Whatman No 7, 4.25 cm wide) was stapled to form a collar around the upper parts of each smaller inner tube at a distance of 20 cm from the aluminum base to provide the source of either test odours or pure solvent. One collar on the pair of the tubes was treated with test odour solution and the other one with the same amount of pure solvent (dichloromethane) alone to serve as control.

The solvent was allowed to evaporate for about 10 minutes after which these tubes were shielded with wider tubes (4.5 cm diameter) from 4 cm above the aluminum base to shield the inner ones and limit the diffusion of the test material laterally and facilitate relatively uniform vertical gradients of the odors along the 3.7 cm gap between two tubes. The upper ends of the larger tubes were plugged with dry cotton wool. The top of the smaller tubes was plugged with wet cotton wool to ensure relatively high relative humidity (>75 %) within the columns.

Ten adult ticks were be placed at the centre of the aluminium base and observed for 60 minutes. The recording was done after every 15 minutes. Each assay was replicated 6 times. The number of ticks that climbed on treated and control columns were counted. Mean % repellency was calculated using the formula

\[
\text{Percentage repellency (PR) } = \frac{N_c - N_t}{N_c + N_t} \times 100
\]

Where \(N_c\) = the number of ticks that climbed on the untreated glass rod tubes and \(N_t\) = the number of ticks that climbed on and or above the filter paper collar strip on the treated glass tube respectively.

Anal and dung odours were analysed using gas-chromatography (GC) and gas chromatography-linked mass spectrometry (GC-MS) techniques (Tholl et al., 2006). One microlitre of the eluent sample was injected into the HP 6890 series gas chromatography interfaced to a 5973 Mass Selective Detector (MSD) and controlled by HP chemstation software (version b.02.05, 1989-1997). The chromatographic separation was achieved using a DB-5 MS capillary column (30.0 m x 0.25 mm x 0.25 µm). The column stationary phase comprised of 5%-diphenyl- 95% dimethylpolysiloxane.

The operating GC condition was an initial oven temperature of 50 °C then programmed to 300 °C at the rate of 10 °C/minute and then kept constant at 300 °C for 3 minutes. The injector and detector temperatures were set at 250 °C. The mass spectrometer was operated in the electron impact mode at 70 eV. Ion source and transfer line temperature was kept at 300 °C. The mass spectra were obtained by centroid scan of the mass range from 40 to 800 amu. The constituents of the odours was identified by analysis of their mass spectra, direct comparison of their mass spectra to the Wiley NBS and NIST database of library of mass spectra, on the GC equipment.

Two blends of anal odour constituents were tested. Blend 1 was made up of 4-methyl-2-methoxyphenol, 3-pentanone, 3-methyl-2-pentanone, and 4-hydroxy-4-methyl-2-pentanone. Blend 2 comprised of 4-methyl-2-methoxyphenol, 3-methyl-2-pentanone, and 4-hydroxy-4-methyl-2-pentanone (i.e. without 3-pentanone).

Data Analysis
The repellency data obtained at different concentrations were subjected to analysis of variance (ANOVA) for a completely randomized design. Treatment means were separated using Student-Newman-Keuls (SNK) at \(p < 0.05\)
significance level. Dose-response relationship was determined using probit analysis and repellent concentrations at $RD_{75}$ values obtained from the regression model.

RESULTS

Anal odour constituents

The anal odour was analyzed using GC–MS. The analysis of the odours revealed a complex mixture of constituents. A total of 43 compounds were identified in the anal odours. These compounds included ketones, phenols, amine and alcohols. Figure 1. The order of occurrence of the 10 major compounds was as follows: 3-methylene-2-pentanone, 5-methyl-2-phenyl-1H-indole, 4-hydroxy-4-methyl-2-pentanone, ethylbenzene, o-xylene), 4-methyl-2-methoxyphenol, 5-ethoxydihydro-2(3H)-furanone, 3-pentanone, thymol and 2,6,6-trimethyl-[1S(1α,β,5α)]bicycloheptane(Table 1).

Figure 1: GC-MS profile of the anal odour

Table 1: Major identified constituents of the anal odours

<table>
<thead>
<tr>
<th>No.</th>
<th>Compound</th>
<th>Relative (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3-Methylene-2-pentanone,</td>
<td>5.8</td>
</tr>
<tr>
<td>2</td>
<td>5-Methyl-2-phenyl 1H-Indole</td>
<td>4.9</td>
</tr>
<tr>
<td>3</td>
<td>4-Hydroxy-4-methyl-2-pentanone</td>
<td>14.1</td>
</tr>
<tr>
<td>4</td>
<td>Ethyl benzene</td>
<td>11.2</td>
</tr>
<tr>
<td>5</td>
<td>O-Xylene</td>
<td>19.2</td>
</tr>
<tr>
<td>6</td>
<td>2-Methoxy-4-methyl phenol</td>
<td>12.4</td>
</tr>
<tr>
<td>7</td>
<td>5-Ethoxydihydro 2(3H)-furanone</td>
<td>4.8</td>
</tr>
<tr>
<td>8</td>
<td>3-Pentanone</td>
<td>4.3</td>
</tr>
<tr>
<td>9</td>
<td>Thymol</td>
<td>4.5</td>
</tr>
<tr>
<td>10</td>
<td>2,6,6-Trimethyl-1S-bicyclo[3.1.1]heptane</td>
<td>3.1</td>
</tr>
</tbody>
</table>

The data in Table 2 summarizes the repellent effects of the synthetic compounds. At the smaller doses (0.001 and 0.01 mg), 3-methyl-2-pentanone had a negative repellency, i.e. it was attractant to the tick. However, at higher dose, it was significantly repellent against *R. appendiculatus*. Of the 5 compounds tested, 3-pentanone was least repellent ($RD_{75}=622.7$) as compared to 3-methylene-2-pentanone ($RD_{75}=1.34$) and 4-hydroxy-4-methyl-2-pentanone ($RD_{75}=4.93$). Further work needs to be done to ascertain whether the position of the carbonyl group has any effect on repellence. 4-Methylguaiacol had the highest repellency ($RD_{75}=0.56$) against *R. appendiculatus*. The repellency of the compounds against *R. appendiculatus* was compared with those obtained with DEET. The repellence of DEET ($RD_{75}=0.0014$) proved to be better compared to compounds identified in the anal region.

Table 2: Repellency of synthetic compounds at different doses

<table>
<thead>
<tr>
<th>Dose (mg)</th>
<th>0.001</th>
<th>0.01</th>
<th>0.1</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compound</td>
<td>Structure</td>
<td>Mean(±SE)</td>
<td>Mean(±SE)</td>
<td>Mean(±SE)</td>
</tr>
<tr>
<td>4-Methylguaiacol</td>
<td><img src="image" alt="Structure" /></td>
<td>33.9±3.9$^{ab}$</td>
<td>41.4±8.4$^{bc}$</td>
<td>53.3±4.8$^{ab}$</td>
</tr>
</tbody>
</table>
3-Pentanone | \( \text{O} \)
---|---
18.3±2.4<sup>cd</sup> | 31.0±5.2<sup>B</sup> | 31.1±4.3<sup>cd</sup> | 50.2±6.4<sup>Ad</sup> | 622.7<sup>c</sup>

3-Methylene-2-pentanone | \( \text{O} \)
---|---
-22.2±9.2<sup>ce</sup> | -13.65±5.2<sup>ce</sup> | 37.5±13.3<sup>Bc</sup> | 76.6±11.4<sup>AAbc</sup> | 1.34<sup>c</sup>

4-Hydroxy-4-methyl-2-pentanone | \( \text{O} - \text{OH} \)
---|---
14.1±3.5<sup>cd</sup> | 28.9±6.4<sup>Bcd</sup> | 36.8±7.9<sup>Bc</sup> | 81.5±8.5<sup>Ab</sup> | 4.93<sup>d</sup>

DEET | \( \text{O} - \text{N} \)
---|---
76.7±4.8<sup>ba</sup> | 83.1±5.8<sup>ab</sup> | 87.8±5.1<sup>aa</sup> | 97.0±3.3<sup>aa</sup> | 0.0014<sup>a</sup>

Mean (±SE) with the same lowercase letter in each column and uppercase letters in each row are not significantly different at \( \alpha=0.05 \) (Student-Newman-Keuls test), respectively.

Repellent effects of synthetic blends against *R. appendiculatus*
One of the blends (made up of 4-methyl-2-methoxyphenol, 3-pentanone, 3-methyl-2-pentanone, and 4-hydroxy-4-methyl-2-pentanone) tested gave \( RD_{75} \) of 0.032. The other blend (without 3-pentanone) was more repellent (\( RD_{75}=0.019; \ p \leq 0.05 \), SNK). The repellency data are given in Table 3. There was no overall significant difference between the repellency of blend 1 and blend 2 as reflected in the \( RD_{75} \) values.

Table 3: Repellency of selected blends

<table>
<thead>
<tr>
<th>Dose(mg)</th>
<th>0.001</th>
<th>0.01</th>
<th>0.1</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAMPLE</td>
<td>Mean±SE</td>
<td>Mean±SE</td>
<td>Mean±SE</td>
<td>Mean±SE</td>
</tr>
<tr>
<td>Blend 1</td>
<td>56.9±5.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>67.1±1.7&lt;sup&gt;Bc&lt;/sup&gt;</td>
<td>83.0±7.7&lt;sup&gt;abha&lt;/sup&gt;</td>
<td>95.2±4.8&lt;sup&gt;aa&lt;/sup&gt;</td>
</tr>
<tr>
<td>Blend 2</td>
<td>64.1±4.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>64.2±3.9&lt;sup&gt;cabc&lt;/sup&gt;</td>
<td>81.2±6.1&lt;sup&gt;ba&lt;/sup&gt;</td>
<td>100.0±.0&lt;sup&gt;Aa&lt;/sup&gt;</td>
</tr>
<tr>
<td>P value</td>
<td>0.343</td>
<td>0.509</td>
<td>0.859</td>
<td>0.341</td>
</tr>
</tbody>
</table>

Mean±SE with the same upper case letters in each row and lower case letter in each column are not significantly different at \( \alpha=0.05 \).

Repellent of selected 4-methylguaicol analogues against *R. appendiculatus*
4-Methylguaicol having been the most repellent of the compounds emanating from the anal region, some analogues were also tested against *R. appendiculatus*. These included guaiacol, eugenol (4-allyl-2-methoxyphenol), 3,4-methylenedioxytoluene and 2,4-dimethylphenol. Their repellent effects against *R. appendiculatus* are as shown in Table 4. At the lower concentration (0.001 and 0.01 mg), guaiacol and 3,4-methylenedioxy toluene had a negative repellency, i.e. they were attractant to the tick. The repellent Dose of 2,4-dimethylphenol at \( RD_{75} \) (0.0089) (Table 6) are the lowest. This implies that 2,4-dimethylphenol was more effective as a repellent compared to the other analogues. 3,4-Methylenedioxytoluene had an extremely low activity and therefore would not be considered as an effective repellent. In this study, 2, 4-dimethylphenol elicited the best response of all the analogues tested.

Table 4: Repellency by 4-methylguaicol analogues

<table>
<thead>
<tr>
<th>Compound</th>
<th>Structure</th>
<th>Dose mg</th>
<th>0.001</th>
<th>0.01</th>
<th>0.1</th>
<th>1</th>
<th>( RD_{75} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guaiacol</td>
<td></td>
<td>38.9±3.5&lt;sup&gt;Od&lt;/sup&gt;</td>
<td>38.7±5.5&lt;sup&gt;cb&lt;/sup&gt;</td>
<td>46.1±11.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>95.2±4.8&lt;sup&gt;aa&lt;/sup&gt;</td>
<td>0.66&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>4-Methylguaicol</td>
<td></td>
<td>33.9±3.9&lt;sup&gt;cb&lt;/sup&gt;</td>
<td>41.4±8.4&lt;sup&gt;cb&lt;/sup&gt;</td>
<td>53.3±4.8&lt;sup&gt;bb&lt;/sup&gt;</td>
<td>89.6±6.6&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.56&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Eugenol</td>
<td></td>
<td>13.7±3.3&lt;sup&gt;cc&lt;/sup&gt;</td>
<td>16.9±4.4&lt;sup&gt;cb&lt;/sup&gt;</td>
<td>56.1±2.9&lt;sup&gt;bb&lt;/sup&gt;</td>
<td>100.0±0.0&lt;sup&gt;aa&lt;/sup&gt;</td>
<td>0.21&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>
3,4-Methylenedioxy toluene

<table>
<thead>
<tr>
<th>Compound</th>
<th>RD50</th>
<th>RD25</th>
<th>RD2.5</th>
<th>Mean±SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,4-Methylenedioxy toluene</td>
<td>-2.6±10.1C</td>
<td>-11.1±8.7C</td>
<td>6.6±3.0A</td>
<td>29.2±7.1Ac</td>
</tr>
<tr>
<td>2,4-Dimethylphenol</td>
<td>61.7±7.9D</td>
<td>76.7±10.5Ca</td>
<td>87.8±7.8Ba</td>
<td>100.0±0.Aa</td>
</tr>
<tr>
<td>DEET</td>
<td>76.7 ±4.8B</td>
<td>83.1 ±5.8Ab</td>
<td>87.8 ±5.1Aa</td>
<td>97.0±3.3Aa</td>
</tr>
</tbody>
</table>

Mean±SE with the same lower case letter in each column and upper case letters in each row are not significantly different α=0.05

### DISCUSSION

Of the anal odour constituents tested against, 4-methylguaiacol had the highest repellency (RD50=0.56) against R. appendiculatus. Interestingly, previous structure-activity studies involving the repellency of a series of guaiacol analogues against tsetse, showed 4-methylguaiacol to be most repellent (Saini and Hassanali, 2007). 3-methyl-2-pentanone had a negative repellency at lower doses but was repellent at higher doses. However; this is not strange to insect behavior as demonstrated by locust which had been found to prefer to be within phenylacetonitrile (PAN) -permeated air column at low relative doses of the pheromone, but away from PAN at high relative doses in a choice assay (Rono et al., 2008).

The choice of the analogues was based on the fact that, 4-methylguaiacol was the most repellent anal odour constituent. In the present study, some of the analogues were significantly the repellent against R. appendiculatus. 2,4-dimethylphenol and eugenol showed high repellence. 2,4-Dimethylphenol was the most effective as a repellent compared to the other analogues. These results suggest that 2,4-dimethylphenol represents a promising tool for protecting individual cattle against East coast fever.

### ACKNOWLEDGMENTS

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SOLID WASTE GENERATION AND COMPOSITION IN EGERTON UNIVERSITY COMMUNITY

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ABSTRACT

Solid waste management is a requirement for any community with management strategies and impacts environmental and human health. For it to succeed, data on waste generation and composition should be availed. This research established the amount and composition of solid waste generated in Egerton University and the surrounding community. It was a cross-sectional survey of 40 households drawn from students, tenants and farmers. Generation and composition was determined using principles outlined by Pfammatter and Schertenleib. Waste generated was generally low for all respondents. Per capita waste generation of 142.31 g for tenants, 70 g for students and 102 g for farmers was lower than the average daily per capita waste generated in low income groups in the urban areas of developing countries. Food waste was the largest component for tenants and students, making up 69% and 73% of total waste generated by weight, respectively. Sweepings (mostly soil) made the largest fraction of waste (93%) of the total waste for farmers. Thus, waste generation was influenced by income with respondents earning highest generating the most. Also, waste composition was characteristic of developing counties with food waste having higher percentage (65%) of all total waste.
INTRODUCTION

Zurbrugg (2003) defines solid waste management as all activities that seek to minimise the environmental and aesthetic impacts of solid waste. It is defined by Pitchel (2005) as a process that comprise the collection, transportation, processing, recycling or disposal of waste materials, usually ones produced by human activity in an effort to reduce their effect on human health or local aesthetics or amenity. Fraser and Gelanis (2003) and Stokoe (1995) assert that waste management aims to reduce the negative impacts of waste on the environment and human health. Since generation of wastes is continuous, management of the waste need to take care of the quantities of wastes produced and their particular properties to ensure that wastes do not become a problem.

The impacts of the waste vary with its type. For example, biodegradable wastes decompose and therefore in the long run, pose no major threat to the environment although in the short term they may cause pollution. Whereas plastics wastes are persistent in nature and remain a problem long after their entry into environment, hazardous wastes require careful disposal measures in order to protect the environment from harm. Anaerobic decomposition of the organic fraction of waste generates methane gas which is a major greenhouse gas. This occurs whenever waste is piled in dumpsites or landfills that lack landfill gas control systems (Bogner, 2007; Fourie and Morris, 2004).

The state of development and income is a good indicator of the amount of waste generated. According to Cointreau-Levine (1997), countries with higher incomes produce more waste per capita with their wastes containing higher portions of packaging materials and recyclable wastes whereas in low income countries, there is less commercial and industrial activity, thus resulting in lower waste generation rates. Cointreau-Levine (1992) reported that the income elasticity of waste generation is 0.1 meaning that a 10% growth in incomes leads to a rise of 1% in the quantity of waste (as cited in Pearce and Turner, 1994: 1). Cointreau-Levine (2006) reported that larger the urban centre and the higher the income level, the high the per capita solid waste produced. For example, for a medium sized and a large sized city in a low income country the per capita waste per day in kilos is 0.35-0.65 and 0.5-0.75 respectively and 0.65-1.5 and 0.75-1.8 for a high income country. In a low income country waste generated in residential areas only was 0.25-0.45 kg waste per day. Troschinetz (2005, as cited in Finn, 2007) avers that cities in the developed world have higher waste generation rates than Third World cities. In the United States, the municipal waste generation rate was estimated at 2.04 Kg/person/day in 2003 while in Western Europe it was 1.51 kg. In some African cities it is less than 200 grams/person/day. In Addis Ababa people living in unplanned and poor housing conditions generate 0.15kg per capital per day of solid waste (Amiga, 2002). The general trend in per capita solid waste generation show an increase over time for instance, in the USA per capita generation was 2.7 pounds per person in 1960, 3.7 in 1980 and 4.7 pounds in 2006 (EPA, 2007). The fraction of putrescible organic content in waste generated in developing countries tends to be very high as compared to waste generated in developed countries. According to Paleczynski (2002) MSW from Accra, Ibadan, Dakar, Abidjan, and Lusaka shows putrescible organic content ranging from 35-80% (generally toward the higher end of this range); plastic, glass, and metals at less than 10%; and paper with a percentage in the low 10s. Furedy (2004) states that the organic fraction of waste streams typically comprises from 35-70% of total municipal waste generated in large cities of developing countries. Xiao et al., (2006) reported that in Beijing, China in 2003, the proportion of organic substances (food waste, paper, plastic, wood and fibre) accounted for 86% of total waste generated. In Kenya the composition of solid waste form low income areas of urban centers was reported as comprising food (57%), paper (16%), plastics (12%), textiles (2%), grass/wood (2%), leather (1%), rubber (2%), glass (2%), cans (1%), other metals (0) others (4%) (Rotich et al., 2005).

In developed countries the fraction of waste food is much lower. According to NIR and CRF (2003. as cited in Skovgaard et al., 2008) in 27 countries making up Europe, municipal waste in 2003 was composed of 38.9% food waste, 0.3% garden waste, 21.2% paper waste, 1.7% wood waste, 3.0% textile wastes, 10.6% plastics and 24.2% inert waste. In the USA, waste composition data in 2007 revealed paper and paperboard at 32.7%, glass 5.3%, metals 8.2%, plastic, rubber and leather, textiles, wood and other related waste were 27% whereas food wastes was 12.5, yard timings 12.8%, and other miscellaneous waste 1.5% (EPA, 2007). The Intergovernmental Panel on Climate Change (IPCC) (2006) reports that there is general lack of comprehensive data on waste generation in developing countries where most waste generation rate reported only account for the urban population. In the study area, where this study was carried out, there was inadequate data on waste generation and composition making the research necessary.
METHODOLOGY

The physical location, climate, population and economic activities of the study are described. The study was carried out in Njoro Division of Njoro District. It covered communities living in Njoro and Mukungugu sub-locations of Njoro Location. Njoro Division lies between longitudes 35° 28’ E to 36° 10’ E and latitudes 00 13’ S to 1° 10’ S which is to the south-west of Nakuru town. It occupies an area of 313.6 km² (Nakuru District Development Plan, 2000). Egerton University (Njoro Campus) is located in Njoro sub-location in Njoro location. Whereas the University is wholly in Njoro sub-location most of the study population is in Mukungugu sub-location (Figure 1).

Figure 29: The study area (Source: modified from Google Maps, 2008)

The area is characterised by annual rainfall of between 760 – 1270mm and experiences a bimodal pattern with long rains in April – June and short rains from July – August. The average temperature is 16.5°C and varies with altitude (Nakuru District Development Plan, 2000).

The study area has a high potential area for both cash crops and food crops. Coincidentally the principal economic activity for the land owners in this area is farming. However, due to the closeness to the University the area has diverse business activities. There is also a large pool of employees within the community. The employee provide labour to the University, companies and other institutions like Njoro Canning Factory, Kenya Highland Nurseries (a flower farm), schools and health facilities in the study area among others. This population of employed people necessitate the establishment of housing facilities for accommodation.

The study population occupy Egerton University and the following villages Mukungugu, Beeston, Mwigito, Eriithia, Njokerio and Ng’ondu. The population for Mukungugu sub-location was 12,415 persons as at 2007 (Kenya National Bureau of Statistics, 2007) which was equivalent to 2483 households given that on average a household had five persons. The inhabitants were land owners, employees and the business persons. Most of the land owners are small scale farmers with land sizes from two and a half acres to five and a half acres, for instance, in Mukungugu village the farm size is 2.5 acres whereas it is 2.75 in Mwigito, 5.5 in Eriithia and 0.5 in Njokerio. The farm size in Ng’ondu is a total of 17 acres, with 2 Acres close to the tarmac road (and the University) and 15 acres further away from the road. There are also informal settlements within the study area for instance, Beeston village is densely populated by squatters who originally lived in villages in the forest while taking care of plantation forests but were forced to move out. About 1000 families occupy an area of 82 acres (Area Chief, personal communication, 2007) in the village.

This study design adopted was a cross section survey and the sampling frame comprised the population within Egerton University and the neighbouring area in the villages Mukungugu, Beeston, Mwigito, Eriithia, Njokerio and Ng’ondu. The sample was made up of tenants, students and farmers who formed the strata. At the University the sample was included students and staff residing within the University. The sampling unit was for tenants and farmers was households. Systematic sampling was used to get to the next respondent from the starting point. The sampling interval
was obtained by dividing the population with the sample size. Only one tenant in every estate was the subject of the survey.

The subject of the study was the household head of every third house in each plot. It had been assumed the minimum number of rental houses in an estate was not less than three. When sampling University students, the halls of residence were sampled first and then the rooms which were treated as households. The sample size for determining the amount of waste generated was 40 and was determined using the principles outlined by Pfammatter and Schertenleib (1996). According to Pfammatter and Schertenleib (1996), waste quantity and composition of a representative number of households could be determined in a period of one week. A reliable estimate could be made by assessing a minimum of 20 households or 1% of the households in the selected area.

Measurement was used to get information on per capita waste generated and on waste composition. Forty randomly selected respondents were provided with waste containers that collected all the waste generated for a period of seven days and each type was weighed and recorded. For those not using waste bins, 20 litre buckets were provided. Plastic bags liners were also provided which were placed inside the containers. The plastic bag liners with the waste were collected every two to three days. In most households, all the waste was placed in one container. In households that normally separated their waste, the waste was placed in different containers depending on category. The waste was weighed and composition determined after a period of one week.

This process was carried out at the middle of the semester to avoid extreme condition of waste generation at the beginning of the semester and towards the end of the semester with high and low generation rates respectively. This is because at the beginning of the semester the student were bound to produce a lot of waste because of more money. At the end of the semester the amount of money with the students would have dwindled hence less waste generation. At the middle of the semester, the average conditions of the students in regard to waste generation would be captured. This was done in the month of March during the January-May semester, 2009. Ashes were not included in the determination of waste generation rate. The reason for this was that most of the farmers used fuel-wood fireplaces where ashes were removed very occasionally, so it was likely that inclusion of the ashes might not have given the actual rates in a seven day period.

Data Analysis
Waste generated was determined by physical measurement of the waste generated for a period of seven days. This was done for students, farmers and tenants. The analysis was done using Statistical Package for Social Sciences (SPSS). Descriptive statistics were used to present of waste amounts and composition results as means, percentages, measures of central tendency and frequencies.

RESULTS AND DISCUSSIONS
The results of waste generation amounts and composition of waste are presented in this section. Waste generation for the study population was generally low for all respondents. Per capita waste generation of 142.31g for tenants, 70g for students and 102g for farmers was lower than the daily per capita generation in low income groups in the urban areas of developing countries. The amount is lower than that given for low income areas of urban centres, 0.25-0.45kg waste per day by Cointreau-Levine (1996), the general waste per day per capita for developing countries of 0.5kg (UNEP 1995). The amount is comparable to what was reported by Amiga (2002) of 0.15kg per day per person in low income areas and figures given for generation in Nigeria ranging from 0.11kg to 0.78kg in urban centers (Federal Ministry of Housing and Environment, 1982 as cited in Sha’Ato et al, 2006: 354).

The per capita waste generated by tenants within the University was greater than for tenants outside the University (Table 1). One of the reasons that could account for this observation was income differences. Tenants within the University earned substantially more than those outside the University earning a mean of Ksh 50,375 and Ksh 5,055 respectively (Kariuki, 2010). It has been established that the higher the income the greater the amount of waste generated. This applies to countries as well as households. According to Cointreau-Levine (2006) a rise in income by 10% leads to a rise in amount of waste generated 1%.
Table 9: Waste generated by tenants within the University and outside

<table>
<thead>
<tr>
<th>Strata</th>
<th>Waste per capita per day (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within University</td>
<td>149.17</td>
</tr>
<tr>
<td>Outside University</td>
<td>136.62</td>
</tr>
<tr>
<td>Mean (weighted)</td>
<td>142.31</td>
</tr>
</tbody>
</table>

Intergovernmental Panel on Climate Change (IPCC, 2006) reported that generation rates reported in most literature in developing countries only account for urban areas. In the study area some waste streams were hardly disposed for instance, waste food, a fact that could be attributed to the mix between rural and urban characteristics of the area. The study site was in a rapidly developing rural area with the communities around the University made up of farmers, businesses, and workers who lived in housing estates. Immediately around the University was the highest concentration of businesses and housing estates interspersed by farmers. Away from the University into the neighbouring community, more farming activities were encountered. This close proximity with farmers led to high reuse of organic wastes in feeding domestic animals. In other places solid waste is primarily valued by farmers in the production of manure. In areas around Ouagadougou, farmers were reported to make informal and illicit arrangements with drivers of the municipal waste lorries to have solid waste dumped near their fields which would then sort out the larger particles and spread out the other waste on the farm before planting (Eaton and Hilhorst, 2003). In Nairobi several community based organisations engage in composting for sale to farmers (Kim, 1998).

**Waste Composition**
Composition of all the waste generated by farmers, tenants and students was as shown in Figure 2. For farmers, the largest fraction of waste was sweepings (mainly made up of soil particles) that made up 93% of the total waste. Among the tenants, food waste was the largest component, making up 69% of total waste generated. For students, food wastes made up 73% of the total waste generated by weight.

Waste from developing countries has food waste as the largest fraction, reported the fraction as ranging between 35-80% (generally toward the higher end of this range). (Palczynski, 2002; Furedy, 2004) On the other hand, Rotich et al (2005) observed that food waste make up 57% of waste generated in low income areas in Kenya. While this information from literature was mainly derived for urban areas, it shows similarity with waste generated from the study location, where food wastes made up over 70% of wastes.

![Figure 30: Waste Composition for farmers, tenants and students](image)

Where “Others” include: Clothes, Ceramics, Rubber, Metals, dry cells and Leaves.

As for waste paper, Palczynski (2002) reported that its percentage was in the lower tens in a study in several African cities while plastic were less than 10%. On the other hand, according to Rotich et al (2005), paper made up 16% of waste generated while plastics were 12%. The proportion of waste paper and plastics generated by tenants and students was comparable. Plastic waste was 14% and 12% of waste generated by all tenants and students respectively while papers waste was 10% and 11%. The percentage of plastics and papers produced by farmers’ households were 2% and 4%, respectively. This is on the lower end of what is reported in literature. In India’s urban centres, the percentage of papers was reported as 2% which was the same case for Jakarta (Diaz and Golueke 1985; Yhdego, 1991 as cited in
Pierce and Turner, 1994). For tenants within the University, food wastes made up 75% of the total waste, followed by plastics and papers at 13% and 11%, respectively. Waste produced by the tenants outside the University comprised 64% food wastes, 16% plastics, 8% papers and 10% sweepings (Figure 3).

![Figure 31: Waste composition for students and tenants within and outside the University](image)

“Aothers” include: Clothes, Ceramics, Rubber, Metals, Dry cells and leaves)

A closer look at the composition of different waste generators, some observations can be made. Food waste was the major waste stream except for farmers. The reason for this observation was that farmers were able to reuse all the waste food and none was disposed mostly by feeding domestic animals. Tenants living outside the University generated the highest amount of plastic waste. The reason for this could be because of buying products in small quantities that are placed in or packaged in plastics due to relatively less incomes. On the other hand, tenants within the University, because of their average income was high would buy products in a comparatively larger quantity thus less plastic waste per product. The students on the other hand, could have generated a smaller fraction of plastic waste due to economies of scale. This is because a number of students lived in the same room so could have bought products in bulk therefore reducing the plastic waste generated.

As for waste papers it was observed that students and tenants within the University had the highest generation with each group’s fraction of papers at 11% while for tenants outside the University the papers were only 8% and that for farmers was 4%. The most likely reason for this could be because of the fact that since these two groups are involved in learning within the University, use of paper was higher than for respondents outside the University. Some waste streams were unique stream to some generators e.g. sweepings. It was generated by farmers and tenants outside the University only. The reason for this observation was because some of the tenants outside the University and most of the farmers lived in semi-permanent houses with earthen floors. Daily sweeping of the floors produced this kind of waste. This waste stream was 10% of the waste generated by tenants outside the University and 93% of that generated by farmers.

CONCLUSION
Waste generation in the study area was comparable to rates reported for developing countries though at the lower end of the given ranges. The generation rates in the study were lower than for urban areas. The composition rates were similarly comparable to data for other developing countries where the largest fraction was food-related wastes.

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DETERMINANTS OF RURAL ELECTRIFICATION ADOPTION AND SOCIO-ECONOMIC BENEFITS AMONG HOUSEHOLDS: A CASE OF MERU-SOUTH SUB-COUNTY, KENYA

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ABSTRACT
Electricity is a critical asset for both human well-being and country’s socio-economic development. However, low adoption and general lack of optimal utilization of electricity continue to undermine maximum socio-economic productivity in most Sub-Saharan African countries. The rural areas are the hardest hit through low economic development and empowerment. There is little information on socio-economic dynamics that preside over the low adoption and potentials of rural electricity in this region. This study evaluated determinants of electricity adoption and explored socio-economic potentials and benefits of electricity in Meru South Sub-County. Interviews were conducted among stakeholders from the energy sector and also 150 randomly selected households using closed and open ended questionnaires. Data analyses used SPSS Vr 19. Results showed that 36% households had electricity compared to 64% non-adopters. Predictor factors that influenced adoption were distance from transformers \( p=0.000 \), education level \( p=0.020 \), gender \( p=0.045 \), household size \( p=0.009 \), and income \( p=0.011 \). Electricity benefits and potentials including improved quality of life through lighting (100%) and business opportunities (38.8%) were cited. Household characteristics influenced electricity adoption but utilization had not been geared towards income generating activities. There is need to continue and increase popularization of electricity potentials among households and communities, and to review existing policies on distribution via grid extension to accommodate household characteristics to increase adoption and optimal utilization.

Key words: Non-adoption, Electricity accessibility, Potentials, Grid extension

1. INTRODUCTION
Electrical energy is a critical facet to a country’s and its populaces’ socio-economic development and well-being. However, the Sub-Saharan Africa (SSA) region emerges as the least electrified region globally, with over over half a billion households having no access to electricity (IEA, 2012). Generally, electrification levels in SSA region stands at less than 30.5% (59.9% urban; 14.3% rural) with the bulk of un-electrified areas stretching into rural areas (IEA, 2010). It has been projected further that households without connectivity to electrical energy in SSA will increase by 11% to 655 million by the year 2030 (IEA, 2012).

Without robust interventions aimed at expanding the growth of the power sector, these trends are anticipated to persist and worsen (IEA, 2012). Like most other SSA countries, Kenya’s electrical energy accessibility and eventual adoption is quite low (World Bank, 2010). There have been efforts to expand electrical energy accessibility in Kenya, nonetheless, its adoption is still quite low (19.2%); much lower than the average adoption of SSA (30.5%) region (GoK, 2014). Conversely, disparities in the electrical energy distribution in Kenya are quite high. For instance, electricity connectivity estimated at 51.3% and 5% in urban and rural areas, respectively. (IEA, 2010). The low electrification and energy growth status in Kenya, occasioned initiatives to establish and increase revenue allocation to an autonomous authority (Rural electrification Authority: REA), whose prime mandate was to accelerate the pace of electrification in rural areas (REA, 2013). This was envisaged to increase accessibility to electrical energy among all households as enshrined in the Vision 2030.

The government’s intentions are that all Kenyans have access to electricity by the year 2030 is envisaged in the country’s long term blueprint for development, the vision 2030 of the Rural Electrification Authority (REA) under section 66 of Energy Act 2006 (No. 12 of 2006). REA has initiated programmes to accelerate rural electrification via national grid extension in the rural areas. Electricity accessibility has been reported to have increased over years (REA, 2013). Despite the efforts of increasing electricity distribution networks in various parts of the country low levels of electricity adoption among households continue to exhibit among households. Owing to electricity’s critical role in rural and household socio-economic development, understanding factors that translate to this low adoption coupled with understanding the potential benefits of electricity during the early stages of the implementation of a rural electrification programme among households helps in clarifying and framing of policies and options for developing countries (Barrios, 2008). There is an enormous consensus that electrification enhances quality of life at the household level and stimulates economy at a broader level (Khandker et al., 2009). Electricity is a critical tool for use at micro level
Studies have showed that energy services are a crucial input to the primary challenge of providing basic needs among households. For instance, household access to electricity facilitates timely cooking of food, provides a comfortable living temperature, lighting, and enables the use of communication appliances, which all contribute to the individual and family quality of life (Mvondo, 2010). This study therefore seeks to fulfill the objective of examining the determinants of electricity adoption and socio-economic potential benefits among rural households in Meru South Sub County, Kenya.

2. METHODOLOGY

2.1 Study area

The study was carried out in Meru South Sub County, of Tharaka - Nithi County. The area lies between longitudes 37°18’37” and 37°28’33”East and Latitude 00°07’23” and 00°26’19”South. Meru-South lies in the Upper zones-LH1, UM1, UM2, Middle zones-UM3 and Lower zones-LM3, LM4, LM5 (Jaetzold et al., 2006) on the eastern slopes of Mount Kenya. The altitude ranges from 830 meters in the lower areas to 1850 meters above sea level at the base of Mt. Kenya. Population density is of 205 persons per Km². The topography of the Sub-County is influenced by the volcanic activity of Mt. Kenya with numerous rivers originating from Mt. Kenya forest (Figure 1).

The major economic activities which are the livelihood systems engaged by the local community include; agriculture and livestock production. Coffee and tea are major cash crops, while maize, beans, potatoes, cassava and bananas are grown for subsistence and cash sale. Livestock keeping is also practiced where households keep dairy cattle goats and sheep and poultry.

2.2. Data Collection and Sampling Technique

The study utilized a survey design approach together with mixed methodologies combining both qualitative and quantitative research methods to enable an in-depth investigation into the subject matter studied. Structured and unstructured questionnaire was the main instrument used to collect primary data. A Multi stage random sampling procedure was employed in selection of divisions, and locations and sub-locations where households were to be interviewed. Simple random sampling was used to obtain the households from each of the selected sub-locations. A total of 150 households were selected from the sub-county for the study.

2.3. Analytical Procedure

Analysis of the general characteristics of the respondents, socio-economic profiles of adopters and non-adopters was done using descriptive statistics such as frequencies, means, standard deviation, percentages. This analysis was performed using SPSS and Microsoft Excel. Binary logistic regression mode was used in analyzing possible predictor factors influencing electricity adoption. This regression method was chosen because binary logistic regression is primarily used when the dependent variable is a dummy categorical variable (usually dichotomous) and has two outcomes such as 0 and 1. More so, logistic regression is often chosen when the predictor variables are a mix of...
continuous and categorical variables or if they are not nicely distributed (logistic regression makes no assumptions about the distributions of the predictor variables) (Peng, 2002). In this study, the dependent variable is adoption of electricity by households, which is a dichotomous variable therefore a value of 0 was assigned if the household was of a non-adopter and 1 if household consisted of an adopter giving a regression of a non-linear form. This was done following a guide line provided by Hilbe (2009) for analysis of the kind. The estimated model can be generally stated as:

$$\ln \left( \frac{p}{1-p} \right) = a + b_1x_1 + b_2x_2 + \ldots + b_nx_n$$

The logit transformation of the probability of adoption is represented as follows:

$$\text{Logit}(p) = a + b_1x_1 + b_2x_2 + \ldots + b_nx_n$$

Where p: is the probability of a case belonging to category 1, p/1-p: the odds of electricity adoption, a: constant, n: number of predictors and b₁-bₙ represents regression coefficients associated with each explanatory variable and x₁-xₙ represents explanatory variables.

3 RESULTS AND DISCUSSION
3.1. Socio-economic Characteristics of the Respondents
The findings revealed that about 94% of the respondents were male headed households while 6% constituted of females headed households. Marital status of household head indicated that 91.3% were married, 4.7% were widowed and 4% were single parents. In levels of education attainment of the household heads was, 5.3%, 40%, 41.3%, and 13.3% for non-formal education, primary level, secondary level and tertiary level respectively. As per the household’s heads occupation, 18.7%, 73.3%, 2.7%, and 5.3% were employed, self-employed daily laborer and unemployed respectively (Table 3.1).

Total monthly income among household heads which was 30.7%, 39.3%, 17.3% 6.0% and 6.7% for less than 5000, 5001to 10000, 10001 to 20000, and 20001 to 30000 and more than 30001 respectively. The study results indicate a distribution of ages of the heads of households interviewed ranging between 25 to 83 years, and the average age of the household head being 48.74 years. The study further revealed that 36.7% were aged between 25 and 45 years, 56.7% between 46 and 65, giving a cumulative figure of about 93.3% of household heads interviewed aged between 25 and 65 years. The average age of household heads was 48.74, median 48.50 and the mode 48 years. Majority of the household had wooden houses (52%) followed by 24% of those who owned stone made houses and 12.7% owned mud houses and 10% had bricked houses.

Table 2.1: Description of variables in the empirical binary logistic model

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
<th>Type of measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADOP</td>
<td>Whether a household has adopted or not</td>
<td>Dummy (1 if yes, 0 if no)</td>
</tr>
<tr>
<td>GENDER</td>
<td>Gender of the household head</td>
<td>1, male; 2, female</td>
</tr>
<tr>
<td>MASTAT</td>
<td>Status of marriage</td>
<td>1, Married; 2, widowed; 3, Single parents; 4, Single</td>
</tr>
<tr>
<td>EDULEV</td>
<td>Educational background of the household head</td>
<td>1, No formal; 2, Primary; 3, Secondary; 4, Tertiary</td>
</tr>
<tr>
<td>OCCUP</td>
<td>Work done by household head</td>
<td>1, employed; 2, self employed; 3, Dairy laborer; 4, unemployed</td>
</tr>
<tr>
<td>MSI</td>
<td>Sources of income by household head</td>
<td>1, salary; 2, farming; 3, wages; 4, business</td>
</tr>
<tr>
<td>MINC</td>
<td>Monthly income of the household head</td>
<td>1, ≤ 5000; 2, 5001-10000; 3, 10001-20000; 4, 20001-30000; 5, &gt;30000</td>
</tr>
<tr>
<td>HWM</td>
<td>House type by wall material</td>
<td>1,wood; 2, stone; 3,mud; 4,brick; 5,iron sheet</td>
</tr>
<tr>
<td>AGE</td>
<td>Household head’s age</td>
<td>Years</td>
</tr>
<tr>
<td>HHS</td>
<td>Household in number of people</td>
<td>Numbers</td>
</tr>
<tr>
<td>DST</td>
<td>Walking distance of the transformer from the dwelling</td>
<td>1, ≤600metres; 2, &gt;600metres</td>
</tr>
</tbody>
</table>

Table 3.1: Distribution of the respondents’ socio-economic characteristics

<table>
<thead>
<tr>
<th>N=150</th>
<th>Variables</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male</td>
<td>94.0</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>6.0</td>
</tr>
</tbody>
</table>
3.2 Determinants of Electricity Adoption using Binary Logistic Regression Model

The binary logistic regression function in SPSS was used to conduct the simultaneous logistic regression analysis. The model was significant ($\chi^2=92.432, df=10, p<0.05$) and the overall percentage of correct predictions is 88.7%.

### Table 3.2: Statistics of variables used in the binary regression model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>GENDER</td>
<td>1</td>
<td>2</td>
<td>1.06</td>
<td>0.238</td>
</tr>
<tr>
<td>AGE</td>
<td>1</td>
<td>5</td>
<td>2.79</td>
<td>1.101</td>
</tr>
<tr>
<td>MASTAT</td>
<td>1</td>
<td>4</td>
<td>2.09</td>
<td>0.468</td>
</tr>
<tr>
<td>EDULEV</td>
<td>1</td>
<td>4</td>
<td>2.61</td>
<td>0.784</td>
</tr>
<tr>
<td>OCCUP</td>
<td>1</td>
<td>4</td>
<td>1.93</td>
<td>0.631</td>
</tr>
<tr>
<td>HWM</td>
<td>1</td>
<td>5</td>
<td>3.11</td>
<td>1.1</td>
</tr>
<tr>
<td>MSI</td>
<td>1</td>
<td>4</td>
<td>2.13</td>
<td>0.8</td>
</tr>
<tr>
<td>DST</td>
<td>0</td>
<td>1</td>
<td>0.6</td>
<td>0.492</td>
</tr>
<tr>
<td>MINC</td>
<td>1</td>
<td>5</td>
<td>2.18</td>
<td>1.136</td>
</tr>
<tr>
<td>ADOPT</td>
<td>0</td>
<td>1</td>
<td>0.36</td>
<td>0.482</td>
</tr>
<tr>
<td>HHSIZ</td>
<td>2</td>
<td>6</td>
<td>4.49</td>
<td>1.214</td>
</tr>
</tbody>
</table>

3.2.1 The validity of the model

The $p$-value 0.93 uses the Hosmer and Lemeshow Goodness-of-Fit Test, which is computed from the Chi-square distribution with 8 d.f. We fail to reject the null hypothesis that there is no difference between the observed and predicted values of the dependent, implying that the model’s estimates very well fit the data at an acceptable level. Sidibe’ (2005) also mentioned that a $p$-value less than 0.05 indicates a poor fit for a binary logistic regression model.

The results of the analysis as shown in Table 3.3 revealed that gender, household size, household head monthly income, distance from the transformer and educational level are the major determinants of electricity adoption in the study area. The analyses show that distance of the transformer from the household was statistically significant $p=0.000$ at $<0.005$. A negative sign of beta ($\beta=-3.367$) indicates that adoption of electricity is negatively influenced by the distance of the household to the transformer. The results imply that increase in the distance from the transformer to the households the less likely that the households will adopt electricity. According to Mapako et al. (2007) households near
grid electrified growth points usually benefit from the proximity of the grid hence get easily connected. According to the results education level is significant (p=0.020) and positively (β=1.001) influence electricity adoption.

Table 3.3 Parameter estimates of binary logistic regression model for socio-economic factors influencing electricity adoption in Meru- South Sub County

<table>
<thead>
<tr>
<th>Variables</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>Sig</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>-2.774</td>
<td>1.386</td>
<td>4.004</td>
<td>0.045*</td>
<td>0.062</td>
</tr>
<tr>
<td>Age</td>
<td>0.036</td>
<td>0.254</td>
<td>0.020</td>
<td>0.887</td>
<td>1.037</td>
</tr>
<tr>
<td>Marital status</td>
<td>1.086</td>
<td>0.575</td>
<td>3.561</td>
<td>0.059</td>
<td>2.963</td>
</tr>
<tr>
<td>Education level</td>
<td>1.001</td>
<td>0.429</td>
<td>5.439</td>
<td>0.020*</td>
<td>2.720</td>
</tr>
<tr>
<td>Occupation</td>
<td>0.612</td>
<td>0.575</td>
<td>3.561</td>
<td>0.059</td>
<td>2.963</td>
</tr>
<tr>
<td>Household size</td>
<td>-0.589</td>
<td>0.575</td>
<td>3.561</td>
<td>0.059</td>
<td>2.963</td>
</tr>
<tr>
<td>House type</td>
<td>0.240</td>
<td>0.240</td>
<td>0.999</td>
<td>0.318</td>
<td>1.271</td>
</tr>
<tr>
<td>Main source of income</td>
<td>-0.293</td>
<td>0.309</td>
<td>0.898</td>
<td>0.343</td>
<td>0.746</td>
</tr>
<tr>
<td>Household income</td>
<td>0.824</td>
<td>0.324</td>
<td>6.458</td>
<td>0.011*</td>
<td>2.281</td>
</tr>
<tr>
<td>Distance from the transformer</td>
<td>-3.167</td>
<td>0.569</td>
<td>31.013</td>
<td>0.000*</td>
<td>0.042</td>
</tr>
</tbody>
</table>

N=150, *Significant at 5% probability level B, Parameter estimate; SE, Standard error. -2log likelihood is 77.37; Chi square statistic is 92.432*; Overall correct prediction is 88.7.

This implies that households with household heads with higher levels of education are likely to be electricity adopters. These results points out that the higher the level of education the higher the likelihood of electricity adoption. With formal education households have a better understanding of the importance of electricity in their households. This study concurs with findings by Olufemi et al. (2012) who stated that electricity adoption and use are positively associated with higher level of education.

The result indicate that household income was found to be significant at (p=0.011 at <0.05) in electricity adoption. A positive sign of beta (β=0.824) indicates that electricity adoption is positively influenced by the household monthly income. This could be because higher income earners have finances to facilitate electricity connection to the households. This signifies that increase in household income increases the likelihood of adopting electricity. The results agree with those of Heltberg (2003) that low income households are less likely to adopt electricity due to the high initial cost of connecting from the grid which includes the infrastructure, cost (obtaining connection to the grid). According to Mills and Schleich (2010) richer households are less likely to face income or credit constraints for investments in modern energy sources such as electricity. Results are in consensus with findings by Barnes (2007) that initial connection charges still remains a challenge when it comes to electricity adoption among low income earners households. According to Mills and Schleich (2010) richer households are less likely to face income or credit constraints for investments in modern energy sources such as electricity.

Gender was statistically significant p=0.045 with a predicted coefficients of -2.774 indicating a negative relationship that implied that male headed households are likely to be electricity adopters as compared to female counterparts. This result is consistent with a study by that of Dreze and Srinivasan (1997), which found out that more male-headed household had electricity connected to their household compared to the female headed households. A study carried out in South Africa found out that female-headed households were consistently less likely to be connected to the main source of electricity than those headed by males; monitored for a period of eight years (StatsSA, 2010) According to Nishimwe et al. (2014) female-headed households appear to be less likely to secure electricity for their homes compared to those headed by males. Dungumaro (2008) revealed that households headed by females are relatively underprivileged in terms of assets and income or are significantly over-represented among the poor.

3.3 Socio-economic benefits of electricity adoption among households

The results revealed that households had been connected to grid electricity for periods ranging from one to ten years. The average was 3.7 years, and a median of four years. Evidently earlier years have presented low connection rate with recent years having a higher number of households getting connected to the electricity. According to the results a cumulative of 87.0% of households connected to grid electricity between 2009 and 2013(Table 4.2). This result can be possibly due to accelerated accessibility to electricity in the last five years where rural electrification saw unprecedented increase in electrifying public facilities and increased connection among households. Prior to 2009
when the rural electrification programme was newly initiated only a few households (9.3%) had access to the grid hence fewer existing connections among households

<table>
<thead>
<tr>
<th>Table 3.4: Years households had connected to grid electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

4.1 Electrical appliance ownership

Lighting devices were the dominant devices in all households the electrified households at 100%, and consequently households used electricity for space illumination as the prime use of electricity. The second most owned electric appliances were radios at 96.3% and television sets at 94.4%. Other electric appliances that eased domestic labour included electric iron and refrigerator, whose ownership was at 27.8%, and 9.3% respectively. This concurs with a study by Wamukonya et al. (2001) who noted that refrigerator is a luxury item owned by a few especially in rural areas and its ownership which is heavily dependent on households’ income. Electric appliances used in increasing productivity in agriculture were not prevalent among the households where only 27.8% owned chaff cutters used in cutting fodder. Majority adopters of the households did not have equipment necessary for agricultural productivity, a paradox for an area that is a highly productive agricultural region.

<table>
<thead>
<tr>
<th>Table 4.2: Electric appliance ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appliances</td>
</tr>
<tr>
<td>Radio</td>
</tr>
<tr>
<td>Television set</td>
</tr>
<tr>
<td>Refrigerator</td>
</tr>
<tr>
<td>Electric iron</td>
</tr>
<tr>
<td>Electric heater</td>
</tr>
<tr>
<td>Mobile phone</td>
</tr>
<tr>
<td>Computer</td>
</tr>
<tr>
<td>Lighting devices</td>
</tr>
<tr>
<td>Chaff cutter</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Source: computed from field survey data, 2013.

Mobile phones were also owned by majority of households at 98.1% indicating ease of charging the mobile phones. This finding differs with the scenario in India where agricultural productive areas had been supplied with appropriate equipment in order to enhance productivity (Badiani, 2011). Electric heater ownership among the households stood at 11.1% and computer ownership at 3.7% as many of the households could not afford to buy or did not use mini-gargets in their homes. Electricity is never in demand for itself, but for the outputs derived from the use of various electric appliances. Once electricity has been produced and distributed hence producing its final output, it is expected that output becomes useful only when consumed by an appliance and produces the derived output. Respondents who owned various electric appliances were asked to state various electricity driven output from the appliances as represented in (Table 4.3).

The findings showed that all connected households owned lighting devices which included fluorescent tubes, incandescent light bulbs and energy saving compact fluorescent light bulbs which were used in lighting spaces. Lighting was the first priority for being connected to the grid electricity. This finding concur with that of Chaurey et al. (2004) whose study found out that the initial use of electricity in rural areas is household lighting because electric light
is much brighter than that provided by kerosene lamps and the price per unit of light can be hundreds of times cheaper. Apart from indoor illumination about 27.8% of the households used electricity for security lighting at various points in the homestead especially at the main entrance (gate) to the residence.

### Table 4.3: Direct Electricity Benefits Driven from Appliances used in households

<table>
<thead>
<tr>
<th>Appliances</th>
<th>Use</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Access to information</td>
<td>48</td>
<td>88.9</td>
</tr>
<tr>
<td>Radio&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Entertainment</td>
<td>4</td>
<td>7.4</td>
</tr>
<tr>
<td>Television&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Entertainment</td>
<td>44</td>
<td>81.5</td>
</tr>
<tr>
<td>Television&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Access to information</td>
<td>43</td>
<td>79.6</td>
</tr>
<tr>
<td>Refrigerator</td>
<td>Preservation of food and beverages</td>
<td>5</td>
<td>9.3</td>
</tr>
<tr>
<td>Electric iron</td>
<td>Convenience</td>
<td>15</td>
<td>27.8</td>
</tr>
<tr>
<td>Mobile phone benefit</td>
<td>Improved communication</td>
<td>53</td>
<td>98.1</td>
</tr>
<tr>
<td>Computer</td>
<td>Access to information</td>
<td>2</td>
<td>3.7</td>
</tr>
<tr>
<td>Lighting device&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Improved lighting of spaces</td>
<td>54</td>
<td>100</td>
</tr>
<tr>
<td>Lighting device&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Improved security</td>
<td>15</td>
<td>27.8</td>
</tr>
<tr>
<td>Chaff cutter</td>
<td>Increased productivity</td>
<td>15</td>
<td>27.8</td>
</tr>
</tbody>
</table>

<sup>1</sup>first priority use  <sup>2</sup>second priority use

About 96.3% of the adopters owned radios and the majority (88.9%) mainly used them in accessing information. This can be explained by reasons such as radios are cheaper to purchase, the availability of local stations that broadcast in vernacular languages; availability of local news and educational programmes especially for farmers. Moreover 7.4% mainly used radios for entertainment purposes, listening to entertainment programs such as music jams storytelling and audio dramas.

Mobile phones were owned by 98.1% of adopters who reported that with electricity it became more convenient for them to use the device. This improved communication in their households with family members in distant places, money transfers, social media and internet. Availability of power for charging the cell phones had made it very convenient to households. Television sets were also a common electric appliance among households whose major output was for entertainment as reported by 81.5% of households and access to information at 79.6%. This finding is almost similar to a study by Barnes et al. (2005) that the next most common use of electricity is television and on average, close to half of all electrified homes in rural India have a television and use it for entertainment. It was noteworthy that prices of television sets have fallen thus making them available to many households.

Quantities of spoiled food. Computers were used by only 3.7% of the households who mainly used it to access information. Chaff cutter agricultural equipment was owned by 27.8% of the households and was reported to have increased agricultural productivity among the users. Chaff cutters were used by farmers especially those who kept livestock and majority who practiced zero grazing. Electric iron use was reported to be at 27.8% of the respondents and was used as a convenient device for ironing clothes although, ironing clothes was not regarded as a priority and the majority did not use it frequent.

Several other electrical appliances were owned by a smaller proportion of households, in particular, the refrigerator, that households used by only 9.3% in preservation of food and beverages. Residents with refrigerators reported that they did not have to worry about wasting perishable food though at times long periods of unplanned power outages resulted in large.

The study sought to establish the benefits that households connected to electricity gained from the use of electricity with a focus on home business opportunities and general appreciation of the quality of life. According to the findings, only 18.0% (27) of the respondents run a business from the home. Out of this small number 77.8% (21) were adopters and 22.2% (6) were non-adopters. Findings revealed that 61.1% of households did not carry out any business requiring electricity, whereas 14.8% had at least one business activity at home. Amongst those that declared having a business activity, 38.1% confirmed only one small business activity; 42.9% reported having two business activities and 19% reported having three businesses. This concurs with finding by Maleko (2005) that with availability of electricity there is diversification of business activities within the same household. Multiple studies have shown that microenterprise development is stimulated by electrification, even though other elements (such as availability of microfinance and
organized local markets) are necessary to ensure that the RE has the desired impact (Kooijman et al., 2010; Bose et al., 2013; Maleko, 2005).

Household members were involved in several conventional small businesses that used electricity which included mobile phone charging at 44.74% as the most prevalent. Mobile phone charging was especially for those households that had not been connected with electricity and household members charged Kshs. 20. Other home businesses done were hair dressing and barber shops at 10.53%, and general shop business at 34.21% selling electronics, food and hardware (Figure 3.1).

![Figure 3.1: Distribution of business activities in households](image)

Rural electrification was beyond comfort and convenience as home-based businesses provided income for the households. The households were asked to state average income on a monthly basis from the small businesses carried out. Households with salon business reported an average monthly total income of Kshs. 6,000. The barber businesses reported a mean monthly income of Kshs. 5,250, mobile phone charging with a mean monthly income of Kshs. 8,500, while general shop business reported a monthly income of Kshs. 14,769, hence having the highest mean monthly income among all small businesses conducted by households.

The study sought to understand the utilization of income from the small business activities by listing their expenditure lines. Based on results three precedence expenditure items were noted; paying school fees for the children was the primary expenditure item at 86%, as indication that children education is an important aspect of these households. Paying electricity bills was reported by 19%. As people, who depended wholly on electricity services paying electricity bill meant ensuring the sustainability of the small business and consequently the continuous improvement of the welfare of the family. Domestic use was at 38% which included purchasing electrical appliances transport costs, household furniture, health matters and leisure for all the family members.

4 CONCLUSION AND IMPLICATIONS
This study was undertaken to unveil the socio economics dynamics of rural electrification adoption in rural areas. Several useful conclusions that provide insight on pathways to increase the electricity adoption in Meru South emerge from this research. First, the results from this paper indicate that the RE project should incorporate consideration of household head income, educational attainment, gender, household size, income and distance from the transformer. Many of the earlier efforts to increase electricity accessibility and adoption are not based on any viable institutional frameworks. The lesson from this paper is that non-consideration of household socioeconomic aspects can lead to inappropriate planning for rural electrification in rural areas. Second, rural electrification planning process should involve assessment of the potential for productive uses of electricity for households and social services and include measures for their promotion. In addition, it has been suggested that there is need for policy support to enable households adopt electricity and make productive use of it.

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DETERMINATION OF GLASS TRANSITION TEMPERATURE AND MODULUS OF PLA FILMS USING DYNAMIC MECHANICAL ANALYSIS AT 50 °C AND AMPLITUDE OF 10 µm

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ABSTRACT

Polylactic acid (PLA) is an environment friendly biodegradable thermoplastic produced by microorganism synthesis
through the fermentation of starch. It can be used in the manufacture of thermoplastic films used to produce packaging material in place of those produced from fossil fuels. It may reduce consumption of petroleum, which releases Carbon IV Oxide, a greenhouse emission, unburned carbon fragments and other compounds that give rise to smog and air pollution on burning. It is also compostable, aiding solid waste management. In this study, the mechanical properties of PLA were determined over a temperature and amplitude range to establish whether it can be used in production of packaging material for single use purposes and disposable items. The storage (\( E'(\omega) \)) and loss (\( E''(\omega) \)) moduli as well as the Loss Tangent (\( \tan \delta \)) and glass transition temperature (\( T_g \)) of PLA films were determined using the Dynamic Mechanical Analyzer (DMA) model 2980, used in the Multistrain mode. At 50°C and amplitude of 10 \( \mu \)m the storage modulus of PLA was 2220.00 MPa, while loss modulus was 112.90 MPa. Consequently, elastic modulus \( E \) of PLA was 2222.87 MPa, indicating that PLA is strong and tough at this temperature. From the peak of the loss modulus graph the \( T_g \) was 65°C. \( T_g \) from variation of loss tangent with temperature occurred at 74.3°C.

**Key words:** Dynamic mechanical analysis, Packaging materials, Polylactic acid

### INTRODUCTION

Environmental conservation is undoubtedly one of the top priorities in the world today. There are major drawbacks associated with the extensive use of plastics manufactured from fossil fuels due to their stability in both photochemical and environmental conditions. According to a report by UNEP/Grid-arendal 1, plastics take over one million years to biodegrade. According to composters, the top contaminant in feed stocks is plastic with plastic bags being an integral part of waste collection infrastructure 2. Over 60% of plastic waste is produced by households, most of it as single use packaging. Polyethylene (PE) is the major packaging plastic and is therefore one of the top environment pollutants. Littered PE bags result in visual pollution, cause blockage of gutters and drains and choke domestic, wild and marine animals. They also result in a reduction in agricultural productivity while providing breeding grounds for mosquitoes 3.

A lot of research and development is being directed towards development of environment friendly bags which should be strong yet biodegradable 4. These can be manufactured from biopolymers. The introduction of biopolymers will reduce the consumption of petroleum, which releases Carbon (\( V \)) Oxide, a greenhouse emission, unburned carbon fragments and other compounds that give rise to smog and air pollution on burning. They are also compostable, and disintegrate within a reasonable time frame leaving no toxic substances or visible traces, aiding solid waste management. According to the American society of testing and materials (ASTM D6400-04) and the European standards (EN 13432) a compostable material should biodegrade such that Carbon is converted to Carbon (\( IV \)) Oxide to the level of between 60% and 90% over a period of 180 days 5.

Polylactic acid (PLA) is a biopolymer which can be used to manufacture thermoplastic films. Lactic acid is one of the most important organic acids produced by lactic acid bacteria (LAB). LAB consists of bacterial genera within the phylum Firmicutes comprised of about 20 genera. These genera include Lactococcus, Lactobacillus and Streptococcus amongst others. Lactobacillus is the largest genera comprising about 80 species. LAB can produce either L (+PLLA) or D (−PDLA), which are optically active, or a racemic mixture of lactic acid 6. The first step in the production of lactic acid involves pretreatment by gelatinization and liquefaction of cheap raw materials such as whey, molasses, starch waste, sugar beet, cane sugar and other carbohydrate rich materials. This is followed by enzymatic saccharification to glucose. The glucose is then converted to lactic acid by Lactobacillus fermentation 7. There have however been restraints of high cost and insufficient technical performance of lactic acid produced in this way 8. In an effort to address these restraints, researchers such as Suszkiw 9 reveal that sugar beet can be turned into biodegradable filler material for PLA making it a cheaper alternative to petroleum-based thermoplastics. Also, PLA’s former filler was corn sugar removed from the kernels. By finding ways to use starch from the entire plant, farmers would be able to sell the corn as produce and the remaining plant for plastic 9. Amylolytic lactic acid producing bacteria have the ability to convert starchy biomass to lactic acid in single step fermentation. This will eliminate the two step process to make it economical 10.

Sugar alcohol, sorbitol is used to plasticize the pulp. The pulp is reshaped into particulate matter, melted into PLA and processed through a twin-screw extruder to produce composite material for subsequent remolding. They are fully biodegradable and result in carbon savings of 30-80% compared with oil based plastic 10. PLA polymer was first used as biodegradable sutures in the 1960’s 5. PLLA is a semi crystalline polymer exhibiting high tensile strength and low elongation with high modulus. According to a polymer data sheet by Mat Base 11, PLA has a Young’s modulus of between 350 MPa and 2800 MPa and a \( T_g \) of between 45°C and 65°C. Its degradation period is between 18 – 24 months. It is however brittle and has a slight milkiness 12.

PLA has mainly been used in biomedical applications 13. It is suitable for medical products in orthopedic fixation.

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(pins, rods, ligaments etc.), cardiovascular applications, dental applications, intestinal applications, and sutures. Other potential applications include packaging for cereals, snack foods, dairy products, food container and candy. PLA is degradable in soil, water or compost. When PLA is incinerated, the heat of combustion is half or less compared with conventional plastics such as PE. In dynamic mechanical methods for locating T<sub>g</sub>, a rapid change in modulus is indicative of the glass transition. Below T<sub>g</sub>, a polymer behaves like a stiff spring storing all the available energy in stretching as potential energy, when work is performed on it and has a high modulus. The elastic modulus for glassy polymers just below the T<sub>g</sub> is constant over a wide range of polymers having the value of approximately 3000 MPa. As the temperature of a polymer rises, molecular motion increases and it begins to behave like a viscous liquid if no degradation occurs. With a further rise in temperature, a transition from glass to rubber-like state takes place. There is a rapid change in stiffness as shown in Figure 1.1 which indicates a transition and T<sub>g</sub> is located within this region.

![Stiffness against temperature](DMA User Manual)

Figure 1.1: Stiffness against temperature. Source: DMA User Manual

As Stiffness and Modulus are directly proportional, a rapid decrease in modulus is also indicative of a transition and T<sub>g</sub> is located within this region. For the loss modulus and loss tangent graphs, T<sub>g</sub> is located at the peak of the graphs. For all polymers, T<sub>g</sub> from the loss tangent graph occurs several degrees higher than from the loss modulus graph. Changes in the physical properties, such as hardness and elasticity are observed. The temperature at which T<sub>g</sub> is observed depends largely on the chemical nature of the polymer chain. T<sub>g</sub> has an important bearing on the potential application of a polymer. After the transition from the glassy to the rubbery state, typical polymers acquire modulus values of approximately 200 MPa.

Polymers such as PLA due to their chain like structure exhibit a viscoelastic response. A stress results in an instantaneous strain, which continues to increase more slowly with time. It is this delay between cause and effect, that is, the stress and strain respectively, which is fundamental to the observed viscoelastic response resulting in creep, stress relaxation and dynamic response. The system is then said to be in a viscoelastic state and exhibits a ‘delayed elasticity’. A Maxwell model can be used to explain the dynamic response. It consists of a Maxwell element which consists of a purely elastic spring and a purely viscous damper connected in series. The application of a sinusoidal stress to a Maxwell element produces a strain with the same frequency as, but out of phase with, the stress. This is illustrated in Figure 1.2 where δ is the phase angle between the stress and the strain. The strain can be described in terms of its angular frequency ω and the maximum amplitude ε using complex notation, by

\[ \varepsilon^* = \varepsilon_0 \exp(i \omega \tau) \]  \hspace{1cm} (1.1)

Where, \( \omega = 2\pi \nu \), \( \nu \) is the frequency. The alternating stress and strain have the following relationship

\[ \sigma^* = \varepsilon^* E^*(\omega) \]  \hspace{1cm} (1.2)

![Harmonic oscillation of a Maxwell model](Cowie (1991))

Figure 1.2: Harmonic oscillation of a Maxwell model. Source: Cowie (1991)
\( E^*(\omega) \), is the frequency dependent complex dynamic modulus given as
\[
E^*(\omega) = E' (\omega) + iE'' (\omega)
\]
(1.3)
Where \( E' (\omega) \) is the storage modulus which measures the amount of energy stored instantaneously. \( E'' (\omega) \) is the loss modulus which lags behind the storage modulus and grows with time. It is defined as the ratio of the component 90° out of phase with the stress to the stress itself. It measures the amount of energy dissipated in the material. The elastic modulus \( E \) and the dynamic modulus \( E^*(\omega) \) have the following relationship;
\[
E = \left| E^* \right|
\]
(1.4)
hence,
\[
E = \sqrt{(E')^2 + (E'')^2}
\]
(1.5)
and,
\[
E = \sqrt{(E')^2 + (E'')^2}
\]
(1.6)
Equation 1.6 shows that the elastic modulus is almost equal to the storage modulus, depending on the value of the loss modulus. It is slightly smaller depending on the value of loss modulus. In this study the mechanical properties of PLA in particular the Storage and Loss Moduli, Loss Tangent and Glass Transition Temperature are determined over a temperature and amplitude range using Dynamic Mechanical Analysis.

2.0 EXPERIMENTAL SECTION
2.1 Samples
PLA films of A4 size and thickness 20 μm were obtained from Polyfilms limited, France. Rectangular strips of dimensions 30mm x 5mm x 0.02mm were used. However, the exact length of the samples was provided by the DMA, which automatically calculates it after the samples had been clamped.

2.2 Determination of the glass transition temperature (\( T_g \))
The DMA machine was set to the Multistrain mode using the tension film clamp. The recommended combination for a single-frequency temperature ramp of a frequency of 1 Hz and ramp rate of 3 °C per min was used. The glass transition temperature was recorded at a temperature of 50 °C using a ramp rate of 3 °C/min, a fixed frequency of 1 Hz and over an amplitude range of between 10 – 20 μm.

2.3 Determination of Modulus
Using the tension film clamp the DMA machine was set to the Multistrain mode. The real (storage) modulus \( E' \) and the imaginary (loss) modulus \( E'' \) components of the complex modulus \( E^* \), for a specimen of each sample were recorded at a temperature of 50 °C using a ramp rate of 3 °C/min, a fixed frequency of 1 Hz and over an amplitude range of between 10 – 20 μm.

3.0 RESULTS AND DISCUSSION
3.1 Glass transition temperature of PLA
Figure 3.1 shows the variation of the storage modulus of PLA with temperature at amplitude of 10 μm. The storage modulus of PLA decreased gradually within the temperature range of 47 – 60 °C from 2270 MPa – 1882 MPa. Between temperatures of 60 – 76 °C the decrease was rapid from 1882 MPa – 285 MPa. The storage modulus then decreased between the temperatures 76 – 85 °C from 285 – 75 MPa. This shows that a transition takes place within the 60 - 76 °C temperature range.

![Figure 3.1 Storage modulus of PLA against temperature](image-url)
For the variation of Loss modulus with temperature and amplitude of 10 μm, Figure 3.2 was obtained. From the peak of the loss modulus graph the T_g of PLA was found to be 65°C. T_g from the variation of loss tangent with temperature occurred at 74.3°C as per Figure 3.3.

Figure 3.4 shows the variation of storage and loss modulus as well as loss tangent with temperature for PLA at amplitude of 10 μm. The loss tangent graph is slightly shifted to the right and hence gives a T_g which is slightly higher than the loss modulus graph. Also, the region within which the storage modulus decreases rapidly coincides with the region where the peaks of the loss modulus and loss tangent arise. PLA is in the glassy state below 65°C according to the loss modulus graph and below 74.3°C according to the loss tangent graph. It has a storage modulus of 2220 MPa at 50°C. It is therefore quite stiff below these temperatures. After the glass transition, its storage modulus comes down to 285 MPa at 76°C.

The storage modulus of PLA at 50°C and amplitude of 10 μm was found to be 2220.00 MPa. The loss modulus for PLA was found to be 112.90 MPa at the same temperature and amplitude. Consequently, the elastic modulus of PLA was found to be 2222.87 MPa. The elastic modulus is directly proportional to the stiffness of a material. PLA is therefore stiff because it has a high elastic modulus at 50°C. This indicates that PLA is strong and tough at this temperature.
4.0 CONCLUSION

From the loss tangent curves, the glass transition temperature of PLA occurred at 74.3°C while from the Loss modulus curve it occurred at 65°C. PLA is therefore in its glassy state at 50°C and is therefore quite stiff. Above T_g PLA acquires a much lower modulus and therefore becomes more flexible. The elastic modulus of PLA is found to be 2222.87 MPa at 50°C. This is quite high as expected of a polymer in the glassy state. Above T_g PLA acquires a much lower storage modulus of 285 MPa at 76°C. These results indicate that PLA is a high modulus Polymer at room temperature and would therefore be suitable for use as a packaging material. Its flexibility would increase if exposed to higher temperatures of between 65 – 75°C and these property changes should therefore be taken into account. Since it is a biodegradable polymer, it would serve as a suitable alternative to the current materials obtained from fossil fuels as it is environment friendly and would decompose after use.
REFERENCES

LONG-TERM MEMORY EFFECT IN STOCK PRICES: AN EMPIRICAL STUDY FROM NAIROBI STOCKS MARKET

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ABSTRACT
This study demonstrated that Nairobi stock market asset return do not behave as any type of white noise processes using the Lo and MacKinlay variance ratio test. This was done by considering the Nairobi All Share Index (NASI) and testing for long memory using Classical Rescaled range analysis, Detrended Fluctuation Analysis and the semi-parametric approach Geweke and Porter-Hudak tests. Data sets consisted of daily return index of NASI for a consecutive period of 8 years, i.e. from when the index was launched in 2008 to 2013 and long memory tests for the returns series. All three tests suggested presence of long memory, while those of randomness test using variance ratio tests rejected the random walk hypothesis. The test for random walk model has a lot of implication in both theoretical as well empirical researches. Rejection of random walk model implies that the market is inefficient in processing information and one can predict future prices using past prices. Results show evidence of long memory in the Kenyan stock returns, which is inconsistent with weak-form market efficiency, implying that Kenyan stock index consists of impact of news and shocks in recent past. Speculative earnings could be gained via predicting stock prices. These findings will help investors, financial managers and regulators dealing with this market.

Key words: Hurst exponent, NASI, GPH, long memory, DFA, Variance Ratio Test.

1. INTRODUCTION
Many financial returns exhibit high autocorrelation at long lags as was first unearthed by Fama and French (1988) and Lo and MacKinlay (1988). The earliest of these studies in long memory were done by Mandelbrot (1971, 1972), Mandelbrot and Wallis (1969) who suggested that in the presence of long memory, arbitrage opportunities may exist as
new market information which cannot be absorbed quickly and martingale models of asset prices may not be justified. Using the rescaled-range (R/S) method, Greene and Fielitz (1977) reported evidence of persistence in daily U.S. stock returns series. However, Lo (1991) finds no evidence to support the presence of long memory in the same U.S. stock returns while using the modified rescaled analysis.

The existence of long memory in returns represents a strong possibility of predictability and evidence against weak form of efficiency. This price predictability would give traders a window for above normal profits that would require government efforts to curb the situation. Since this subject is critical both in theory and practice, it has attracted many and extensive research and a lot of literature exist on long memory dynamics with diverse results though in the Kenyan context none of these studies exist. It is with this background that this paper presents an attempt to investigate weak form efficiency of Kenyan stock market taking daily return index of NASI for a consecutive period of 8 years taken for the period 2008-2013 with 1462 observations. The study has employed various methods to examine the efficiency of Kenyan stock. The rest of the paper is divided into five sections as follows; Section one is introduction. The second section reviews some important literature on stock market efficiency. The third section describes data and methodology used. The empirical results are discussed in the fourth section followed by conclusion in the fifth section.

2. LITERATURE REVIEW
An attempt is made in this section to review important studies made on the same area. The phenomenon of long-range dependence has a long history and has remained a topic of active research in the study of economic and financial time series (e.g., see Lo (1991) and Cutland et al. (1995) and references therein). It is widespread in other areas in the physical and natural sciences (e.g., see Mandelbrot (1982) and Beran (1994) for details) and has been extensively documented in hydrology, meteorology and geophysics (see for example Mandelbrot and Wallis, 1968, 1969a,b,c). More recently, long-range dependence has also started to play an important role in the engineering sciences, especially in the analysis and performance modeling of traffic measurements from modern high-speed communications networks (for a recent bibliographical survey of this area, see Willinger et al., 1996).

The existence of long memory in returns and volatility suggests the presence of dependencies among observations. Kasman and Torun (2009) found that Long memory in return and volatility series were related with the high autocorrelation function which decays hyperbolically and finally died out. In contrast, if correlation between distant observations is negligible, the series possesses short memory and exhibits exponential decaying observations.


3. METHODOLOGY
3.1 Variance ratio test
The first attempt is to test for random walk hypothesis of NASI index. We consider a class of variance ratio tests used to test the hypothesis that a given time series or its first difference is a collection of i.i.d observations that follow a martingale difference sequence. Define the variance ratio of $k$-period return as

$$v(k) = \frac{\text{var}(x_t + x_{t-1} + \ldots + x_{t-k+1}) / k}{\text{var}(x_t)} = \frac{\text{var}(y_t - y_{t-1}) / k}{\text{var}(y_t - y_{t-1})} = 1 + 2 \sum_{i=1}^{k-1} \left( \frac{(k-i)}{k} \right) \rho_i$$

(1)
Where $\rho_i$ is the $i$th lag autocorrelation coefficient of $\{x_t\}$. $v(k)$ is a particular linear combination of the first $(k-1)$ autocorrelation coefficients, with linearly declining weights. When the returns are uncorrelated over time the relation $= \text{var}(x_i + x_{i+1} + ... + x_{i-k+1}) = k \text{var}(x_i)$, meaning that $V(k)=1$ exists.

A test can be constructed by considering a statistic based on the estimator of $v(k)$ such that

$$ VR(k) = \frac{\sigma^2(k)}{\sigma^2(1)} $$

of the one-period return variance and is defined as

$$ \sigma^2(1) = (T-1)^{-1} \sum_{i=1}^T (X_i - \mu)^2 $$

Where $\sigma^2(1)$ is the unbiased estimator

$$ = (T-1)^{-1} \sum_{i=1}^T (y_i - y_{i-1} - \mu)^2 $$

$$ = (T-1)^{-1} \sum_{i=1}^T (y_i - y_{i-1} - \mu)^2 $$ (2)

With $\mu = T^{-1} \sum_{i=1}^T X_i$ being the estimated mean. The estimator of $k$-period return variance $\sigma^2(k)$ can be estimated by various methods, Lo and MacKinlay (1988) suggested a method of overlapping long horizon return defined as

$$ \sigma(k) = m^{-1} \sum_{i=1}^T (x_i + x_{i-1} + ... + x_{i-k+1} - k \mu)^2 $$

$$ = m^{-1} \sum_{i=1}^T (y_i + y_{i-k} - k \mu)^2 $$ (3)

Where $m = k (T - k + 1)(1 - k T^{-1})$. $m$ is chosen such that $\sigma^2(k)$ is an unbiased estimator of the $k$-period return variance when $\sigma_T$ is constant over time.

3.2 Lo and Mackinlay (1988) variance ratio tests

Lo and MacKinlay (1988) by assuming $k$ if fixed when $T \to \infty$ proposed an asymptotic distribution of $VR(x;k)$. They showed that if $x_t$ is i.i.d under the null hypothesis that $v(k)=1$, the test statistic $M.(k)$ is given by

$$ M.(k) = \frac{VR(x;k) - 1}{\phi(k)^{1/2}} $$ (4)

which follows the standard normal distribution asymptotically. The asymptotic variance, $\phi(k)$, is given by

$$ \phi(k) = \frac{2(2k-1)(k-1)}{3kT} $$ (5)

To accommodate $x_t$ exhibiting conditional heteroscedasticity, Lo and MacKinlay (1988) proposed the heteroscedasticity robust test statistic $M.(k)$ as it is a general consensus among the financial economist that the variance of financial time series data changes over time. Lo and Mackinlay (1988) however states that the variance ratio test will approach unity despite the fact that the data is heteroscedastic. The statistic $M.(k)$ is given by

$$ M.(k) = \frac{VR(x;k) - 1}{\phi^*(k)^{1/2}} $$ (6)

which follows the standard normal distribution asymptotically under null hypothesis that $v(k) = 1$, and

$$ \phi^*(k) = \sum_{j=1}^k \left[ \frac{2(k-j)}{k} \right]^2 \delta(j) $$ (7)

The $M.(k)$ test is applicable to a time series generated from a martingale difference process. The usual decision rule for the standard normal distribution is applied to both tests.
3.3 The Hurst coefficient, $H$

The second technique we use is due to the hydrologist H.E Hurst dealing with the data of water heights of the Nile river around 1951. He constructed the Range Statistics, here denominated (R/S) which is now known as the Hurst coefficient or exponent “$H$” and he defined a rescaled range “R/S” statistics, which can be described as the span of the partial sums of the gap of a time series to its average divided by its standard error:

$$\left(\frac{R}{S}\right)_t = \frac{1}{\frac{T}{\sum (X_t - X\bar{t})^2}} \left(\max_{1<k<T} \sum_{j=1}^{k} (X_j - X\bar{t}) - \min_{1<k<T} \sum_{j=1}^{k} (X_j - X\bar{t})\right)$$  \hspace{1cm} (8)

It has been proved (Mandelbrot, 1972) that this statistics is asymptotically proportional to $T^H$, where $T$ is the number of observations and the constant $H$, $0 < H < 1$ is precisely the Hurst exponent.

We can thus write;

$$\left(\frac{R}{S}\right)_t = cT^H$$ \hspace{1cm} (9)

Where $c$ is a constant. The Hurst exponent it therefore the estimated slope coefficient obtained by regressing with the OLS technique the logarithm of $\left(\frac{R}{S}\right)_t$ versus the logarithm of the time $T$. i.e.

$$\ln \left(\frac{R}{S}\right)_t = \ln(c) + H \ln(T)$$ \hspace{1cm} (10)

The $H$ obtained has some disadvantages. Its theoretical distribution is unknown (Hosking 1984), it is highly sensitive to the short term dependence (Lo 1991). It is also impossible to have the standard error and the probability law associated with the estimator. To overcome this Lo (1991) developed another test to short range dependence given by

$$\frac{1}{\sqrt{T}} \left(\max_{1<k<T} \sum_{j=1}^{k} (X_j - X\bar{t}) - \min_{1<k<T} \sum_{j=1}^{k} (X_j - X\bar{t})\right)$$

With $\sqrt{T}$ being a non-parametric estimator of the weighted sum of auto covariances at lag $q$. When $q = 0$ the modified Lo’s statistics is similar to Hurst’s. Teverovsky Taquq and Willinger (1995) showed however that the Lo’s estimator might after all eliminate a long term memory which is actually present. In view of this we stick to the $H$ statistic and don’t attempt to compute Lo’s statistic but use other tests for long memory.

The R/S approach was transposed in the field of finance by Mandelbrot (1965, 1972). The value of the exponent $H$, which lies between 0 and 1, allows to distinguish the time series. When $H = 0.5$, this can be modeled by the white noise, there is no long term dependence, the financial market might be efficient and is independent; when $0.5 < H < 1$ there is a long term memory, the market is inefficient and one can speak of a persistence effect, the time series will show clusters of comparable values. On the other hand, when $0 < H < 0.5$, there is a short term memory; one can speak of an anti persistence effect. In general Hurst exponent tells us when there is a long memory process and does not provide the local information needed for forecasting.

3.4 Detrended Fluctuation Analysis (DFA)

The Detrended Fluctuation Analysis (DFA) proposed by Peng(1994) is an improvement of classical Fluctuation Analysis (FA) and, according to Grau-Carles (2006), is supposed to deal with power-law correlations in non-stationary time series. This is accomplished by performing linear or higher polynomial order time detrending of the time series in several non-overlapping intervals separately. The method can be summarized as follows:-

1. Calculate cumulative sum series: $Z_t = \sum_{i=1}^{t} (Y_i - Y\bar{t})$ for $t = 1, 2, \ldots, n$

2. Divide the whole set into $k$ non-overlapping intervals with $m$ observations in each and perform least squares regression of $Z_t$ on a (linear or higher polynomial order) function of time.

3. Calculate the fitted values from these regressions $\hat{Y}_{mt}$

4. Compute $F_m = \sqrt{\frac{1}{m.k} \sum_{i=1}^{m.k} \left[ y_i - \hat{Y}_{mt} \right]^2}$ for several values of $m$ and $k$
5. Regress $\log(F_m)$ on $\log(m)$ and estimate the slope parameter $\gamma$ by OLS

The slope parameter $\gamma$ has similar interpretations as the Hurst parameter, $H$ discussed above. Unfortunately, no asymptotic distribution theory has been derived for the DFA statistics so far (Grau-Carles, 2006). Hence, no explicit hypothesis testing can be performed and the significance relies on subjective assessment.

3.5 Geweke and Porter-Hudak Estimator (GPH Estimator)

Geweke and Porter-Hudak (1983), henceforth GPH, suggested a semi-parametric estimation of the fractional differencing estimator, $d$, that is based on observations of the slope of the spectral density function of a fractionally integrated series around the angular frequency $\omega = 0$ and does not require complete parameterization of unknown ARMA dynamics. They showed that the spectral density function of a general fractionally integrated model with differentiating parameter $d$ is identical to that of a fractional Gaussian noise with Hurst exponent $H = d + 0.5$. The GPH method can be used to estimate $H$. The estimator exploits the theory of linear filters to write the process $(1-L)^d Y_t = \mu + \epsilon_t$, where $\mu \leq I(0)$, as

$$SY(\omega) = \frac{1}{1 - e^{-i\omega}} s\mu(\omega),$$

where $SY(\omega)$ and $s\mu(\omega)$ are the spectral densities of $Y_t$ and $\mu$, respectively. Consider a sample series of $Y_t$ of size $T$. Taking logarithms of (13) and evaluating at harmonic frequencies $\omega_j = 2\pi j / T$, $j = 0,1,\ldots,T-1$ where we have

$$\ln(S(\omega_j)) = \ln(s(0)) - d \ln(4\sin^2(\omega_j / 2)) + \ln[s\mu(\omega_j)/s\mu(0)]$$

For low-frequency ordinates $\omega_j$ near 0, say $j \leq n < T$, the last term is negligible compared with the other terms. Adding $I(\omega_j)$, the periodogram at ordinate $j$, to both side of (14) yields

$$\ln(I(\omega_j)) = \ln(s(0)) - d \ln(4\sin(\omega_j / 2)) + \ln[I(\omega_j)/SY(\omega_j)]$$

This suggest estimating $d$ using a simple linear regression equation

$$\ln(s(\omega_j)) = \beta_0 + \beta_1 \ln(4\sin^2(\omega_j / 2)) + \varepsilon_j, j=1,2,\ldots,n$$

where $\varepsilon_j$ equal $\ln[I(\omega_j)/s(\omega_j)]$ is asymptotically i.i.d. across harmonic frequencies and

$$n = g(T)$$

is an increasing function of $T$. The theoretical asymptotic variance of $\varepsilon_j$ is known to be equal to $\frac{\pi^2}{6}$ which is often imposed in estimation to raise efficiency. Under some regularity conditions on $g(T)$, Geweke and Porter-Hudak (1983) showed that the least-square estimate of $\beta_1$ provides a consistent estimate of $d$ and hypothesis testing concerning the value of $d$ can be based on the $t$-statistics of the regression coefficient. When $d=0$, the random process $X_t$ equals to $\epsilon_t$ and therefore,

On the other hand, when $d=1$, $X_t$ follows a unit root process with a zero mean and infinite variance (Tkacz, 2001). If $d$ is non-integer, the random process $X_t$ becomes fractionally integrated, namely ARFIMA process. Hosking (1981) shows that when $0<d<\frac{1}{2}$ the autocovariance function of the random process declines hyperbolically to zero as a long-memory process. When $\frac{1}{2}<d<1$, the random process takes an infinite variance but still reverts to its trend in the very long run (Tkacz, 2001). Periodogram regression is the only of the presented methods, which has known asymptotic properties. The features of the fractional integration parameter ($d$) are summarized in Table 1 below:

<table>
<thead>
<tr>
<th>$d$</th>
<th>Variance</th>
<th>Shock Duration</th>
<th>Stationarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Infinite</td>
<td>Short Memory</td>
<td>Stationary</td>
</tr>
<tr>
<td>0&lt; $d$ &lt;0.5</td>
<td>Finite</td>
<td>Long Memory</td>
<td>Stationary</td>
</tr>
<tr>
<td>0.5 $\leq$ $d$ &lt;1</td>
<td>Infinite</td>
<td>Long Memory -Finite Impact Reflect</td>
<td>Nonstationary</td>
</tr>
<tr>
<td>$d$=1</td>
<td>Infinite</td>
<td>Finite-Not Revert to Its Mean</td>
<td>Nonstationary</td>
</tr>
<tr>
<td>$d$&gt;1</td>
<td>Infinite</td>
<td>Finite-Not Revert to Its Mean</td>
<td>Nonstationary</td>
</tr>
</tbody>
</table>

4. **EMPIRICAL RESULTS**

4.1 **Data**

The study utilizes daily close of business return for Nairobi All Share Index (NASI) from January 2008 to 31 December 2013 primarily sourced from NSE. This period is the most recent. The economy during this period has been characterized by various challenges at different point in time e.g the post-election violence of Dec 2008 and the March 2013 elections that pessimists expected it to be chaotic, leading to some fluctuations in the stock prices. This study which uses the data set covering the crisis period and the ‘hoped’ crisis is, therefore, relevant and instructive for the analysis. The returns are calculated in the usual format by taking the first differences of the natural logarithm of the stocks rates as follows:

\[ Y_t = \log P_t - \log P_{t-1} \]

Where \( Y_t \) is the present day index and \( \log P_t \) is the natural logarithm of the present day’s index and \( \log P_{t-1} \) is the natural logarithm of the previous day’s index. The descriptive statistics of NASI index is reported in table 2 below.

<table>
<thead>
<tr>
<th>Indices</th>
<th>Mean</th>
<th>Median</th>
<th>Std.Dev</th>
<th>Skewness</th>
<th>Ex-Kurtosis</th>
<th>Jarque-Bera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return</td>
<td>0.0001043</td>
<td>2.7198e-005</td>
<td>0.0040636</td>
<td>0.99327</td>
<td>10.776</td>
<td>7314.06</td>
</tr>
</tbody>
</table>

The average return of the index is positive accompanied with a positively skewness. The index is also leptokurtic suggesting that the distribution has a higher peak around the mean compared to normal distribution. These peaks further suggest that the index is highly concentrated around the mean, due to lower variations within observations. All these together with a large value of Jarque-Bera statistic of 7314.06 leads to rejection of null hypothesis of zero P-value indicates that the return series of NASI index has non-normal distribution. These findings are in accordance with many other previous studies on stock market indices. This does not however disqualify the market efficiency hypothesis but makes it less simple to ascertain.

4.2 **Unit root test**

There is need to have some regularity in the way the random nature of the time series is generated if at all one has to be sure that the information on the past behavior of an asset’s price is of some value in predicting its future. This also implies that any models that claim to explain this behavior must also possess this fundamental regularity. One way of doing this is the concept of stationarity. To this aim, we apply alternatively three standard tests of stationarity: the Augmented Dickey Fuller (ADF), the Phillips Perron (PP) and the Kwiatkowskiet al (1992) (KPSS) test in an attempt to detect presence of unit root. Three tests differ in the null hypothesis. The null hypothesis of the ADF and PP test is that a time series contains unit root while KPSS test has the null hypothesis of stationarity. Based on the three tests we conclude that the index is stationary. Further differencing is therefore unjustified.

<table>
<thead>
<tr>
<th>Series</th>
<th>Coeff</th>
<th>t-ratio</th>
<th>P-value</th>
<th>Coeff</th>
<th>t-ratio</th>
<th>P-value</th>
<th>Coeff</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NASI index</td>
<td>-0.5423</td>
<td>-7.304</td>
<td>4.9e-01*</td>
<td>0.3830</td>
<td>0.642743</td>
<td>0.084</td>
<td>-815.6195</td>
<td>0.01*</td>
</tr>
</tbody>
</table>

* Represent the rejection of null hypothesis at 5% level of significance.

The null hypothesis for the presence of unit root in ADF and PP test is rejected at 5% confidence interval. KPSS test does not reject the null hypothesis of stationarity and thus based on the three tests we conclude that the index is stationary. Further differencing is therefore unjustified.

4.3 **The Variance Ratio Test**

Table 4 below shows the results of the Lo-MacKinlay,VR(k) test.
Table 4: Variance Ratio Test.

<table>
<thead>
<tr>
<th>Number of lags(k)</th>
<th>VR(q)</th>
<th>M₁(k)</th>
<th>M₂(k)</th>
</tr>
</thead>
<tbody>
<tr>
<td>k=2</td>
<td>1.447371</td>
<td>17.105721*</td>
<td>6.091656*</td>
</tr>
<tr>
<td>k=4</td>
<td>1.993627</td>
<td>20.307815*</td>
<td>7.578439*</td>
</tr>
<tr>
<td>k=8</td>
<td>2.260978</td>
<td>16.299608*</td>
<td>6.610438*</td>
</tr>
<tr>
<td>k=16</td>
<td>2.238889</td>
<td>12.064810*</td>
<td>5.554083*</td>
</tr>
<tr>
<td>k=32</td>
<td>2.492629</td>
<td>8.947363*</td>
<td>4.744462*</td>
</tr>
</tbody>
</table>

The variance ratio VR(k) and \(M₁(k)\) are calculated for the data set for the cases \(k = 2, 4, 8, 16,\) and 32. The heteroscedasticity consistent variance ratio tests are also performed by calculating the \(M₂(k)\) for each of the cases i.e. \(k = 2, 4, 8, 16,\) and 32. The variance ratios are reported in the row one, while the \(M₁(k)\) and \(M₂(k)\) statistics are reported in row two and three. The variance ratio estimates in Table 4 above are more than unity for all the \(k\) periods suggesting a persistence behavior. The RVH is rejected under the assumptions of the hypothesis of homoscedasticity and heteroscedasticity in all five sampling intervals at 5% confidence interval. The 95% confidence interval in figure 2 below clearly shows the confidence band and that the test statistics \(M₁(k)\) and \(M₂(k)\) lie outside their respective confidence interval band.

![Figure 2: Variance ratios and 95% confidence band](image)

Results in Table 5 below further shows the p-values which supports rejection of RWH both under homoskedastic and heteroskedastic assumption.

Table 5: Confidence interval for a two sided Variance ratio test

<table>
<thead>
<tr>
<th>Holding period</th>
<th>2.5%</th>
<th>97.5%</th>
<th>Lo McKinley P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>k=2</td>
<td>-2.001386</td>
<td>1.859152</td>
<td>0</td>
</tr>
<tr>
<td>k=4</td>
<td>-1.952516</td>
<td>1.828788</td>
<td>0</td>
</tr>
<tr>
<td>k=8</td>
<td>-1.802827</td>
<td>1.817451</td>
<td>0</td>
</tr>
<tr>
<td>k=16</td>
<td>-1.659788</td>
<td>1.746088</td>
<td>0</td>
</tr>
<tr>
<td>k=32</td>
<td>-1.814930</td>
<td>1.820448</td>
<td>0</td>
</tr>
</tbody>
</table>

Thus the null hypothesis that variance ratio is not statistically different from zero is rejected for the NASI return index.

4.4 Result for tests for long memory

We now turn out attention to investigate the existence of long memory having established that NASI return index does not follow a random walk. Figure 1 below shows the rescaled range analysis for NASI return series together with an estimated Hurst exponent value of 0.679796 which suggesting existence of long memory.

![Figure 1: Rescaled range figures for Return series](image)
Regression results (n = 8)

<table>
<thead>
<tr>
<th>coeff</th>
<th>std. error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.14302</td>
</tr>
<tr>
<td>Slope</td>
<td>0.019413</td>
</tr>
</tbody>
</table>

Estimated Hurst exponent = 0.679796

Results of DFA are displayed as in figure 3 below with an estimated H of 0.633.

![Figure 3: DFA performed on the NASI data](image)

As noted in methodology DFA result interpretation is similar to that of rescaled range. This result in figure 3 differs slightly from those in figure 1 above. Hence the DFA further rejects RWH and suggests long memory property in NASI return. Finally the fractional differencing test GHP is performed on the NASI stock data. The fractional differencing test serves to unearth the fractal structure in a time series based on the spectral analysis of its low frequency dynamics. In applying GHP spectral procedure, the number of low frequency ordinates, ω used in the spectral regression is a matter of choice. While too large value of ω will lead to over estimation of d due to medium or high frequency components a small ω will lead to imprecise estimates due to limited degrees of freedom in estimation. To balance these two considerations, we experiment with a range of μ used for the sample size function ω = T^μ where T is the number of observations. The results reported are for μ = 0.5. Table 7 below contains estimate for the fraction parameter d from the GHP fractional regression.

<table>
<thead>
<tr>
<th>Series</th>
<th>d</th>
<th>std</th>
<th>Residual std</th>
</tr>
</thead>
<tbody>
<tr>
<td>NASI index</td>
<td>0.09548047</td>
<td>0.1212834</td>
<td>0.1267542</td>
</tr>
</tbody>
</table>

The d estimates are reported together with their standard error and residual standard error. Using Table 1 above to interpret the result we conclude presence of significant memory in NASI return series.

5. CONCLUSION

Using the variance ratio as a test to check the random walk hypothesis, we conclude that the NASI index does not follow a random walk. Therefore, the NASI index can be considered to be a weak-form efficient. Having known this,
we went ahead to test the existence of long memory by the use of the classical rescaled range analysis, DFA and GHP and concluded the existence of long memory. The test for random walk model has a lot of implication in both theoretical as well empirical researches. The rejection of random walk model implies that the market is inefficient in processing the information and one can predict the future prices using past prices. A Possible extension is to work with individual stocks instead of indices because one can suspect that some equities might be subject to semi-strong inefficiency.

Generally, the results show the evidence of long memory in the Kenyan stock returns, which is inconsistent with the weak-form market efficiency, implying that the Kenyan stock index (NASI) consists of the impact of news and shocks occurred in the recent past. Hence, speculative earnings could be gained via predicting stock prices. These findings would be helpful to the investors, financial managers, and regulators dealing with the Nairobi stock market. The regulators should understand sources of long-term memory in the market to improve efficiency.

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MORPHOLOGICAL, GENETIC AND SYMBIOTIC CHARACTERIZATION OF ROOT NODULE BACTERIA ISOLATED FROM BAMBARA GROUNDNUTS IN SOILS OF LAKE VICTORIA BASIN

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ABSTRACT

Bambara groundnut (Vigna subterranea L. Verde) was used to trap root nodule bacteria in four soils obtained from farmers' fields in Lake Victoria basin, western Kenya. Sixty four isolates were obtained and morphological and genetic evaluation resulted in different groups whose distribution was strongly influenced by characteristics of the soil at the site of isolation. Morphologically, majority (70%) of the isolates grew fast and very fast on Yeast Manitol Extract Agar, 26% were intermediate, while 3% were slow growers. The fast, very fast and some intermediates showed positive acid reaction, while the rest showed positive reaction in alkaline conditions. The 16S rRNA gene sequences had above 97% similarities to diverse groups including Rhizobium sp., Bradyrhizobium sp., Burkholderia sp. and Agrobacterium sp. previously isolated from crop plants. Phylogenetic analysis of 18 representative sequences yielded 3 clades with Rhizobium and Agrobacterium type sequences belonging to a single clade, while Bradyrhizobium and Burkholderia type sequences clustering into separate clades. In glasshouse experiments, 7 isolates identified as Bradyrhizobium sp. and Burkholderia sp. produced above 20 effective nodules per plant and corresponding high total biomass values, with one Rhizobium sp. producing similar results. The rest of the isolates showed low levels of nodulation, most of which were ineffective. This study revealed a high diversity of rhizobium bacteria symbiotic to bambara groundnuts in the soils of L. Victoria basin, which should be utilized to enhance its productivity and to improve databases on indigenous rhizobia populations.

Key words: Characterization, 16S rRNA gene phylogenetics, Nitrogen fixation

INTRODUCTION

Symbiotic nitrogen fixation between leguminous plants and the α- and β-proteobacteria bacteria, collectively known as the ‘rhizobia’, results in reduction of free atmospheric nitrogen into ammonia that can fully or partially satisfy the nitrogen demand of the host plant (Sprent, 2001; Chen et al., 2003; MacLean et al., 2007; Dai et al., 2012). This process is a sustainable and low-cost alternative to inorganic fertilizers in African small farming systems, although it is highly underutilized partly because of insufficient information on its mechanism, biological background and management. An important strategy for overcoming this drawback is the identification of resident (both native and naturalized) and environmentally adaptable rhizobial strains with superior symbiotic abilities and their utilization in local cropping systems (Mothapo et al., 2013). Through methodical isolation and screening for symbiotic effectiveness, it is possible to identify elite resident strains with adaptive abilities for higher nodulation, increased plant nitrogen content and improved crop productivity.

Bambara groundnut (Vigna subterranea L. Verde) is the second most important African indigenous grain legume after cowpea (Azam-Ali et al., 2001) and it belongs to the family Leguminosae, subfamily Papilionoideae and ‘tribe’ Phaseoleae (Sprent et al., 2010). In Lake Victoria basin of Western Kenya, bambara groundnuts has gained prominence as an alternative dietary protein source with numerous agronomic advantages to smallholder farmers. It is drought tolerant (Azam Ali., 2001) and is grown in mixed intercropping systems with no addition of fertilizers because of its ability to form symbiosis with root nodule bacteria fixing nitrogen into the soil (Mkandawire et al., 2007). However, information on nitrogen-fixing bacteria symbiotic to bambara groundnuts in the soils of this region...
is largely unexplored yet it has great potential in soil fertility management and resultant increased crop yields. Given
the variation in physicochemical properties of the soils of Lake Victoria basin (Jaetzold et al., 2007), selection of
competent rhizobia for bambara groundnuts in the different soils is a necessary step towards improving its production.

Studies on bambara groundnut symbioses in other parts of the world have indicated it is non-selective in its rhizobial
requirements (Doku and Karikari, 1971) although it shows increased yield and symbiotic efficiency under inoculation
with Bradyrhizobium sp. (Gueye et al., 1998). Sprent and colleagues (Sprent et al., 2010) listed five α-proteobacteria
members, including Rhizobium, Bradyrhizobium, Azorhizobium, Ensifer and Mesorhizobium, as possible nodulators
of bambara groundnuts although their levels of effectiveness is not fully established (Kanu et al., 2012). More
recently, Mohale et al., (2013) reported the highly ‘promiscuous’ nature of bambara groundnuts forming nitrogen-
fixing symbiosis with a wide range of bacteria, including some members of the β-proteobacteria such as the N-fixing
Burkholderia. Despite these advances, it still remains to be determined if the diverse groups symbiotic to bambara
groundnuts exist in the soils of Lake Victoria basin in Kenya, and more crucially if they have agronomic advantages
to smallholder farming systems.

Edaphic factors and prevailing environmental conditions have previously been shown to determine the distribution of
resident rhizobial populations. For instance, soil pH and P (Graham et al., 1994; Anyango et al., 1995; Chemining’wa
and Vessey, 2006; Mothapo et al., 2013), temperature (Prevost et al., 2003) salinity and moisture content (Giller,
2001) have a strong influence on the diversity of rhizobial strains within diverse agro-ecological regions. Resident
rhizobia develop ecological strategies to survive the prevailing conditions and comparative tests against commercial
strains might reveal strains with better influence on N-fixation and plant growth promotion. In this study, we isolated
64 strains of root nodule bacteria symbiotic to bambara groundnuts in four soil types of Lake Victoria basin in Western
Kenya and combined morphological and molecular identification using 16S rRNA gene sequences to determine their
diversity. The symbiotic status of eighteen representative isolates from Lake Victoria basin soils was determined
against one reference strain Bradyrhizobium sp. strain KFR269 and one commercial strain Bradyrhizobium japonicum
strain USDA110.

MATERIALS AND METHODS

Soil sampling procedures

Soil sampling was done at selected farmers’ fields, that had no history of inoculation, in Kisumu, Port Victoria, Kendu
Bay and Karungu within the Lake Victoria basin. Site characteristics are listed in Table 1. At each sampling point, 1
kg of soil was collected from a depth of 5 - 20 cm using a shovel. The shovel was cleaned before sampling with 5%
sodium hypochlorite solution, then rinsed with water three times and dried using a sterile cloth. Within each site, four
replicate samples were collected within an area of 10 m² by randomly sampling four corners. The soil samples were
then mixed to form a composite sample. The soil samples were placed in brown paper bags and stored away from
sunlight at room temperature and subsequently used for soil analysis and rhizobia isolation.

Soil analysis

Soil samples were air dried, crushed using a wooden roller and passed through a 0.5 cm mesh to remove any plant
or grass fragment. Four hundred grams of the prepared soil samples were placed in brown paper bags, tightly sealed
and submitted to Kenya Agricultural Research Institute’s National Agricultural Research Laboratories in Nairobi for
soil chemical analysis. Soil pH was evaluated using a Pye-Unican pH meter Model 290-MK2, (Mettler-Toledo Inc,
Canada) at a soil to water ratio of 1:2.5. A modified Walkley-Black dry combustion method was used to determine the
percentage of organic C in the soil samples (Anderson and Ingram, 1993). Total N was evaluated using the macro-
Kjedahl method as modified by Anderson and Ingram (1993), while available P was analyzed by the Bauschand Lomb
supertonic spectrophotometer after extraction using the BrayP1 method (Bray and Kurtz, 1945). Exchangeable K and
Na were evaluated using flame photometry while Mn, Cu, Zn and Mg were determined by titration using 0.02 N EDTA
solution (Lindsay and Norvell, 1978).

Soil trapping, isolation and morphological characterization

The host plant infection technique according to Bala, (2011) was used to trap indigenous root nodule bacteria symbiotic
to bambara groundnuts from the collected soil samples. A local landrace of bambara groundnut with cream colored
seeds, preferred by farmers in the region because of early maturity, superior cooking quality and taste, was chosen for
this study. The seeds were surface sterilized in 95% ethanol for 1 min, followed by 2% sodium hypochlorite solution
for 30 seconds and finally rinsed in five exchanges of sterile water. Plastic pots (20 cm diameter and 25 cm height)
were filled with collected soil samples and watered with sterile water until adequately wet. Five seeds were planted in each pot allowing adequate space for germination but were later thinned to two. Watering was done twice a day in the morning and evening. After 45 days of growth, the plants were carefully uprooted and soil carefully washed off the roots without detaching the nodules.

Three to five well-formed nodules were sampled per pot and categorized depending on the size (small or large) for isolation. Nodules were surface sterilized by immersion in 96% ethanol for 3 seconds followed by immersion in 2% sodium hypochlorite for 3 minutes and finally rinsed several times in sterile water. They were crushed in three drops of sterile water using a sterile glass rod and streaked on Yeast Extract Mannitol Agar (YEMA) media with 10% Congo red (CR) and repeated on YEMA with 0.5% Bromothymol blue (BTB). The plates were sealed and incubated in dark cabinets at 28 °C and observed daily for isolated colonies. Repeated streaking of single colonies on fresh YEMA plates resulted in sixty four isolates which were allocated identities as per the site of origin (Table 1). Morphological characterization was done to determine their growth rate, colony shape, colony appearance, colony texture and reaction in media pH, according to the methods of Woomer et al., (2011).

Evaluation of isolates using the 16S rRNA gene

Sixty four pure isolates were genetically characterized using a 16S rRNA gene approach. Genomic DNA was extracted from pure bacterial isolates using the ZR Bacterial DNA MiniPrep™ kit according to the manufacturer’s specifications (Zymo Research Corp, South Africa).

Table 1. Characteristics of soil sampling sites and identities of isolates obtained per site

<table>
<thead>
<tr>
<th>Site</th>
<th>Site location</th>
<th>Agro-climatic zone</th>
<th>Soil type</th>
<th>Legume history</th>
<th>No. of isolates</th>
<th>Isolate identities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kisumu</td>
<td>0°6'0N 34°45'0E</td>
<td>Sub-humid lower midland</td>
<td>Clay loam</td>
<td>Common beans</td>
<td>22</td>
<td>BAMKis1–22</td>
</tr>
<tr>
<td>Karungu</td>
<td>0°51'0S 34°8'60E</td>
<td>Semi-humid lower midland</td>
<td>Sandy loam</td>
<td>Common beans</td>
<td>16</td>
<td>BAMKar1-16</td>
</tr>
<tr>
<td>Kendu bay</td>
<td>0°22'0S 34°38'60E</td>
<td>Semi-humid lower midland</td>
<td>Sand</td>
<td>Groundnut</td>
<td>14</td>
<td>BAMKbay1-14</td>
</tr>
<tr>
<td>P. Victoria</td>
<td>0°6'0N 33°58'0E</td>
<td>Sub-humid lower midland</td>
<td>Sandy loam</td>
<td>Common beans</td>
<td>12</td>
<td>BAMSsp1-12</td>
</tr>
</tbody>
</table>

The concentration and purity of DNA was estimated using a Nanodrop™ Lite Spectrophotometer (Thermo Scientific Inc, USA) at 260-280 nm and by horizontal gel electrophoresis (Thistle Scientific Ltd, USA) on a 0.8% (w/v) agarose gel at 100 V for 30 min and visualized under UV after staining with GelRed™ (Thermo Scientific, USA). The PCR primers targeting the bacterial 16S rRNA gene used were: 27F (AGA GTT TGA TCM TGG CTC AG) and 1492R (GGT TAC CTT GTT ACG ACT T) (Eden et al., 1991; Jiang et al., 2006). Bioneer AccuPower® PCR Premix (Bioneer Inc, USA) was used to perform PCR. To each 20 μl Bioneer tube μl of 50 ng template DNA, 0.5 μl of 10 picomole of each primer and 18 μl nuclease free water were added and mixed. Amplification of 16S rRNA gene region was performed in a programmable Mastercycler thermocycler (C1000-BioRad, USA) with an initial denaturing step at 94°C for 5 min, 30 cycles of denaturing at 94°C for 30 sec, primer annealing at 58°C for 1 min, and primer extension at 72°C for 1 min, followed by a final extension step at 72°C for 7 min. PCR products were separated by horizontal gel electrophoresis on 1.5 % (w/v) agarose gel at 100 V for 45 mins and visualized under UV after staining with 2 μl GelRed™ (Thermo Scientific, USA). PCR products were purified using a Qiagen MinElute PCR Purification Kit (Qiagen Inc, USA) according to the manufacturer’s protocol. Purified PCR products were sequenced at the Segolip Sequencing Unit, BecA-ILRIHub, by capillary sequencing on a 3730x/ DNA Analyzer, (Thermo Fisher Scientific Inc, USA). Forward and reverse sequences were assembled on CLC Main Workbench (CLC Bio, Version 6.8.3). Assembled sequences were transferred to MEGA Version 6.0 software and aligned using CLUSTAL W according to Tamura et al., (2011). Sequences were submitted to the NCBI BLAST portal (www.ncbi.blast.nlm.nih.gov) for a sequence similarity search, and sequences with greater than 97% similarity were retrieved for phylogenetic analysis. Evolutionary histories were inferred using the Neighbor-Joining method and distances computed using the Maximum Composite Likelihood (Tamura and Kumar, 2004). Bootstrap tests (1000 replicates) were used to cluster associated taxa and replicate trees with above 50 % likelihoods indicated on the branches. All trees were drawn to scale, with branch lengths in the same units as those of the evolutionary distances used to infer the phylogenetic tree. All positions containing gaps and missing data were eliminated.
Determination of symbiotic status

Sixty four root nodule bacteria colonies isolated from bambara groundnuts were evaluated by 16S rRNA gene sequences and the maximum identity with those at the NCBI gene bank obtained. Based on the results, 18 isolates representative of all the genera identified were selected for determination of symbiotic status. One strain *Bradyrhizobium* sp. KFR 269 from Dr. David Odee’s rhizobial collection at Kenya Forestry Research Institute’s headquarters in Muguga and a commercial strain *Bradyrhizobium japonicum* USDA110 were chosen as reference strains based on previous reports that bambara groundnuts nodulate better with *Bradyrhizobium* sp. (Sprent *et al.*, 2010). Bambara groundnut seeds were prepared as previously described and spread on water-agar (ratio 4:1) plates. The seeds were inverted and incubated in dark at 25°C for germination and were considered to be successfully germinated when their radicles reached the same length as the seed or longer. Improvised Leonard jars were prepared by sterilizing in 5% sodium hypochlorite solution for 15 minutes. Vermiculite obtained from a commercial supplier in Nairobi’s industrial area was sterilized at 121°C for 1 hour and the pH normalized to near neutral using 5% CaCO₃ solution and then filled in the jars. Two seedlings were aseptically transferred into the vermiculite and watered using sterile N-free nutrient solution (Somasegaran and Hobben, 1984) and covered with clean brown paper bags to minimize evaporation while the seedlings became established. The inoculum was prepared by streaking each isolate on freshly prepared YEMA plates. One ml of the pure culture was aseptically picked, re-suspended into sterile bottles containing 10 ml of YEMA broth and left on a shaker overnight.

Eight replicates per isolate were inoculated directly around seedling hypocotyls three days after establishment using sterile disposable pipette tips. On each occasion, 1 ml (about 10⁷ cells) of bacterial suspension was used to inoculate each seedling. Immediately after inoculation, vermiculite surfaces were covered with steam sterilized sand to inhibit contamination. Glasshouse controlled conditions were a 16/8 h light/dark cycle, 25/18°C day/night temperature and 70% relative humidity. Test seedlings and the negative control were irrigated twice per week with a nitrogen-free nutrient solution while the positive control was inoculated with 0.05% KNO₃ solution to supply the plants with nitrogen. After 5 weeks, the growth media was gently shaken off, the roots carefully washed and the number of well-formed nodules counted.

Nodules, roots and shoot from the same pot were considered to belong to the same unit and were put in marked 2×1.75 cm zip lock polythene bags for laboratory analysis. Fresh weights in grams of each unit was taken in four replicates and recorded. Dry weights of nodules, shoots and roots were obtained by putting the samples in an oven set at 70°C for four days followed by weighing on an analytical electronic balance (The Lab Depot Inc, USA). Data values were subjected to analysis of variance using Genstat 16th Edition (www.genstat.co.uk) and significant means were separated using Least Significant Difference at *P*≤0.05.

RESULTS

Chemical analysis of soils

Soils chemical properties of the four study sites are given in Table 2. Soil samples from Kendu Bay and Port Victoria were moderately acidic with pH value ranges of 6.26–6.30 unlike Karungu and Kisumu which had strongly acidic soils at 4.10–4.11. Soil P varied with soils from Kendu Bay and Port Victoria having high values ranging between 19.5–23.00 ppm while soils from Kisumu and Karungu had quite low values ranging from 5 to 10 ppm. Other soil chemical factors varied as follows: Mg (7.60–7.85 m.e% for Kendu Bay and Port Victoria and 2.52–2.76 m.e% for Kisumu and Karungu); K (0.19–0.20 m.e% for Kisumu and Karungu and 0.56 – 0.62 m.e% for Kendu bay and Port Victoria); Ca (3.50–3.95 m.e% for Kendu Bay and Port Victoria and 1.37–2.48 m.e% for Kisumu and Karungu) Na; 0.26-0.25 m.e% for Kendu Bay and Karungu and 0.07 m.e% for Kisumu and Karungu).

<table>
<thead>
<tr>
<th>Site</th>
<th>pH</th>
<th>N (%)</th>
<th>Org. C (%)</th>
<th>P (ppm)</th>
<th>K (m.e%)</th>
<th>Ca (m.e%)</th>
<th>Mg (m.e%)</th>
<th>Mn (m.e%)</th>
<th>Cu (ppm)</th>
<th>Fe (ppm)</th>
<th>Zn (ppm)</th>
<th>Na (m.e%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kendu Bay</td>
<td>6.26</td>
<td>0.17</td>
<td>1.66</td>
<td>23.00</td>
<td>0.62</td>
<td>3.50</td>
<td>7.60</td>
<td>0.84</td>
<td>1.19</td>
<td>14.50</td>
<td>6.23</td>
<td>0.26</td>
</tr>
<tr>
<td>P. Victoria</td>
<td>6.30</td>
<td>0.15</td>
<td>1.51</td>
<td>19.50</td>
<td>0.56</td>
<td>3.95</td>
<td>7.85</td>
<td>0.61</td>
<td>1.04</td>
<td>15.98</td>
<td>8.46</td>
<td>0.25</td>
</tr>
<tr>
<td>Kisumu</td>
<td>4.10</td>
<td>0.15</td>
<td>1.44</td>
<td>10.00</td>
<td>0.20</td>
<td>2.48</td>
<td>2.52</td>
<td>0.59</td>
<td>1.09</td>
<td>14.80</td>
<td>8.91</td>
<td>0.07</td>
</tr>
<tr>
<td>Karungu</td>
<td>4.11</td>
<td>0.14</td>
<td>1.29</td>
<td>5.00</td>
<td>0.19</td>
<td>1.37</td>
<td>2.76</td>
<td>0.67</td>
<td>1.06</td>
<td>18.07</td>
<td>6.00</td>
<td>0.07</td>
</tr>
</tbody>
</table>
Morphology of isolates

Morphological differences and distribution of 64 isolates based on the site of origin are listed on Table 3. Seventy percent were classified as fast and very fast growers, 26% intermediate and 3% were slow growers. Most of slow and intermediate growing isolates were from Kisumu soils (23%) while the fast and very fast ones were evenly distributed in the other study sites. Reaction on YEMA with BTB distinguished 67.19% acid producers most of which were isolated from Kendu Bay and Karungu soils and majority had watery or milky translucent coloration. In a few cases, there was no clear distinction of pH reaction as depicted by a remotely yellow-green color of the medium, but these were however grouped with acid producers due to occurrence of the yellow color. Only eight isolates (12.5%) were dense and elastic in appearance, four of which were native to Kisumu soils while 87.5% were diffuse and non-elastic out of which 14, 18, 11 and 13 were from Kendu Bay, Kisumu, Port Victoria and Karungu soils respectively. Colony shape separated 84% dome shaped colonies with entire margins out of which 20 originated from Kisumu soils while the rest, either flat and entire (14%) or conical and glabrous (one isolate) colonies originating from the other sites.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>No. of isolates</th>
<th>% isolates</th>
<th>Distribution based on sites of origin</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Growth Rate (days)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤2 (Very fast)</td>
<td>4</td>
<td>4.67</td>
<td>Khay (1), Kis (2), Sp(0), Kar (1)</td>
</tr>
<tr>
<td>3 to 5 (Fast)</td>
<td>34</td>
<td>65.61</td>
<td>Khay (11), Kis (5), Sp(7), Kar (11)</td>
</tr>
<tr>
<td>6 to 7 (Intermediate)</td>
<td>15</td>
<td>26.65</td>
<td>Khay (2), Kis (9), Sp(3), Kar (1)</td>
</tr>
<tr>
<td>8 to 15 (Slow)</td>
<td>11</td>
<td>3.12</td>
<td>Khay (0), Kis (6), Sp(2), Kar (3)</td>
</tr>
<tr>
<td><strong>Alkaline/Acid reaction</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alkaline</td>
<td>21</td>
<td>32.81</td>
<td>Khay (2), Kis (14), Sp(2), Kar (3)</td>
</tr>
<tr>
<td>Acid</td>
<td>43</td>
<td>67.19</td>
<td>Khay(12), Kis (8), Sp(10), Kar (13)</td>
</tr>
<tr>
<td><strong>Color and Texture</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White and opaque</td>
<td>35</td>
<td>54.68</td>
<td>Khay (10), Kis (8), Sp(7), Kar (10)</td>
</tr>
<tr>
<td>Watery and translucent</td>
<td>16</td>
<td>25</td>
<td>Khay (3), Kis (8), Sp(2), Kar (3)</td>
</tr>
<tr>
<td>Milky and translucent</td>
<td>13</td>
<td>20.31</td>
<td>Khay (1), Kis (6), Sp(3), Kar (3)</td>
</tr>
<tr>
<td><strong>Appearance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dense and elastic</td>
<td>8</td>
<td>12.5</td>
<td>Khay (0), Kis (4), Sp(1), Kar (3)</td>
</tr>
<tr>
<td>Diffuse and non elastic</td>
<td>56</td>
<td>87.5</td>
<td>Khay (14), Kis (18), Sp(11), Kar (13)</td>
</tr>
<tr>
<td><strong>Shape</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dome with entire margin</td>
<td>54</td>
<td>84.37</td>
<td>Khay (14), Kis (20), Sp(9), Kar (11)</td>
</tr>
<tr>
<td>Flat with entire margins</td>
<td>9</td>
<td>14.06</td>
<td>Khay (0), Kis (2), Sp(2), Kar (5)</td>
</tr>
<tr>
<td>Conical round margins</td>
<td>1</td>
<td>1.56</td>
<td>Khay (0), Kis (0), Sp(1), Kar (0)</td>
</tr>
</tbody>
</table>

**KEY:** Khay – Kendu Bay, Kis – Kisumu, Sp – Port Victoria and Kar – Karungu isolates. The number of isolates per site are in parenthesis.

**16S rRNA gene analysis**

BLAST analysis of the 16S rRNA gene sequences resulted in 97% and above similarity indices with four rhizobia genera including *Bradyrhizobium* sp., *Rhizobium* sp., *Burkholderia* sp. and *Agrobacterium* sp. Eighteen representative sequences from this study and sequences with the greatest homologues from NCBI genebank used in phylogenetic analysis are listed in Table 4. The phylogenetic tree constructed divided the isolates into three groups as shown in Fig 1. Group A had *Rhizobium* and *Agrobacterium* that diversified into two separate sub-clades at 100% bootstrap support. In sub-clade A1 were isolates BAMsp1 and BAMsp2 from Port Victoria, BAMKbay2 from Kendu bay and BAMKar1 from Karungu which clustered with *Rhizobium leguminosarum* strains 3Hoq18 and IAM12690 and *Rhizobium phaseoli* strain ATTC14482 at 97% support. Four isolates (BAMKis1, BAMKis2, BAMKar2 and BAMsp5) separated from the first group at 100% bootstrap to cluster with *Rhizobium tropici* strain CIAT899, *Rhizobium tropici* strain Br859 and *Agrobacterium rhizogenes* strain IFO13257.

Sub-clade AII constituted three isolates from Kendu bay (BAMKbay1, BAMKbay3 and BAMKbay9) which clustered at 100% bootstrap support with *Agrobacterium vitis* strain NCPB3554 and *A. vitis* strain IAM14140. In the same clade was one BAMKar5 from Karungu which was closely related to *Agrobacterium tumefaciens* strain 2001025242 and *Rhizobium radiobacter* strain TA-AT-6 (formerly *A. tumefaciens*). Three isolates from Kisumu soils and one from Karungu were grouped together in clade B with *Bradyrhizobium* sp. strain NBRC14791, *Bradyrhizobium* sp. strain R7 and *B. japonicum* strain SEMIA 511 at 100% bootstrap support. Group C had two isolates BAMsp3 and BAMKbay6 clustering in the same group as *Burkholderia taberum* strain STM4287 and *Burkholderia phymatum* strain JNVU IC14.
Symbiotic characterization of isolates

Inoculation of Bambara groundnuts with eighteen isolates and two reference strains resulted in variation in nodule, shoot and root factors evaluated as shown in Table 5. Isolates genetically identified as *Bradyrhizobium* sp., *Burkholderia* sp. and one *Rhizobium* sp. produced highly effective nodules which numbered above 20 per plant; as was observed in the reference strains. Interestingly, the *Bradyrhizobium* isolates were obtained from Kisumu and Karungu soils while the latter two genera were evenly distributed in other sites. Partly effective nodules were mostly found in isolates genetically identified as *Rhizobium* sp. except one *Agrobacterium* sp., a group that otherwise produced ineffective nodules. Comparison of shoot dry weight showed that two of our isolates (BAMKis1 and BAMKis12) achieving statistically similar (P≤0.05) dry weights to the un-inoculated positive control while none was statistically identical (P≤0.05) to the un-inoculated negative control. Interestingly the two isolates were from the same site and were morphologically determined as slow growers. Root dry weight, total biomass and leaf color values were significantly higher in the isolates which gave high nodule number per plant and were mostly classified as *Bradyrhizobium* sp. or *Burkholderia* sp.

![Fig 2. A Neighbor joining phylogenetic tree built using eighteen 16S rRNA gene sequences obtained from root nodule bacteria isolated from bambara groundnuts in four soils of Lake Victoria basin. *Bacillus* sp. strain L106 (KJ944112) was used as an out-group to root the tree.](image-url)

Fig 2. A Neighbor joining phylogenetic tree built using eighteen 16S rRNA gene sequences obtained from root nodule bacteria isolated from bambara groundnuts in four soils of Lake Victoria basin. *Bacillus* sp. strain L106 (KJ944112) was used as an out-group to root the tree.
Table 4. Identities of eighteen rhizobial isolates based on 16S rRNA gene sequences and accession numbers and origins of sequences with highest similarity values

<table>
<thead>
<tr>
<th>Isolate Identity</th>
<th>Acc. No.</th>
<th>16S rRNA gene identification</th>
<th>% Identity</th>
<th>NCBI sequences with greatest similarity</th>
<th>Country of origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAMKar1.</td>
<td>KJ668869</td>
<td><em>Rhizobium</em> sp.</td>
<td>99%</td>
<td>NR_044112</td>
<td>Peru</td>
</tr>
<tr>
<td>BAMKar2.</td>
<td>KJ668862</td>
<td><em>Rhizobium</em> sp.</td>
<td>100%</td>
<td>HQ394213</td>
<td>Spain</td>
</tr>
<tr>
<td>BAMKar3</td>
<td>KF879077</td>
<td><em>Bradyrhizobium</em> sp.</td>
<td>99%</td>
<td>AB973677</td>
<td>Thailand</td>
</tr>
<tr>
<td>BAMKar9</td>
<td>KM362440</td>
<td><em>Agrobacterium</em> sp.</td>
<td>99%</td>
<td>KF673154</td>
<td>China</td>
</tr>
<tr>
<td>BAMKay1</td>
<td>KM362437</td>
<td><em>Agrobacterium</em> sp.</td>
<td>100%</td>
<td>NR_115517</td>
<td>Japan</td>
</tr>
<tr>
<td>BAMKay2.</td>
<td>KJ668864</td>
<td><em>Rhizobium</em> sp.</td>
<td>99%</td>
<td>JQ085251.1</td>
<td>Mexico</td>
</tr>
<tr>
<td>BAMKay3</td>
<td>KM362430</td>
<td><em>Agrobacterium</em> sp.</td>
<td>100%</td>
<td>EF566975</td>
<td>Japan</td>
</tr>
<tr>
<td>BAMKay9</td>
<td>KM362441</td>
<td><em>Agrobacterium</em> sp.</td>
<td>99%</td>
<td>AY513492</td>
<td>USA</td>
</tr>
<tr>
<td>BAMKis1</td>
<td>KJ736763</td>
<td><em>Rhizobium</em> sp.</td>
<td>100%</td>
<td>HQ850704</td>
<td>Spain</td>
</tr>
<tr>
<td>BAMKis2</td>
<td>KJ668867</td>
<td><em>Rhizobium</em> sp.</td>
<td>97%</td>
<td>HQ787792</td>
<td>China</td>
</tr>
<tr>
<td>BAMKis4</td>
<td>KF879078</td>
<td><em>Bradyrhizobium</em> sp.</td>
<td>97%</td>
<td>HQ704815</td>
<td>Peru</td>
</tr>
<tr>
<td>BAMKis8</td>
<td>KF879074</td>
<td><em>Bradyrhizobium</em> sp.</td>
<td>97%</td>
<td>AB973677</td>
<td>Thailand</td>
</tr>
<tr>
<td>BAMSp1.</td>
<td>KJ668865</td>
<td><em>Rhizobium</em> sp.</td>
<td>100%</td>
<td>N_R036938</td>
<td>Mexico</td>
</tr>
<tr>
<td>BAMSp2.</td>
<td>KJ668866</td>
<td><em>Rhizobium</em> sp.</td>
<td>99%</td>
<td>D14513</td>
<td>Japan</td>
</tr>
<tr>
<td>BAMSp3.</td>
<td>KM362438</td>
<td><em>Burkholderia</em> sp.</td>
<td>99%</td>
<td>EF566975</td>
<td>South Africa</td>
</tr>
<tr>
<td>BAMSp6.</td>
<td>KM362439</td>
<td><em>Agrobacterium</em> sp.</td>
<td>100%</td>
<td>NR_043398</td>
<td>Japan</td>
</tr>
</tbody>
</table>

Table 5. Symbiotic status of 18 bambara groundnut rhizobial isolates in comparison with 2 reference strains

<table>
<thead>
<tr>
<th>Isolate</th>
<th>Growth rate</th>
<th>16S rRNA gene</th>
<th>EFF</th>
<th>NNO</th>
<th>NIC</th>
<th>LCL</th>
<th>NFW (g)</th>
<th>NDW (g)</th>
<th>SDW (g)</th>
<th>RDW (g)</th>
<th>TBM (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+N</td>
<td>C</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>2.00</td>
<td>0.00</td>
<td>0.00</td>
<td>2.121</td>
<td>0.132</td>
<td>2.253</td>
<td>4.583</td>
</tr>
<tr>
<td>-N</td>
<td>C</td>
<td>0.0</td>
<td>0.0</td>
<td>1.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.991</td>
<td>0.200</td>
<td>1.191</td>
<td>2.191</td>
</tr>
<tr>
<td>KFR 259</td>
<td>Slow</td>
<td>Bradyrhizobium sp.</td>
<td>R</td>
<td>34.8</td>
<td>3</td>
<td>3.00</td>
<td>0.286</td>
<td>0.044</td>
<td>0.661</td>
<td>0.186</td>
<td>0.891</td>
</tr>
<tr>
<td>USDA 110</td>
<td>Slow</td>
<td>Bradyrhizobium sp.</td>
<td>R</td>
<td>21.2</td>
<td>3</td>
<td>3.00</td>
<td>0.314</td>
<td>0.040</td>
<td>0.842</td>
<td>0.259</td>
<td>1.141</td>
</tr>
<tr>
<td>BAMKis12</td>
<td>Slow</td>
<td>Bradyrhizobium sp.</td>
<td>HE</td>
<td>49.0</td>
<td>3</td>
<td>3.00</td>
<td>0.387</td>
<td>0.064</td>
<td>1.005</td>
<td>0.168</td>
<td>1.237</td>
</tr>
<tr>
<td>BAMKis8</td>
<td>Slow</td>
<td>Bradyrhizobium sp.</td>
<td>HE</td>
<td>43.0</td>
<td>3</td>
<td>3.00</td>
<td>0.321</td>
<td>0.061</td>
<td>0.933</td>
<td>0.159</td>
<td>1.153</td>
</tr>
<tr>
<td>BAMKis4</td>
<td>Slow</td>
<td>Bradyrhizobium sp.</td>
<td>HE</td>
<td>35.8</td>
<td>3</td>
<td>3.00</td>
<td>0.316</td>
<td>0.056</td>
<td>0.907</td>
<td>0.154</td>
<td>1.177</td>
</tr>
<tr>
<td>BAMKbay8</td>
<td>Fast</td>
<td>Burkholderia sp.</td>
<td>HE</td>
<td>34.2</td>
<td>3</td>
<td>3.00</td>
<td>0.293</td>
<td>0.040</td>
<td>0.896</td>
<td>0.149</td>
<td>1.085</td>
</tr>
<tr>
<td>BAMsp3</td>
<td>Fast</td>
<td>Burkholderia sp.</td>
<td>HE</td>
<td>37.2</td>
<td>3</td>
<td>3.00</td>
<td>0.360</td>
<td>0.053</td>
<td>0.795</td>
<td>0.186</td>
<td>1.034</td>
</tr>
<tr>
<td>BAMKis1</td>
<td>Fast</td>
<td><em>Rhizobium</em> sp.</td>
<td>HE</td>
<td>25.8</td>
<td>3</td>
<td>3.00</td>
<td>0.328</td>
<td>0.059</td>
<td>1.296</td>
<td>0.299</td>
<td>1.654</td>
</tr>
<tr>
<td>BAMKar3</td>
<td>Slow</td>
<td>Bradyrhizobium sp.</td>
<td>HE</td>
<td>22.0</td>
<td>3</td>
<td>3.00</td>
<td>0.175</td>
<td>0.026</td>
<td>0.759</td>
<td>0.208</td>
<td>0.993</td>
</tr>
<tr>
<td>BAMKar2</td>
<td>Fast</td>
<td><em>Rhizobium</em> sp.</td>
<td>E</td>
<td>15.5</td>
<td>2</td>
<td>3.00</td>
<td>0.288</td>
<td>0.037</td>
<td>0.767</td>
<td>0.210</td>
<td>1.014</td>
</tr>
<tr>
<td>BAMKar1</td>
<td>Fast</td>
<td><em>Rhizobium</em> sp.</td>
<td>E</td>
<td>13.3</td>
<td>2</td>
<td>3.00</td>
<td>0.223</td>
<td>0.068</td>
<td>0.944</td>
<td>0.513</td>
<td>1.575</td>
</tr>
<tr>
<td>BAMKis2</td>
<td>Fast</td>
<td><em>Rhizobium</em> sp.</td>
<td>E</td>
<td>12.6</td>
<td>2</td>
<td>3.00</td>
<td>0.217</td>
<td>0.013</td>
<td>0.665</td>
<td>0.477</td>
<td>1.155</td>
</tr>
<tr>
<td>BAMKbay1</td>
<td>Intermediate</td>
<td><em>Agrobacterium</em> sp.</td>
<td>E</td>
<td>11.3</td>
<td>2</td>
<td>3.00</td>
<td>0.197</td>
<td>0.029</td>
<td>0.873</td>
<td>0.386</td>
<td>1.288</td>
</tr>
<tr>
<td>BAMsp2</td>
<td>Fast</td>
<td><em>Rhizobium</em> sp.</td>
<td>E</td>
<td>10.9</td>
<td>2</td>
<td>3.00</td>
<td>0.148</td>
<td>0.026</td>
<td>0.754</td>
<td>0.379</td>
<td>1.159</td>
</tr>
<tr>
<td>BAMsp1</td>
<td>Fast</td>
<td><em>Rhizobium</em> sp.</td>
<td>E</td>
<td>10.1</td>
<td>2</td>
<td>3.00</td>
<td>0.098</td>
<td>0.023</td>
<td>0.661</td>
<td>0.346</td>
<td>1.030</td>
</tr>
<tr>
<td>BAMKbay2</td>
<td>Fast</td>
<td><em>Rhizobium</em> sp.</td>
<td>I</td>
<td>1.5</td>
<td>1</td>
<td>1.00</td>
<td>0.027</td>
<td>0.030</td>
<td>0.615</td>
<td>0.337</td>
<td>0.982</td>
</tr>
<tr>
<td>BAMKar6</td>
<td>Intermediate</td>
<td><em>Agrobacterium</em> sp.</td>
<td>I</td>
<td>1.3</td>
<td>1</td>
<td>1.00</td>
<td>0.011</td>
<td>0.019</td>
<td>0.581</td>
<td>0.185</td>
<td>0.785</td>
</tr>
<tr>
<td>BAMsp5</td>
<td>Intermediate</td>
<td><em>Agrobacterium</em> sp.</td>
<td>I</td>
<td>1.8</td>
<td>1</td>
<td>1.00</td>
<td>0.017</td>
<td>0.020</td>
<td>0.695</td>
<td>0.191</td>
<td>0.906</td>
</tr>
<tr>
<td>BAMKbay9</td>
<td>Intermediate</td>
<td><em>Agrobacterium</em> sp.</td>
<td>I</td>
<td>0.0</td>
<td>0</td>
<td>1.00</td>
<td>0.000</td>
<td>0.000</td>
<td>0.519</td>
<td>0.258</td>
<td>0.777</td>
</tr>
<tr>
<td>BAMKbay3</td>
<td>Intermediate</td>
<td><em>Agrobacterium</em> sp.</td>
<td>I</td>
<td>0.0</td>
<td>0</td>
<td>1.00</td>
<td>0.000</td>
<td>0.000</td>
<td>0.838</td>
<td>0.131</td>
<td>0.669</td>
</tr>
<tr>
<td>SE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.571</td>
<td></td>
<td>0.113</td>
<td>0.265</td>
<td>0.793</td>
</tr>
<tr>
<td>LSD (p &lt; 0.05)</td>
<td>06.25</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.449</td>
<td>0.134</td>
<td>0.177</td>
<td>0.605</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CV (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16.6</td>
<td></td>
<td>38.8</td>
<td>31.0</td>
<td>31.4</td>
</tr>
</tbody>
</table>

DISCUSSION
Bambara groundnut was used as a trap plant on soils from four sites within Lake Victoria basin in Kenya and resultant root nodule bacteria isolates characterized and evaluated for symbiotic status. The results showed high levels of diversity within the sixty four isolates both phenotypically and by 16S RNA gene identities. Edaphic factors of the
Comparison of our 16S rRNA gene sequences with those deposited in the NCBI gene bank database showed that in its natural habitat, bambara groundnut forms symbiosis without root nodule bacteria of different genera including *Bradyrhizobium* (BAMKis12, BAMKis8, BAMKis4 and BAMKar3), *Burkholderia* (BAMKbay8, BAMsp3), *Rhizobium* (BAMKis1, BAMKar1, BAMKar2, BAMKis2, BAMsp2, BAMsp1 and BAMKbay2) and *Agrobacterium*(BAMKbay1, BAMKar6, BAMsp5, BAMKbay9 and BAMKbay3). The wide diversity of micro-symbionts of bambara groundnuts established in this study concurs with a previous report by Sprent *et al.*, (2010) showing that it is capable of free nodulation with different rhizobial groups making it a ‘promiscuous’ host. Symbiotic promiscuity has been shown to be beneficial when legumes associate effectively with different rhizobia species allowing their adaptation to different environments (Lafay and Burdon, 2006; Mierzwia *et al.*, 2010; Ulrich and Zaspel, 2000), although differences in the number of symbiotic partners and the level of their effectiveness has also been observed (Moschetti *et al.*, 2005). For instance, common beans (*Phaseolus vulgaris*) are promiscuous hosts nodulated by six species of *Rhizobium*, five species of *Sinorhizobium*, and several *Bradyrhizobia* Martinez-Romero,(2003) yet it has preference for some species depending on the site environmental characters. Similar findings of diverse nodulators of bambara groundnuts was observed in this study, which necessitated tests to determine their symbiotic preferences although differences in soil characteristics of the site of isolation could have played a role in the diversity.

Soil chemical factors, particularly soil pH and P levels seemed to affect the distribution of the isolates into different genera as they varied within the four study sites. For instance, all the slow growing *Bradyrhizobia* isolates were obtained from the extremely acidic and low P soils of Kisumu and Karungu demonstrating the tolerance of this group to these extreme conditions. When tested in inoculation trials, all the treatments with *Bradyrhizobium* sp. isolates produced highly effective nodules with intensely pink internal nodule colors. The treatments involving *Bradyrhizobium* sp. isolates also resulted in high total biomass values outperforming the commercial *Bradyrhizobium japonicum* strain USDA110 and the nitrogen control. On the other hand, we were unable to obtain *Bradyrhizobia* sp. isolates from the moderately acidic and high P soils of Kendu bay and Port Victoria soils which were dominated by the fast growing *Rhizobium* sp. and *Agrobacterium* sp. and to a lesser extent *Burkholderia* sp. strains. Brockwell *et al.*, (1991) averaged the probable number of rhizobial populations in soils of different pH and observed the gradual reduction of fast growing groups of rhizobia as the pH was reducing while Slattery *et al.*, (2004) observed an increase in the population of *Bradyrhizobium* as the pH decreased as observed in this study. A few exceptions to this trend were noted within isolates identified as *Rhizobia* sp. and *Agrobacterium* sp. which occurred in both the highly acidic and low P soils of Kisumu and Karungu as well as the moderately acidic and high P soils of Kendu bay and Port Victoria.

A remarkable outcome of this study was the occurrence of two *Burkholderia* strains (BAMKbay8 and BAMsp3) as N-fixing associates of bambara groundnuts, which was confirmed by highly effective and above twenty nodules per plant in the glasshouse plant tests. Isolate BAMKbay8 outperformed the commercial isolate USDA110 and nearly equalled the reference strain KFR 259 in symbiotic performance as shown in Table 3. The N-fixation ability of some members of the genus *Burkholderia* was first proposed by Moulin *et al.*, (2001) and later confirmed by Vandamme *et al.*, (2002) and Chen *et al.*, (2005). The 16S rRNA genes phylogeny of our two isolates depicted their close relations to *Burkholderia tuberum* strain DUS833 and *B. phytatum* strain JVNU IL24 with the former having been isolated from the root nodules of *Aspalathus callosa* in South Africa (Elliot *et al.*, 2007). According to Ngugi *et al.*, (1997) the bambara groundnuts landraces cultivated in Kenya are of West and South African descent and were introduced into East African farming systems through Uganda and Tanzania. It is therefore plausible to argue that the N-fixing *Burkholderia* strains found in this study may have been introduced together with the bambara germplasm during this period. Furthermore, the two isolates occurred in the soils of Port Victoria and Kendu bay which were active inter-border trading points through Lake Victoria. The absence of *Burkholderia* isolates from Kisumu and Karungu soils...
may be due to its preference to acidic soils as was observed in the isolates reaction on BTB. Botempts and colleagues (Botempts et al., 2010) confirmed the preference of *Burkholderia* sp. to acidic and low N soils in their study of the association of this group with Brazilian legumes.

We found the occurrence of *Agrobacterium* sp. in all soils tested indicating the high distribution of this group within the region although results of the plant tests showed only one isolate (BAMKbay1) produced effective nodules. Numerous studies comparing *Agrobacterium* and *Rhizobium* genera have been done which led Young et al., (2001) to propose merging the two genera based on similarity of 16S rDNA genes. According to Bergey’s Manual of Bacterial Systematics, there is no clear phenotypic distinction between the two groups which was evident in our study despite the phenotypic variation tests done. It was apparent that the *Agrobacterium* isolates did not absorb Congo red which is a basic discriminatory test for N-fixing rhizobia against other soil microbes. It was however surprising to find isolate BAMKbay1 producing effective nodules since the N-fixation ability of this genus is still disputed as this process is mediated by *nif* and *nod* genes which are absent in this group (Lindstrom et al., 2011). Thus, the effective nodules produced by BAMKbay1 may have been as a result of acquisition of *nif* genes through lateral gene transfer from other groups which possess them naturally (Martinez et al., 1987). Since *Agrobacterium* sp. is an effective endophytic inducer of tumors in plant roots Wang et al., (2006), it is possible that these pathogenic structures were transformed into useful nitrogen fixing agents after gaining the necessary genes. Alternatively, the isolate may have acquired both *nif* and *nod* genes which enabled it to produce the high number of nodules recorded. However, further PCR investigations are necessary on natural populations of *Agrobacterium* sp. in the soils of Lake Victoria basin to determine the occurrence of *nif* and *nod* genes.

Some of the most promising strains were BAMKis12, BAMKis8, BAMKis4 and BAMKar3 (*Bradyrhizobium* sp.) and BAMKbay8 and BAMSip3 (*Burkholderia* sp.) which produced highly effective nodules and high plant biomass values. These strains have potential use as bio-fertilizers in the production of bambara groundnuts although they were relatively not well distributed in the four soils used for isolation unlike isolates identified as *Agrobacterium* and *Rhizobium* which occurred in all the soils. Possibly, stiff competition for infection and nodulation amongst different strains may have favored the fast growing strains (*Rhizobium* and *Agrobacterium*) which are known to have better rates of competition for nodule occupancy (Howeison et al., 2000). Thus, bambara groundnuts is arguably more compatible with *Bradyrhizobium* and *Burkholderia* but are seemingly out-competed for nodule occupancy in the local soils by the less/ineffective *Rhizobium* and *Agrobacterium* respectively. Conversely, since competitive ability and nodule occupancy is influenced by the prevailing status of the media Slattery et al., (2004); the near neutral pH of the vermiculite used in the glasshouse experiment may have impacted negatively on some of the acid tolerant strains. Based on the findings of this study, isolates BAMKis12, BAMKis8, BAMKis4, BAMKbay8 and BAMSip3 genetically characterized as *Bradyrhizobium* sp. and *Burkholderia* sp. respectively can potentially be used as biofertilizers in inoculation programmes to improve the productivity of bambara groundnuts in the region. Further investigations on their symbiotic performance under natural conditions might reveal the actual symbiotic preferences of bambara groundnuts, and confirm the effect of inoculation on plant yield factors.

CONCLUSIONS

This study revealed high levels of heterogeneity within resident bambara groundnut rhizobium populations in the soils of Lake Victoria basin. Our findings under controlled conditions showed better competence of indigenous strains compared to the market available commercial strain USDA110. Field inoculation trials and tests on competition for nodule occupancy are needed to evaluate the potential of this abundant genetic resource for sustainable production of the under-utilized bambara groundnuts which can supply alternative sources of nutrient rich diets to resource poor farmers in the region.

ACKNOWLEDGEMENTS

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REFERENCES


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PHYTOCHEMICAL SCREENING, MACRONUTRIENTS ANALYSIS AND ANTIMICROBIAL ACTIVITY OF WATER FROM MATURE COCONUT FRUIT GROWN IN SANDY AND LOAM SOILS AT COAST OF KENYA

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ABSTRACT
Mature coconuts fruits were collected from two blocks in Kilifi and Kwale Counties at the Coast in Kenya. They were broke open and the water inside extracted using n-hexane, ethanol and ethyl acetate for 18 hours. For macronutrients analysis, plain (untreated) coconut water was used, n-hexane and ethanolic extracts for phytochemical screening and n-hexane and ethyl acetate extracts for antimicrobial activity against bacteria (E. coli, S. aureus, P. aureginosa) and fungi (C. albicans) with tetracycline, gentamycin, streptomycin and fluconazole as the standards, respectively. The results of different extracts and soils were compared using student’s t-test at 95% confidence level. Coconut water had macro-nutrients: carbohydrates, proteins, fats and oils. Phytochemicals present included: flavonoids, tannins, phenols, alkaloids, glycosides and acidic compounds. The macro-nutrients and proximate composition of coconuts from palm growing in sand and loam soils were significantly different (p<0.05) with higher concentration found in coconuts from palm growing in sand soils. However, the macro-nutrients proximate composition of the different extracts from the same soil had no significant difference (p>0.05). The antimicrobial of different extracts from different soils had no significant difference (p>0.05). Thus, growth of coconut palms in sandy soils may be encouraged for better quality products from the coconut palms.

Key words: Coconut water, Phytochemicals, Proximate composition

INTRODUCTION
Cocos nucifera belongs to the Aracaceae (Palm family) and one of the most extensively grown and used nuts in the world. It is rated as one of the most important of all palms and the only accepted specie of the genus Cocos. (Onifade and Jeff-Agboola, 2003; Popeneoe, 1969). Coconut is grown throughout the tropics for decorative, as well as culinary and non-culinary uses. Virtually all parts of coconut palm can be utilized by humans. It provides almost all the necessities of life-food, drink, oil, medicine, fiber, timber, thatch, mats, fuel, and domestic utensils. For good reason, it has been called the ‘tree of heaven’ and ‘tree of life’ (Chan et al., 2006). It produces products that are directly or indirectly important in world trade. These are whole coconut, copra, coconut oil, coconut oil cake, coir, desiccated shredded coconut, coconut skim milk and coconut protein (Onifade and Jeff-Agboola, 2003). Desired texture in cookies, candies, cakes, pies, salads and desserts has been produced using coconut. Coconut is commercially viable because of its rich nutritive values (Akubugwo et al., 2008; Kyari, 2008; Child, 1964).

The medicinal use of C. nucifera aqueous extract has been reported in a large extent (Esquenazi et al., 2002; Mendonca-Filho et al., 2004). The extracts of coconut oil obtained from the kernel consist of monolaurin and lauric acid, which helps the immune system in a beneficiary manner. The monolauric acids are used by the body to produce high levels of antimicrobial (Mid-American Marketing Corp., 2004). Lauric acid is the basic of monolaurin and a part of the chemical constituent of sodium lauryl sulfate that promote health and used in adjunct treatment of viral diseases. It is also found to be one of the active chemicals in controlling Human Immunodeficiency Virus (HIV) disease (Davrit, 2004). The extracts also possess antibacterial properties (Alaris et al., 2005) and antiproliferative effect on animal lymphocytes (Kirszberg et al., 2003). Coconut oil possesses antimicrobial, antiviral and antiprotozoal activities (Isaacs and Thormar, 1991; Thormar, 1996; Enig, 2003). However, comprehensive studies on coconut water nutritional and pharmacological properties are still inadequate.

Coconut water is a clear, sterile, colourless, slightly acidic and naturally flavoured drink. The flavor of the water varies with the stage of maturity. Each coconut may contain about 200-1000 ml of water depending on the cultivar type and size. However, any nuts young than 5 months of age tend to be bitter in taste and devoid of nutrients. The water has adequate natural minerals and high quality proteins, which are valuable for growth and repair of the body (Pehowich et al., 1992), certain carbohydrates, fats and oils, amino acids and active biological compounds making useful both as food and medicine (Fife, 2008). It has been demonstrated that C. nucifera natural water present antioxidant properties (Evans and Hallowell, 2001; Mantena and Alvies, 2003).
The water is known to be a heart tonic, anti-hypertensive agent (Alleyne et al., 2005), a rehydrating agent (Saat et al., 2001; Ismael et al., 2007), promote dehydration when other pyrogen-free fluids are not available (Campbell-Falck et al., 2000; Effiong et al., 2010) and skin smoothenier (Enig, 2004). Studies also demonstrate that its consumption reduces the risk of heart failure in heart disease patients (Hemanth et al., 2011). The kernel of tender coconut exhibit antibacterial, antifungal, antiviral, antiparasitic, antidermatophytic, antioxidant, hyperglycemic, lepatoprotective and immunostimulant (DebMandal and Mandal, 2011). Phytohormones; cytokinins, auxins, tans-zeatins and gibberlins present in coconut water are essential in the callus formation (Overbeek et al., 2007). This extends the application of the coconut water in plant tissue culture as a growth-promoting component in tissue culture medium.

Coconut water is highly versatile and its chemical profile is affected by soil, altitude and environmental conditions. Different varieties of C. nucifera contain water with varying concentration of compounds that varies at different stages of maturity (Yong et al., 2009). The physical properties of coconut water were affected by varying nitrogen and potassium application. Although coconut water is already well studied in terms of its chemical content, there may still be unknown solutes which contribute to its special biological effects. This study was therefore designed to identify phytochemicals, comparing macronutrients composition and antimicrobial activity of coconut water from sandy and loam soils. This may contribute knowledge that can have a bearing on promotion on the use of the coconut water for primary health care, solving malnutrition problem and food security through the production of various products for food and animal feeds and development of new drugs.

MATERIALS AND METHODS
Healthy mature coconuts were collected from specific farms in Kilifi and Kwale counties. The nuts were taken to national museum of Kenya, where they were authenticated by a taxonomist. The nuts were then transported to TUM laboratory in the department of pure and applied sciences where they were broken and water collected for analysis.

Qualitative analysis macronutrients was done as described by Obidao et al., 2010 with modification to test the presence of carbohydrates (sulfuric acid test and Molisch test), reducing sugars (Fehlings’ test and Benedict’s test), non-reducing sugars, starch (iodine solution test), fats and oils (translucency test) and proteins (Millon’s test and Biuret’s test).

Macro-nutrients analysis was carried out on the coconut water to determine concentration of different sugars (glucose, sucrose, maltose and fructose) using colorimetric method-phenol sulfuric acid method as described in Current Protocols in Food Chemistry, (2001) with some modifications.

Phytochemicals in the coconut water were subjected to solvent extraction as described by Obidoa et al., 2010, with modification using n-hexane, ethanol, ethyl acetate and water for 18 hours in a separation funnel and the aqueous phase collected for phytochemical screening.

The phytochemical tests below were carried out on the liquid extract of coconut water to determine the active constituents according to the procedures and methods described by Trease and Evans, 1983 and Harborne, 1973. Flavonooids (Pew’s test, Shinoda test, ammonium test and NaOH test), Tannin (gelatin test), Phenols (phenol test), resins, saponins (foam test and emulsion test), Alkaloids (Iodine test and picric acid test), glycosides (Keller-Kiliani test, concentrate H2SO4 test and Molisch’s test) and acidic compounds (litmus test).

Four test microorganisms were used in antimicrobial sensitivity tests. They were standard strains and clinical isolates; gram positive bacteria Staphylococcus aureus and gram negative bacteria Escherichia coli and Pseudomonas aeruginosa and the yeast Candida albicans obtained from the Department of Pure and Applied Sciences, Mombasa Polytechnic University College.

The microbes were inoculated on specific media and incubated for 24-36 hrs. Muller and Sabouraud Dextrose Agar were used for antibacterial and anti-fungal analysis. Paper discs of diameter of 6mm prepared from punching Whatman No. 1 filter paper were used. These discs were sterilized at 15 lbs pressure at 121°C for 15 minutes in a well sealed universal bottle. The sterile paper discs were soaked in the coconut water extracts (hexane, ethyl acetate and water) for five minutes then using a sterile wire loop, transferred to culture plates inoculated with test microorganisms. The impregnated paper discs were transferred to Petri dishes with test organisms and the plates incubated at 35°C for 24-36 hours and the microbial susceptibility assayed by observing and measuring the zones of inhibitions. Standard
antimicrobial drugs—streptomycin for \textit{S. aureus}, fluconazole for \textit{C. albicans}, gentamycin for \textit{P. aeruginosa} and tetracycline for \textit{E. coli}, were used as positive controls while sterilized distilled water was used as a negative control.

All extractions and analysis were performed in triplicates. Results were expressed as Mean±Standard error (SE) Tables were used to present the experimental results. Positive (+) and negative (-) signs were used to indicate the presence and absence of phytochemicals respectively. Comparisons were made using student’s t-test with a p < 0.05 being considered significantly different between two parameters.

**RESULTS**

The results are presented in two parts reflecting analysis using both polar solvents (ethanol, ethyl acetate, water) and non-polar solvent (n-hexane) extracts of coconut water from palms growing in sandy and loam soils. Both polar and non-polar extracts revealed the presence of macronutrients; carbohydrates, proteins, fats and oils [Tables 1].

**Table 1: Macronutrient analysis of coconut water extracts using polar and non-polar solvents**

<table>
<thead>
<tr>
<th>Macronutrient</th>
<th>Test</th>
<th>Water</th>
<th>Loam soils</th>
<th>Sandy soils</th>
<th>Coconut water extract</th>
<th>Water</th>
<th>Loam soils</th>
<th>Sandy soils</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Loam soils</td>
<td>Sandy soils</td>
<td>Loam soils</td>
<td>Sandy soils</td>
<td>Loam soils</td>
<td>Sandy soils</td>
<td></td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>Sulfuric acid test</td>
<td>++</td>
<td>+++</td>
<td>++</td>
<td>+++</td>
<td>++</td>
<td>+++</td>
<td></td>
</tr>
<tr>
<td>Starch</td>
<td>Iodine test</td>
<td>++</td>
<td>+++</td>
<td>++</td>
<td>+++</td>
<td>++</td>
<td>+++</td>
<td></td>
</tr>
<tr>
<td>Fats and oils</td>
<td>Translucency test</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td></td>
</tr>
<tr>
<td>Reducing sugars</td>
<td>Benedict’s test</td>
<td>++</td>
<td>+++</td>
<td>++</td>
<td>+++</td>
<td>++</td>
<td>+++</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Molisch’s test</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
<td>+++</td>
<td></td>
</tr>
<tr>
<td>Non reducing sugars</td>
<td>Melon’s test</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td></td>
</tr>
<tr>
<td>Proteins</td>
<td>Biuret’s test</td>
<td>_</td>
<td>_</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Key: (-) Absent, (+) Present in low, (++) Present in moderate, and (+++) present in high concentration

Qualitative analysis of the coconut water from palms growing in both sandy and loam soils for both polar and non-polar extracts revealed the presence of saponins, phenols, resins, alkaloids, glycosides and acidic compounds. Flavonoids were present only in the ethanol extract [Table 2].

**Table 2: Qualitative phytochemical screening of coconut water in palms growing on loam and sand soil using ethanolic and n-hexane extracts**

<table>
<thead>
<tr>
<th>Phytochemical</th>
<th>Test</th>
<th>Ethanol extract</th>
<th>n-hexane extract</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Loam soil</td>
<td>Sand soil</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>Ammonia test</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Pew’s test</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Shinoda test</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>NaOH test</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Tannins</td>
<td>Gelatin test</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Phenols</td>
<td>Phenol test</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Saponins</td>
<td>Foam test</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Emulsion test</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Alkaloids</td>
<td>Picric acid test</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Iodine test</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Glycosides</td>
<td>Keller-Killian test</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Cone H$_2$SO$_4$ test</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Molisch’s test</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Acidic compounds</td>
<td>Litmus test</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Key: (+) phytochemical present (-) phytochemical absent
There was a significant difference in lipid total carbohydrates between coconut of water from palm growing from sand and loam soils (p<0.05). Quantitative analysis of sugars; glucose, fructose and sucrose in coconut water from palm growing in loam and sand soils revealed substantial amount of these sugars [Table 3].

Table 3: Concentration (mg/mL) of glucose, fructose and sucrose of coconut water from palms growing in sand and loam soils

<table>
<thead>
<tr>
<th>Sandy soil palms</th>
<th>Loam soil</th>
<th>Sandy soil palms</th>
<th>Loam soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coconut</td>
<td>Glucose</td>
<td>Fructose</td>
<td>Sucrose</td>
</tr>
<tr>
<td>S01</td>
<td>0.39±0.05</td>
<td>0.22±0.04</td>
<td>0.39±0.02</td>
</tr>
<tr>
<td>S02</td>
<td>0.35±0.06</td>
<td>0.36±0.05</td>
<td>0.42±0.09</td>
</tr>
<tr>
<td>S03</td>
<td>0.38±0.07</td>
<td>0.39±0.03</td>
<td>0.56±0.06</td>
</tr>
<tr>
<td>S04</td>
<td>0.69±0.02</td>
<td>0.41±0.03</td>
<td>0.51±0.02</td>
</tr>
<tr>
<td>S05</td>
<td>0.57±0.08</td>
<td>0.65±0.10</td>
<td>0.42±0.06</td>
</tr>
<tr>
<td>S06</td>
<td>0.42±0.06</td>
<td>0.35±0.13</td>
<td>0.25±0.12</td>
</tr>
<tr>
<td>S07</td>
<td>0.52±0.05</td>
<td>0.65±0.06</td>
<td>0.40±0.05</td>
</tr>
<tr>
<td>S08</td>
<td>0.60±0.04</td>
<td>0.37±0.06</td>
<td>0.41±0.02</td>
</tr>
<tr>
<td>S09</td>
<td>0.58±0.07</td>
<td>0.51±0.08</td>
<td>0.43±0.06</td>
</tr>
<tr>
<td>S10</td>
<td>0.50±0.05</td>
<td>0.44±0.08</td>
<td>0.45±0.06</td>
</tr>
<tr>
<td>S11</td>
<td>0.46±0.14</td>
<td>0.32±0.06</td>
<td>0.25±0.12</td>
</tr>
<tr>
<td>S12</td>
<td>0.28±0.63</td>
<td>0.40±0.06</td>
<td>0.39±0.02</td>
</tr>
</tbody>
</table>

Each data is the mean of three replicates ±Standard Error (SE)

The sucrose and fructose concentration from palm growing in sand and loam soil differed significantly (p<0.05). However, the concentration of glucose in the coconut water was not affected by soil type (p>0.05).

Figure 1: Standard curves for (a) glucose, (b) fructose and (c) galactose

The n-hexane, ethyl acetate extracts and plain coconut water from palms growing in sand and loam soils were tested against E. coli, S. aureus, P. aeruginosa and C. albicans with tetracycline, gentamycin, streptomycin and fluconazole as standard drugs respectively and distilled sterilized water as the negative control [Table 4].

Table 4: Antimicrobial activity of coconut water from coconut palms growing in sandy soils

<table>
<thead>
<tr>
<th>Microorganism</th>
<th>Zone of inhibition (Diameter in mm ±SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sand soil palms</td>
</tr>
<tr>
<td></td>
<td>n-Hexane Ethyl acetate</td>
</tr>
<tr>
<td>P. aeruginosa</td>
<td>7.13±0.12 7.27±0.06</td>
</tr>
<tr>
<td>S. aureus</td>
<td>7.17±0.15 7.13±0.06</td>
</tr>
<tr>
<td>E. coli</td>
<td>7.00±0.10 7.20±0.01</td>
</tr>
<tr>
<td>Candida</td>
<td>6.30±0.10 6.03±0.21</td>
</tr>
</tbody>
</table>

Each data is the mean of three replicates ±Standard Error (SE)
Plain coconut water and distilled water did not interfere with the growth kinetics of any of the tested microorganisms. The n-hexane and ethyl acetate extracts showed inhibition of the tested microorganisms [Table 4]. The antimicrobial activity of the extracts differed with soil types (p<0.05). No significant difference in zone of inhibition between n-hexane and ethyl acetate extracts (p>0.05). However, significant differences were observed when comparing the hexane and ethyl acetate extracts with the standard drugs (p<0.05).

**Figure 2: Plates showing inhibition of different micro-organism by water from coconut**

**DISCUSSION**

Coconut water is the liquid endosperm of the coconut fruit. The study revealed the presence of macronutrients; carbohydrates, proteins, fats and oils in varying concentration depending on environmental conditions of growth. On exposure to air for long, it loses its organoleptic and nutritional characteristics and begins to ferment losing its worth and credibility (Adolf et al., 2011) thus it’s consumed when still fresh.

The present study carried out on coconut water using ethanol and hexane extracts revealed the presence of phytochemicals; glycosides, alkaloids, flavonoids, tannins, phenols, saponins and acidic compounds. Phenols and polyphenols contribute to the antioxidant properties. They also possess biological properties such as anti-apoptosis, anti-aging, anti-carcinogen, anti-inflammation, anti-atherosclerosis, cardiovascular protection and improvement of endothelial function, as well as inhibition of angiogenesis and cell proliferation activities (Bergsson, 2001). Tannins and resins are employed as astringent both in gastro-intestinal tract and on skin abrasions. Glycosides have the ability to lower blood pressure (Delanty and Dichter, 2000). Flavonoids activity is probably due to their ability to complex with extracellular and soluble proteins and to complex with bacterial cell wall (Portillo et al., 1998). Saponins are known to produce inhibitory effect on inflammation (Thorner et al., 1987) while alkaloids are known for their cytotoxicity (Trease and Evans 1983), analgesic, antispasmodic and antibacterial (Rice et al., 1995).

The presence of oil in coconut water makes it a good source of lipids. The various fatty acids may be responsible for the health benefits of coconut water. Lauric acid, a medium chain fatty acid, considered responsible for many health benefits (Enig, 1999) may be present in coconut water. It is converted to monolaurin in the human body which has antifungal, antibacterial, antiprotozoal and antiviral properties (Fife, 2000). The antifungal and antibacterial properties of coconut water observed may be due to presence of such fatty acids along side other phytochemicals.

The coconut water extracts from palm growing in sand and loam soils exhibited nominal antibacterial and antifungal activity against the test microorganisms though to levels of no significant difference between them with plain coconut water showing no antimicrobial activity. However, nominal susceptibility of fungal and bacterial species to coconut water extracts could be associated with the presence of super-molecular complexes of its cell wall including chitin, which may be difficult to digest, thus imposing resistance to prospective drugs (Marcilla et al., 1991).

It is not surprising that there are differences in the antimicrobial effects of plant species, due to the phytochemical properties and differences among the species. The potential for developing antimicrobials from higher plants appears rewarding as it will lead to the development of a phytomedicine to act against microbes. Plant based antimicrobial have enormous therapeutic potential as they can serve the purpose with lesser side effects hat are often associated with synthetic antimicrobials (Iwu et al., 1999). In this context, coconut water is a prime candidature for the development of nutraceutical compounds.
CONCLUSION
The presence of macronutrients; carbohydrates, proteins, fats and oils in coconut water indicate that it can be used in the manufacture of energy drinks. The presence of phytochemical; saponins, glycosides, flavonoids, phenols, acidic compounds, alkaloids, tannins and resins in coconut water suggests its use in development of therapeutic agents. The fact that the different extracts from coconut water portrayed potency against the test microbes justifies the rationale for use of coconut water for treatment of related ailments. The study unveils rich resources of bioactive compounds present in coconut water from palms growing in the coast region of Kenya and lays crucial needs for isolation and development of pharmaceuticals from the extracts.

RECOMMENDATION
Although the chemical composition of coconut water is well studied, it is recommendable that; research should intensified to quantify and compare the phytochemical composition of coconut water and how these concentrations are affected by both environmental and chemical factors. Studies need to be done to identify the best combination of factors that gives the highest composition of secondary metabolites of medicinal value and nutrients in the coconut water. Breeding studies should be carried out to produce coconut water rich in specific chemical compounds.

ACKNOWLEDGEMENTS
The Department of Pure and Applied Sciences, Technical University Mombasa (TUM) is highly indebted to the funding on this study. We thank the general community of Kilifi and Kwale counties for their cooperation in the field during sample (coconuts) collection period.

REFERENCES
Adolf et al., 2011
STUDY OF CRUDE EXTRACTS OF Ajuga remota BENTH (LABIATAE) AS POTENTIAL ANTI-MALARIAL DRUG

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ABSTRACT

Malaria is among the killer diseases in the tropics and the parasite has been noted to develop resistance to many synthetic drugs. This study screened and tested the efficacy of crude extracts of different parts of Ajuga remota. Aqueous crude extracts of Ajuga remota which have been traditionally used to treat fevers and malaria, were used...
in vivo against *Plasmodium berghei* malaria infections in mice using the four-day suppressive test. Leaves, stems, roots and flowers either boiled wet in water immediately after collection or dried first before boiling in water were then injected intravenously through the tail vein of mice infected with *Plasmodium berghei* parasite. Chloroquine, a standard antimalarial drug, was used as a control. On day four, parasitized blood smears were made from tail strip for determination of parasitaemia and calculation of percentage suppression. The different preparation showed different suppressive activities against *P. berghei* parasites. The leaves showed the highest antimalarial activity compared to stems, roots and flowers for wet and dry parts, respectively. Thus, *A. remota* has potential antimalarial compounds which need further evaluation to determine their activity against human malaria parasites.

**Key words:** *Plasmodium berghei*, Parasitaemia, Malaria, Chloroquine

**INTRODUCTION**

Although malaria has been eradicated or controlled in the developed nations, it still remains a common tropical disease in South East Asia, Africa and Eastern Mediterranean that account for 99% of global malaria cases and deaths (WHO, 2013). In 2010, 219 million cases of malaria were reported as well as 660,000 deaths (WHO, 2012). This is alarming especially in tropical Africa where the disease is endemic with the region accounting for a high percentage of both the incidence of malaria and resulting deaths. According to Farook (2004) Sub-Saharan Africa and countries in tropical Africa account for more than 90% of total malaria incidence and great majority of deaths due to the disease. Together, the Democratic Republic of the Congo and Nigeria account for over 40% of the estimated total of malaria deaths globally (WHO, 2012).

Artemisinin is one of the best anti-malaria drugs in use today and is usually used in combination with other drugs (Krungkrai et al, 2010). By the end of 2011, Artemisinin Combination Therapy (ACTs) had been adopted as national policy for first-line treatment in 79 of 88 countries where *P. falciparum* is endemic and chloroquine is still used in some countries in the Region of the Americas where it remains efficacious (WHO 2012). Recent studies have shown that malaria parasite has started developing resistance to this drug. A decrease in clinical efficiency was noted of the artemisinin derivative in treatment in falciparum malaria patients at the Thai-Cambodian border in 2009, showing that the parasite clear slowly from the patients’ blood after the ACTs treatment without corresponding reduction in-vitro susceptibility testing (Dondorp et al 2009, as cited in Krungkrai et al, 2010).

It is not only the developing of resistance of ACTs to malaria parasite that is a hindrance to treatment of malaria, the affordability is also important. The cost and availability of ACT in the public sector remains a major challenge in Africa. In 2008, ACT coverage in the public sector in high-burden African countries was only 42% and a survey in seven African countries showed that the percentage of fever cases in children < 5 years treated with ACTs was only 16% (WHO, 2009 as cited in Achan et al, 2011).

According to Bloland (2001) as long as drugs are used, the chance of resistance developing to those drugs is commonly noted. This is the case for *P. falciparum* which has developed resistance to nearly all available antimalarial drugs and it is highly likely that the parasite will eventually develop resistance to any drug that is used widely. This shows the need for continued research in the identification and development of new anti-malaria drugs to pre-empt any crisis that may result in the use of current drugs hence the need for the current research. Ideally, new drugs for uncomplicated *P. falciparum* malaria should be efficacious against drug-resistant strains, provide cure within a reasonable time (three days or less) to ensure good compliance, be safe, be suitable for small children and pregnant women, have appropriate formulations for oral use and, above all, be affordable (Thaithong et al, 1981; Peters, 2002 as cited in Fidozek 2004).

*Ajuga remota* is a herb which grows widely in East Africa. Locally, the leaves are pounded and steeped in cold water and the infusion drunk as a remedy for fever, malaria, toothache, dysentery and for the treatment of high blood pressure (Kokwaro, 1976). Traditionally, it is believed to be antimalarial by many communities in East Africa. As part of this study towards the development of new antimalarial drugs from indigenous plants, the antimalarial activity of the crude extracts from the various morphological parts of the *A. remota* species were examined.

The previous work done on the *A. remota* plant has shown it to have insecticidal activity and antihypertensive properties. Kubo et. al. (1981) isolated the chemical compound phytoecdysones from the *A. remota* which is reported as insect ecdisis inhibitor and feeding deterrent. He further reported the insect ecdisis inhibition by cyasterone and ecdysterone both extracted from the leaves and roots of the same species. Study on the antimalarial activity of a plant in the same genus *Ajuga bracteosa* on *Plasmodium berghei* using its ethanolic leaf extract was not only found to inhibit
parasitaemia in dose dependent manner but also enhanced the mean survival time period of treated mice (Chandel and Bagai, 2010). Kassa et al (1998) found ethanolic aerial extracts of Artemisia afra, Artemisia rehan and Ajuga remota to have significant in-vitro activity against P. falciparum. Kubo et. al. (1981) has also reported the ajugarin IV isolated from A. remota, structure of which was determined by spectroscopic and chemical data means, to have insecticidal activity against the insect Bombyx Mori at 500ppm but only growth inhibitory activity against insect Pectinophora gossypella. Similarly, Kubo et al (1976) established the structure of Ajugarin V previously isolated from A. remota using spectroscopic and chemical data means. The anti-hypertensive studies on the crude extract of A. remota and its major component ajugarin I, clerodane diterpene by Odek-Ogude and Rajab (1994), revealed that administration of the crude extract and ajugarin I at 10mg/l in the drinking water of experimentally hypertensive rats lowered their blood pressure by 40mmHg and 50mmHg respectively.

MATERIAL AND METHODS

Extraction preparation
The plant materials were collected from Limuru (Kiambu county) and Njoro (Nakuru County), Kenya. They were detached off their individual parts separately and the experiment was then divided into two parts. The various individual detached parts of the wet plants; leaves 578.95g, stem 300.00g, roots 219.02g and flowers 100.00g were extracted by boiling them separately in water for a duration of two hours at 90°C. The crude extracts were then filtered and the various filtrates were freeze dried. The remaining various detached parts of the wet plant were dried under shade in the laboratory where the plant parts were laid on clean trays on benches for 21 days until consecutive constant weights were obtained; leaves 362.96g, stem 596.05g, roots 423.52g and flowers 66.75g. They were then exhaustively extracted by boiling them separately in water for a duration of two hours at 90°C. After filtration, the various filtrates were then freeze dried.

In vivo anti-malarial test
The animals used were Swiss mice weighing 20-25g each and bred locally in the animal house of Kenyatta National Hospital Laboratory (K.N.H.L.). They were divided into groups of N=8 with 4 males and 4 females per group. Each group of mice was kept in wired cages and provided with pelleted diet together with some water. A single donor mouse was bled into sterile heparinized culture medium and centrifuged for five minutes at 350g's. After aspirating the supernatate, 0.4*PRBC volume of glycerolyte ‘57’ was added over two minutes interval with gentle shaking. It was then frozen at -70°C in 0.4 ml aliquots. This was then thawed rapidly in hand and placed in 15ml centrifuge tube while slowly adding 0.1ml of 12% NaCl then left to stand for two minutes. 10ml of 1.6% NaCl was slowly added over a two minutes period, vortexed gently and then left to stand for five minutes. After centrifuging for five minutes at 350g’s, the supernatate was aspirated and 10ml of 0.9% NaCl, 0.2% Dextrose slowly added and left to stand for five minutes followed by centrifuging for five minutes. The supernatate was aspirated and the desired volume for infection made with RPML 1640 medium. The diluted blood (0.2ml) containing 1 x 10^7 parasitized (P. berghei) red blood cells was injected intravenously via a tail vein into normal mice. A single donor mouse was used to infect all the animals in order to minimize variability in the induced parasitaemia. The day of infection was termed “D0” and subsequent days “D1”, “D2” etc. Each drug was administered in 0.2ml solution per mouse as a single daily dose intravenously for four days.

Evaluation of Parasitaemia
Blood films were made from the cut tail vein of animals infected with P. berghei. These were stained with Giemsa stain after fixing with methanol. Parasite counts were done under oil immersion with the x1000 objective x10 eye piece of compound microscope. The number of microscopic fields counted was obtained by dividing 10^4 rbc by the mean of rbc in two fields. The total number of parasitized rbc were then counted in the above number of fields. Percentage parasitaemia was assessed for each field and the mean percentage parasitaemia for each field and the mean percentage parasitaemia for each mouse were then calculated as:

% Parasitaemia = No. of infected Rbc x 100
10,000

Evaluation of antimalarial Activity
The four day technique employed here was similar to that described by Peters and Porter (1975). Infected animals were divided into groups of eight mice. The crude aqueous extracts from A. remota, both wet and dry were given intravenously to the animals. Each animal received a dose of 30mg/kg/day (equivalent to 0.2ml solution per mouse) for four consecutive days. Parallel tests with chloroquine (a standard anti malarial drug) were conducted for reference purposes. The drugs were administered intravenously (injections with microlitre syringes). Tail blood film
was taken from each animal on D4. These were stained with Giemsa stain and percentages suppression of parasitaemia in relation to the control was calculated as follows:

\[
\text{AV. \%} = \frac{\text{Parasitaemia} - \text{AV. \% Parasitaemia in untreated ctrls}}{\text{Suppression Av. \% Parasitaemia in untreated ctrls}} \times 100
\]

**RESULTS**

The results of the study are presented in the table below.

<table>
<thead>
<tr>
<th>Drug</th>
<th>Nature of Drug</th>
<th>Average (N=8) Parasitaemia (%)</th>
<th>Average (N=8) Suppression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated ctrl</td>
<td>-</td>
<td>0.850</td>
<td>90.35</td>
</tr>
<tr>
<td>Leaves extract</td>
<td>Wet</td>
<td>0.820</td>
<td>90.35</td>
</tr>
<tr>
<td></td>
<td>Dry</td>
<td>0.146</td>
<td>82.82</td>
</tr>
<tr>
<td>Stem extract</td>
<td>Wet</td>
<td>0.565</td>
<td>33.53</td>
</tr>
<tr>
<td></td>
<td>Dry</td>
<td>0.621</td>
<td>26.94</td>
</tr>
<tr>
<td>Roots extract</td>
<td>Wet</td>
<td>0.476</td>
<td>44.00</td>
</tr>
<tr>
<td></td>
<td>Dry</td>
<td>0.586</td>
<td>31.06</td>
</tr>
<tr>
<td>Flowers extract</td>
<td>Wet</td>
<td>0.553</td>
<td>34.94</td>
</tr>
<tr>
<td></td>
<td>Dry</td>
<td>0.704</td>
<td>17.18</td>
</tr>
<tr>
<td>Chloroquine</td>
<td>Powder</td>
<td>0.300</td>
<td>84.71</td>
</tr>
</tbody>
</table>

**DISCUSSION**

The crude aqueous extracts, of *Ajuga remota* were shown to possess higher antimalarial activity than Chloroquine in this four-day test using sensitive strain of *P. berghei* in mice. The different parts of *A. remota* showed different suppressive activities against *P. berghei* parasites in mice with the wet and dry plant preparations. The leaves showed the highest antimalarial activity (90.4%, 82.8%) compared to the stems (33.5%, 26.9%), roots (44.0%, 31.1%) and the flowers (34.9%, 17.2%) for wet and dry parts respectively. Chloroquine showed 84.7% suppression of parasitaemia. The results indicate that the activity is reduced with drying of the plant which is true for all the parts of the plant. Among the plant parts, the leaves had the highest activity which was even higher than that of the control which was Chloroquine. The present study with the crude aqueous extracts of *A. remota* is indicative that the plant has considerable antimalarial potential. This is a confirmation of the knowledge of malaria treatment by traditional practitioners. From this study it is recommended that more should be done to advice the traditional practitioners on the parts of the plants to use, the mode of preparation and the dosage to be administered in the treatment of malaria by use of *A. remota*.

**ACKNOWLEDGEMENTS**

We wish to thank the staff from Department of Biological Sciences, Egerton University for identifying the plant for this work, B.C.R.U. Section staff of I.C.I.P.E. where we freeze dried the extracts, Kenyatta National Hospital for providing the mice and farmers in Limuru and Njoro field sites.

**REFERENCES**


REDUCTION OF BACTERIA AND OTHER POLLUTANTS IN SEWAGE STABILIZATION PONDS

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ABSTRACT
Management of water resources is one of the biggest problems facing developing countries today where sewage water treatment plants only serve the urban population. The rural areas and informal settings often lack mechanisms of sewage water treatment thereby posing potential harm to the environment. Different sewage water treatment options must therefore be developed to protect the environment. Sewage Stabilization Ponds (SSPs) are artificially constructed ponds that use biological treatment mechanisms to purify sewage water. They are simple to construct and maintain, have low capital investment and annual running costs, and also require less skilled personnel. This study evaluated performance of SSPs to determine whether they can efficiently treat sewage. It was conducted at the University of Eldoret sewage treatment plant which has 4 SSPs. Performance of these SSPs was achieved by determination of numbers of bacteria and levels of physicochemical pollutants in the sewage water at 5 different points (raw sewage influent, pond 1 effluent, pond 2 effluent, pond 3 effluent and pond 4 effluent) for 10 months. Results indicated that levels of all physicochemical parameters, except pH, temperature and total suspended solids reduced significantly \((p<0.05)\) from one station to the next and the least values were recorded for station 5. The numbers of bacteria, except for total bacteria counts, reduced significantly \((p<0.05)\) from one station to the next and the least values were recorded in station 5. Thus, SSPs are effective in sewage water treatment and can be adopted in small communities to protect aquatic environments and alleviate contamination of drinking water sources.

Key words: Environmental sustainability, Sewage treatment, Water resources

INTRODUCTION
Surface water bodies in developing countries are highly polluted as a result of indiscriminate discharge of wastewaters from industrial, agricultural, and domestic/sewage activities (Kambole, 2003; Hodgson, 2007). In developing countries only a small proportion of the wastewater produced by sewered communities is treated. Only 10-15% of the urban population in Africa is connected into the sewer network (WUP, 2003). There is a great need to wastewater treatment systems to avoid the health risk problems in these communities (Mara 2003).

A stabilization pond is a large shallow excavation that receives sewage from a sewer system, detains the sewage so that biological process can destroy most of the disease-causing organisms, and discharges the effluent as treated sewage (Kayombo et al, 2001; USDOD, 2004). Sewage stabilization pond systems provide reliable, low-cost, and relatively low-maintenance treatment for domestic discharges especially in areas that may be out of reach of Municipal sewage treatment plants such as refugee camps, schools and hospitals in rural areas. Operation and maintenance involves starting up the pond, managing pond surface conditions, maintaining the pond site, draining the pond and removing sludge.

In Kenya today where economic problems are complex, the sewage stabilization ponds should be popularized to let Public Health Engineers use them with confidence as a simple and reliable means of treatment of sewage and certain industrial sewages, at a fraction of the cost of conventional sewage treatment plants. Adopting as low a level of
treatment as possible is especially desirable in developing countries, not only from the point of view of cost but also in acknowledgement of the difficulty of operating complex systems reliably.

Sunlight is an important factor in the significant inactivation or removal of pollution indicator organisms in sewage stabilization ponds (Ainon and Chuan, 2002; Sinton et al., 2002). The ultraviolet portion of solar radiation from sunlight is bactericidal, causing direct deoxyribonucleic acid damage. At high intensities, photo-oxidation becomes more important acting through photosensitizers to damage organelles principally the cytoplasmic membrane (Davies-Colley et al., 1999).

The general objective of this study was to evaluate the performance of the sewage stabilization ponds at University of Eldoret in removing organic matter, nutrients and pathogens and to assess the physicochemical characteristics of the resulting effluents. The specific objective of this study was to evaluate pollutant removal efficiency of the SSPs for the selected physicochemical and bacteriological parameters and to identify the characteristics of pond influents and effluents.

**METHODOLOGY**

University of Eldoret has four oxidation ponds that are arranged in series with wide dykes separating them. They were constructed in 1967 but became operational in 1968. They are located in the Southwestern part of the University and drain sewage water and sewage from the students’ hostels, academic area and staff residence (population: about 40,000). Each of the ponds is 150 × 32 × 1.5 m and only one of these receives sewage water influent at a time. The sewage water and sludge are retained in the pond for about two weeks during which algae, bacteria and other organisms act on them by mineralizing the organic matter content. The effluents are conveyed through sewers made of concrete pipes from one pond to the next until the effluent gets to the last pond from where it is channeled into a nearby river.

**Experimental design and sampling**

Water samples were collected from five sites: raw sewage in-flow to the first oxidation pond, the oxidation pond itself, inflow into the second pond and the second pond itself, inflow into the third pond and the third pond itself, inflow into the fourth pond and the effluent from the fourth pond and the effluent receiving stream (Marura river) and the pond effluent/stream mixture, over a 10 month period (February 2013 to October 2013). Sampling was done twice every month for the months that have been mentioned. Samples was collected by filling 500 ml sterile brown bottles, iced and processed within 12 hours of collection. Figure 1 gives an illustration of the study area.

![Figure 1: Illustration of the University of Eldoret Sewage Stabilization Ponds](image)

The sampling stations and their descriptions are further described in Table 1 below.

<table>
<thead>
<tr>
<th>Station number</th>
<th>Description of station</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Point of entry of raw sewage into pond 1</td>
</tr>
<tr>
<td>2</td>
<td>Point of entry of pond 1 effluent into pond 2</td>
</tr>
<tr>
<td>3</td>
<td>Point of entry of pond 2 effluent into pond 3</td>
</tr>
<tr>
<td>4</td>
<td>Point of entry of pond 3 effluent into pond 4</td>
</tr>
<tr>
<td>5</td>
<td>Point of exit of pond 4 effluent into Marura river</td>
</tr>
</tbody>
</table>

**Examination of water samples for bacteriological indices of water quality**

Analyses of water samples for total bacterial counts (TBCs), Total Coliform counts (TCs), Faecal Coliform counts
(FCs), Faecal Enterococci counts (FECs) and Clostridium perfringens counts (CPCs) were performed using standard pour plate techniques on differential and selective bacteriological media. The colonies growing on the specific media was enumerated and identified based on morphological characteristics, staining reactions, and biochemical tests. The API 20E kit was used for rapid biochemical characterization of bacterial isolates. Table 2 illustrates the isolation criteria for C. perfringens, total bacteria, total coliforms and faecal streptococci and faecal coliforms.

Table 11: The isolation criteria for Clostridium perfringens (CP), Total coliforms (TC), Faecal coliforms (FC), Faecal Enterococci (FE) and Total bacteria (TB) in water samples

<table>
<thead>
<tr>
<th>Isolation medium</th>
<th>Incubation temperature °C</th>
<th>Incubation period (hours)</th>
<th>Bacteria isolated</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCA</td>
<td>37</td>
<td>48</td>
<td>TB</td>
</tr>
<tr>
<td>MAC</td>
<td>37</td>
<td>48</td>
<td>TC</td>
</tr>
<tr>
<td>MAC</td>
<td>44.5</td>
<td>48</td>
<td>FC</td>
</tr>
<tr>
<td>CPAB</td>
<td>37</td>
<td>48</td>
<td>CP</td>
</tr>
<tr>
<td>BA</td>
<td>37</td>
<td>48</td>
<td>FE</td>
</tr>
</tbody>
</table>

PCA-Plate Count Agar, MAC- MacConkey Agar, CPAB – Clostridium Perfringens Agar Base

Determination of the physicochemical parameters of sampled water

Temperature was measured with a thermometer while the pH was measured with a portable pH meter (E.I.L., Model 30C, Gallenkamp) in situ. Dissolved Oxygen (DO), turbidity, total dissolved solids (TDS), nitrates, nitrites, phosphates, chlorides and sulfates in water samples were determined using a multiparameter analyzer (HACH company) using methods described in the Manufacture’s manual. The biochemical oxygen demand (BOD₅) of water samples was determined by getting the difference between DO of samples on day 1 and day 5. The total suspended solids (TSS) of water samples was determined by filtering water samples on pre-weighed filter papers, drying overnight in the oven and getting the difference in weight between the initial weight and final weight of the filter paper. The electrical conductance of water samples was determined using a conductivity probe/meter.

Data Analysis

The data from this research was analyzed using spreadsheets such as Ms Excel and SPSS programs. Analysis of variance was done to determine the significance differences in parameters of pond influents and effluents.

RESULTS

Table 12: Means of physicochemical parameters per station

<table>
<thead>
<tr>
<th>Station</th>
<th>BOD₅</th>
<th>Cl⁻</th>
<th>Cond.</th>
<th>DO</th>
<th>NO₃</th>
<th>NO₂</th>
<th>pH</th>
<th>PO₄</th>
<th>SO₄</th>
<th>TDS</th>
<th>temp</th>
<th>TSS</th>
<th>Turb.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.85</td>
<td>16.6</td>
<td>582</td>
<td>2.37</td>
<td>15.42</td>
<td>0.094</td>
<td>7.65</td>
<td>23.6</td>
<td>0.375</td>
<td>0.562</td>
<td>21.83</td>
<td>0.423</td>
<td>315</td>
</tr>
<tr>
<td>2</td>
<td>2.16</td>
<td>16.6</td>
<td>551</td>
<td>6.66</td>
<td>6.07</td>
<td>0.057</td>
<td>7.95</td>
<td>18.63</td>
<td>0.377</td>
<td>0.442</td>
<td>21.83</td>
<td>0.338</td>
<td>73</td>
</tr>
<tr>
<td>3</td>
<td>2.21</td>
<td>16.1</td>
<td>481</td>
<td>6.35</td>
<td>4.28</td>
<td>0.056</td>
<td>8.2</td>
<td>17.72</td>
<td>0.317</td>
<td>0.373</td>
<td>22.17</td>
<td>0.307</td>
<td>65</td>
</tr>
<tr>
<td>4</td>
<td>3.04</td>
<td>15.9</td>
<td>459</td>
<td>7.31</td>
<td>3.78</td>
<td>0.066</td>
<td>8.22</td>
<td>16.48</td>
<td>0.303</td>
<td>0.322</td>
<td>22.67</td>
<td>0.34</td>
<td>62</td>
</tr>
<tr>
<td>5</td>
<td>1.16</td>
<td>15.6</td>
<td>441</td>
<td>9.79</td>
<td>1.35</td>
<td>0.025</td>
<td>8.23</td>
<td>15.4</td>
<td>0.23</td>
<td>0.273</td>
<td>22.5</td>
<td>0.225</td>
<td>55</td>
</tr>
</tbody>
</table>

e.s.e. 1.667 1.076 32.5 1.663 1.864 0.0823 0.239 1.504 0.0559 0.0543 0.453 0.0806 28.9

I.s.d. 4.918 3.176 95.7 4.905 5.498 0.0279 0.706 4.436 0.165 0.1602 1.337 0.2378 85.3

P value 0.009 0.049 0.025 0.053 <0.01 0.042 0.381 0.01 0.004 0.011 0.599 0.682 <0.01

NB: All the parameters are in mg/l or ppm except for conductivity (µS/cm), pH, Turbidity (NTU) and temperature (°C)

The means of all the physicochemical parameters under study are shown in Table 3 above. The levels of all except pH were found to reduce from one station to the next with most parameter recording the most values in station 1 and the least values in station 5. Reduction of all except for pH, temperature and TSS was found to be significant at p<0.05. The reduction of nitrates and turbidity across the stations was highly significant even at p<0.001.

The pH levels in fact tended to increase slightly from one station to the next with station 1 recording the least pH (7.65) and station 5 recording the most pH (8.23). The means of temperature for the 5 stations were found not to differ significantly from one another. Although the means of TSS reduced from one station to the next, this reduction was not significant. Unlike the rest of the physicochemical parameters, DO increased from one station to the next with station 1 recording the least DO (2.37 mg/l) and station 5 recording the most DO (9.79 mg/l).

The means of bacteriological indices in this study are provided in Table 3 below. The levels of all these parameters were found to reduce from one station to the next with most parameter recording the most values in station 1 and the
least values in station 5. Reduction of all except for TBC was found to be significant at p<0.05. The reduction of FC across the stations was highly significant even at p<0.001.

Table 13: Means of bacteriological indices in colony forming units (CFUs) per station

<table>
<thead>
<tr>
<th>Station</th>
<th>TBC</th>
<th>CPC</th>
<th>FC</th>
<th>FE</th>
<th>TC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>210692</td>
<td>68167</td>
<td>19867</td>
<td>90613</td>
<td>28717</td>
</tr>
<tr>
<td>2</td>
<td>103223</td>
<td>46840</td>
<td>14000</td>
<td>22295</td>
<td>27133</td>
</tr>
<tr>
<td>3</td>
<td>45517</td>
<td>25680</td>
<td>12317</td>
<td>24922</td>
<td>22367</td>
</tr>
<tr>
<td>4</td>
<td>30383</td>
<td>23050</td>
<td>5117</td>
<td>18067</td>
<td>11450</td>
</tr>
<tr>
<td>5</td>
<td>26067</td>
<td>21470</td>
<td>3550</td>
<td>11747</td>
<td>9100</td>
</tr>
<tr>
<td>e.s.e.</td>
<td>73298</td>
<td>18294.9</td>
<td>2586.2</td>
<td>32894.4</td>
<td>4635.5</td>
</tr>
<tr>
<td>l.s.d.</td>
<td>216229.1</td>
<td>53969.9</td>
<td>7629.3</td>
<td>97038.4</td>
<td>13674.7</td>
</tr>
<tr>
<td>P value</td>
<td>0.004</td>
<td>0.035</td>
<td>0.001</td>
<td>0.049</td>
<td>0.019</td>
</tr>
</tbody>
</table>

DISCUSSION

The principal objective of sewage treatment is generally to allow human and industrial effluents to be disposed of without danger to human health or unacceptable damage to the natural environment thus enhancing environmental sustainability. Water bodies when polluted with untreated sewage constitute health hazards to users and to aquatic life. Sewage pollution forms a greater part of the man’s activity and it is the immediate need of every community of today to combat sewage pollution. It is needless to stress that if an economic balance of the many varied services which a stream or a body of water is called upon to render is balanced and taken into consideration one could think of ending up in a wise management programme. In order to eliminate the existing water pollution levels of the natural water one has to think of preventive and treatment methods. The design of sewage treatment plants is usually based on the need to reduce organic and suspended solids loads to limit pollution of the environment (Mara, 2003).

The use of SSPs has therefore been considered as the ideal way of improving effluent quality by means of natural processes (Mtethiwa et al., 2007). The SSPS are one of the lower cost methods for treating the sewage emanating from small communities and this is achieved at minimum maintenance and operational requirements (Arar, 1988). Microorganisms constitute essential agents of the sewage purification system due to their metabolic activities (Imhoff and Fair, 1956). The organic matter is broken down by aerobic bacteria into simple inorganic materials such as carbon dioxide and water. Algae utilize these compounds to produce complex organic materials that make up algal cells. During this process algal cells generate oxygen which is utilized by bacteria (Bian and Li, 1992). In essence all these lead to the efficient mineralization of organic matter, that is, lower Biochemical Oxygen Demand (BOD) and inactivation of pathogenic bacteria, yeasts and viruses (Taber and Taber, 1976).

According to the results obtained, we concluded that the natural lagoon acts via biological process of purification allowing the organic matter elimination and physical process of settling allowing the evacuation of the suspended particles towards the sediment on which the various germs are adsorbed. The University of Eldoret Sewage SSPs appears to be very efficient in wastewater treatment. It generates a nearly complete removal of organic matter and a satisfactory reduction of germs of fecal contamination and pathogens by the germicidal action of sunlight.

In this study, the bacterial load showed a maximum mean at the entrance to the first pond (station 1) and decreased with the minimum means being recorded at the point of release of the treated effluents into the receiving water body (Station 5). At the entrance, the average number of bacteria per 100 ml is 140×10⁸ and at exit, this number decreased to a value of 3.5×10⁶ with an average yield purification of 99.9%. Most of the work on pathogen removal in SSPs has concentrated on the removal of the bacterial indicator organisms (E. coli and FC). The reduction in numbers of bacteriological indices in the consecutive ponds could be attributed to the damage to the cytoplasmic membranes of bacteria caused by sunlight (Masters et al., 2011). The processes that may remove pathogens in stabilization ponds include natural die-off, sedimentation, filtration, ultra-violet light ionization, unfavorable water chemistry, temperature effects, and predation by other organisms and pH (Kadlec and knight 1996). These authors showed that vegetated stabilization ponds seemed more effective in pathogen removal since they allow a variety of microorganisms which may be predators to pathogens to grow.

Results on the levels of the physicochemical parameters in the SSPs revealed similar results as the bacteriological indices. pH in the initial ponds tended to be acidic but as the wastewaters moved to the 3rd and 4th stabilization ponds, the pH tended to rise slightly to become basic although even the rise was not statistically significant. The reason for
the acidic nature in the initial ponds could be attributed to the acidogenic phase in the inflow waters (Kayombo et al. 2002) and higher photosynthesis due to prolific algal growth in ponds (Veeresh et al. 2009). The basic nature of the effluents in the last 2 ponds (Stations 3 and 4) could be attributed to heavy algal growth observed in these stations. The high pH values are attributed to higher photosynthetic rates of algae, drawing more dissolved CO₂ from the waters and thereby causing high bicarbonate and carbonate concentrations, known as alkalinity. High carbonates cause calcium and magnesium ions to form insoluble minerals, leaving sodium as the dominant ion in solution (Craggs et al., 2012).

There was a marked increase in levels of DO in sewage effluents leaving the treatment plant (Station 5; 9.79 mg/l) than there was in the effluents coming into the treatment plant (Station 1; 2.37 mg/l). The increase in levels of DO could be attributed to the fact that the more and more organic matter was being degraded in the effluents as they were channeled from one pond to the next thereby decreasing the BOD and allowing for levels of DO to go up. The means of DO across the stations were inversely proportional to the means of BOD. The raw incoming sewage effluents (station 1) had high BOD (4.85 mg/l), while the effluents leaving the treatment plant into the receiving water body had lower BOD (1.16 mg/l). The high BOD in inflows could be contributed by the high levels of organic matter in the raw sewage that required high levels of oxygen to be oxidized. The decrease of BOD in the outflows illustrates the functioning of anaerobic zone of the ponds. Anaerobic bacteria convert organic carbon into methane and in the process, remove up to 60% of the BOD (Mara, 2003; Hodgson, 2007; Navaraj, 2005). The aerobic and anaerobic organisms work together to achieve BOD reductions of up to 75%. The heavy solids settle to the bottom where they are decomposed by bacteria. The lighter, suspended material is broken down by bacteria in suspension.

The suspended and dissolved solids in the sewage effluents also reduced significantly from one station 1 to 5. The means of TDS and TSS at the sewage inflows (Station 1) were 0.652 mg/l and 0.423 mg/l respectively while these levels in sewage outflows were 0.273 mg/l and 0.225 mg/l respectively. Higher levels of these solids at inlets could be due to semi decomposed and decomposed solids arising from organic matter. The removal of TDS and TSS followed the same trend as removal of turbidity. This could be because turbidity is often associated proportionally with the quantity of solids in water (Tadesse et al. 2004). The physical processes responsible for removing suspended solids include sedimentation, filtration, adsorption onto biofilm and flocculation/precipitation. Wetland plants increase the area of substrate available for development of the biofilm.

The reduction of conductivity in the sewage effluents also followed the same trend as the suspended and dissolved solids. These means were high in sewage inflows (Station1; 582) and reduced significantly in sewage outflows (Station5; 441). Conductivity of electric currents is usually effected by the suspended and dissolved solids in water and it followed that as these solids were being eliminated from the effluents then the electric conductance of the effluents reduced at the same rate.

Turbidity level in sewage inflow (Station 1) was recorded at 315 NTU and this value reduced to 55 NTU in sewage outflow (Station 5). Turbidity is influenced by several factors among them the levels of suspended and dissolved solids. It followed that as the suspended and dissolved solids were eliminated from the sewage effluents, then turbidity was also reduced at more or less the same rate.

Nitrogenous compounds (NO₂⁻ and NO₃⁻) were also found to reduce substantially in effluents leaving the stabilization ponds. The raw influent sewage has NO₃⁻N of 15.42 mg/l while the NO₃⁻N level in the sewage outflow (Station 5) was 1.35 mg/l. The raw influent sewage (station 1) had NO₃⁻N of 0.094 mg/l. NO₃⁻N in the effluent of maturation pond (Station 5) was 0.025 mg/l. Removal of nitrogenous compounds in the SSPs could be attributed to the hydrolysis of organic nitrogen to ammonia. Nitrogenous compounds are utilized by algae to make more algal cells (Mara, 2003). Higher values of nitrates and nitrites at the inflows could be due to their high levels in raw effluents (Mahapatra et al. 2011). Nitrate nitrogen (NO₃⁻N) is a necessary primary macronutrient for the biota in aerated treatment systems and therefore was consumed in the ponds by the available microorganisms. Earlier studies have reported nitrate concentrations >10 mg/l at higher organic loads with competitive algal activities (Faleschini et al. 2012). The trend shows that there is a drop in nitrogenous compounds present in the pond outflows. This could also be due to settling of particulate organic matter and consequent higher microbial activities, which is similar to an earlier report (Faleschini et al. 2012).

Phosphorous levels in sewage inflows (station 1) and the sewage outflows (station 5) were also found to be significantly different. Phosphorus removal in wetlands is based on the phosphorous cycle, and can involve a number of processes. Primary phosphorus removal mechanisms include adsorption, filtration and sedimentation. Other processes include precipitation and assimilation/uptake. Particulate phosphorus is removed by sedimentation, along with suspended
solids. Means of phosphates were higher at the inflow (station1; 23.6 mg/l) indicating active mineralization with higher algal biomass and the lowest values of phosphates were recorded in the pond outflows and final effluents (Station 5; 15.4 mg/l). This could be attributed to the high organic matter in the raw effluents and therefore higher organic phosphorous.

The elimination of chlorides and sulfates in sewage effluents also followed the same trend as removal of phosphorous and nitrogenous compounds. The reason for this could be because chlorides and sulfates are also nutrients that are necessary for growth of microbial biomass and just like the phosphates and nitrogenous compounds were consumed or metabolized by these microbes for growth thereby eliminating them in the effluents.

ACKNOWLEDGMENTS

Our gratitude goes to the Government of Kenya through the National Commission for Science, Technology and Innovation (NACOSTI) for financial support. We thank University of Eldoret for permitting this study and for provision laboratory facilities

CONCLUSION AND RECOMMENDATION

Efficient sewage treatment before disposal is necessary in order to avoid problems that are related to eutrophication of receiving water bodies and degradation of the environment at large. From this study, it was concluded that SSPs can be efficient and simple methods of treating sewage water before releasing them into the environment. They can become handy in areas where households or institutions are not connected to municipal sewers and therefore require alternative means of sewage treatment. The University of Eldoret SSPs were found to be efficient in reduction of numbers of bacteria as well as most of the physicochemical pollutants. The physicochemical pollutants that were not reduced significantly include pH, TSS and temperature. Dissolved oxygen was found to increase in the final effluents leaving the treatment plant showing that the SSPs were quite efficient in reduction of organic content of the sewage water. This study recommends the construction and use of these ponds in places that are out of reach of the conventional treatment plants so as to protect the environment from untreated discharges.

REFERENCES


USDOD United States Department of Defense 2004: Domestic Wastewater Treatment.


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DYNAMIC MECHANICAL ANALYSIS and THERMAL PROPERTIES OF BITUMEN-ACACIA SAP COMPOSITES

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ABSTRACT

Bitumen binder mechanical and thermal properties have been unsatisfactory. Different synthetic binder modifies that have been used to improve its performance have led to environmental problems such as incineration and landfill. Acacia sap, a natural and environment-friendly polymer, has been used successfully as a modifier. Composites of bitumen-acacia sap with different composition of sap percentage ranging from 0% to 62.5% cell sap were prepared by injection drawing process. The composites were analyzed by dynamic mechanical analysis (DMA) for mechanical properties and Thermogravimetric Analysis for thermal properties. Storage modulus and Loss modulus of bitumen binder increased with acacia sap loading. Glass transition temperatures were found to shift to higher values as acacia sap loading increased. Activation energies were determined from the thermogravimetric data of the bitumen-acacia composites using the Broido model. Pure bitumen binder had the highest thermal stability. Modification of bitumen binder with 25% acacia sap loading gave optimum mechanical properties. Further studies should dwell more on understanding morphological properties of bituminous binding elements and using different kinds of natural polymers and different grades of bitumen obtained from different crudes.

Key words: Acacia, Bitumen, Modulus, Thermogravimetric

1.0 INTRODUCTION

Bitumen is a low molecular weight hydrocarbon obtained by fractional distillation of crude oil and catalytic cracking of hydrocarbons [11]. Because of its good adhesive, impermeability and viscoelastic properties, it has wide range of applications such as used as a binder of aggregate in road construction, waterproofing agent, coating, insulation, to more specialized purposes such as when blended with proportion of polymers used in built up membranes for the roofing industry [4]. However, its performance when subjected to high traffic levels and rigorous climatic changes has been unsatisfactory. Road performances depend mainly on the rheological properties (storage modulus, loss modulus and loss factor) of the bitumen because in asphalt mixtures bitumen is the only deformable component [6]. Different types of binder modifiers used to improve performance have led to environmental problems such as incineration and landfill. Most commonly used synthetic polymers for bitumen modification are styrene-butadiene styrene (SBS), styrene-butadiene rubber (SBR), ethylene-vinyl-acetate (EVA), styrene-ethylene-butylene-styrene (SEBS), ethylene butyl acrylate (EBA) and polyethylene among others. Use of acacia sap (natural polymer) as a modifier has improved bitumen performance and has a much better disposal solution compared synthetic polymers which cause environmental problems during disposal. Viscoelastic properties of the modifiers are important in predicting road characteristics over wide range of temperatures and traffic loadings [9, 14]. Materials that are stable at extremely low and high temperatures are likely to be better performances. Since the binders are subjected to very low and high temperatures and to high traffic loadings during their applications, knowledge of mechanical properties and thermal degradation behavior of the modified binders is essential for understanding their performance. This study was carried out with the objective of investigating the mechanical and thermal properties of bitumen binders modified using different proportions of acacia sap.
MATERIALS AND METHODS
The materials used in the study were bitumen and acacia sap. Bitumen, 80/100 penetration grade was obtained from Kenya oil Refineries companies in Mombasa, Kenya, with an asphaltene content of 25 wt.% and softening point of 52°C. The acacia sap was obtained from Acacia trees.

Bitumen was put in a melting chamber with the opening closed by a stopper screw. The melting chamber was placed on a hot plate at 160°C and maintained at that temperature for 5 minutes to melt the bitumen. Dry acacia sap was added and the mixture mechanically stirred continuously with a screw for 5 minutes to obtain a homogeneous composite. The mixing process was achieved by using the mixing screw that almost fitted to the inside walls of the chamber as shown Figure 2.1. During injection, the mixing screw and the stopper screw were carefully removed. A piston was used to quickly inject the mixture into the Petri dish as illustrated in Figure 2.2. The mixture was allowed to cool at room temperature. This procedure was repeated in preparing all the composites. However, bitumen-acacia sap composites samples which were highly viscous in such a way that they could not be injected were prepared by mechanical stirring. The corresponding polymer acacia sap weight percentage was added to bitumen and the mixing was maintained at 160°C. After mixing, the resulting dispersion was poured into the Petri dish and then stored at room temperature to retain the morphology. The paste was scooped and stuck in the jaws of the shear sandwich clamp. It was then compressed by application of force on the screw producing circular sheets. The sheets were then cut into rectangular shapes of dimensions 10 ± 0.5mm x 10 ± 0.5mm x 2 ± 0.5mm.

2.5 Thermogravimetric Analysis of the composites
The thermogravimetric analysis (TGA) was carried out using the Lindberg/blue TF55035C mini Tube furnace in oxidative atmosphere. Heating was done from room temperature (25°C) at a rate of 5°C/min in the range of 80-550°C with aluminium containers as reference materials. Weight loss of the composites was calculated. The natural logarithm of fraction decomposed was plotted against reciprocal temperature to determine the activation energy of the bitumen composites.
2.3 Dynamic Mechanical Analysis
Dynamic mechanical analysis was carried out using DMA 2980 TA instrument in the shear sandwich mode on samples about 10 ± 0.5 mm x 10 ± 0.5 mm x 2 ± 0.2 mm that were cut off from the composites of bitumen-acacia sap. The instrument was calibrated according to the manufacturer specifications, as outlined in the user manual. The instrument parameters were set at 0.44, data sampling interval of 2.0 sec/point, static force of 0.5 N and oscillation amplitude of 20 µm. The storage modulus (\(E'\)), loss modulus (\(E''\)) and loss tangent (\(tan \delta\)) were recorded in DMA multi-Frequency tensile shear sandwich mode system in order to get required data. A suitable configuration for the geometry of the samples was used. The equipment was programmed to scan across a frequency range of 0.3, 1, 3, 5, 10, 15, 20, and 30 Hz. The temperature used was in the range of 276 to 323 K and in steps of 2 K after every frequency sweep. Measured data on dynamic mechanical analyzer TA 2980 and TGA was analyzed using microcal card origin 8 software.

3.0 RESULTS AND DISCUSSION
3.1 Thermal analysis
3.1.1 Thermogravimetric analysis
TGA studies have been carried out to determine thermal stability and degradation temperatures of the composites. Figure 3.1 shows the TGA thermograms of pure bitumen and bitumen-acacia sap composites obtained at heating rate of 5°C/min. The curves follow sigmoidal fit shown by solid lines. The curve of pure bitumen show single stage of remnant mass with well-defined initial and final degradation temperatures, this has been attributed to random chain scission and pyrolysis of the sample occurring concurrent or evaporation of moisture associated with release of gases prior to decomposition. This result may be confirmed by the presence of single peak in the derivative thermogravimetric curve at temperature of 432°C, the point at which mass loss is most apparent. Above 480°C, the quantity of bitumen residue was very small due to breakdown of the bitumen residue into gaseous products.

![Figure 3.1: TGA and DTGA thermograms for pure bitumen and bitumen-acacia sap composites containing 0, 25, 50 and 62.5wt% acacia sap loading at heating rate of 5°C/min.](image)

Table 3.1 Decomposition temperature of the bitumen-acacia sap composites

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>Decomposition Temperature(°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B100AS0</td>
<td>432.30 ± 2.55</td>
</tr>
<tr>
<td>B75AS25</td>
<td>429.41 ± 1.78</td>
</tr>
<tr>
<td>B50AS50</td>
<td>400.19 ± 2.34</td>
</tr>
<tr>
<td>B37.5AS62.5</td>
<td>379.73 ± 1.47</td>
</tr>
</tbody>
</table>

It is also evident from Figure 3.1 that percentage remnant mass for all composites correspond to single-stage degradation, which might have been the result of chain scission and branching occurring concurrently. This result is also confirmed by the presence of single peak in the DTG curve as shown by solid lines. The total remnant mass of the composites decreased with increase in acacia sap content at same temperature because the thermal degradation temperature of the sap is lower than that of bitumen. Thermal degradation retarded above 480°C due to increased ash content. From the TGA thermograms it is also seen that below 100°C there was no mass change and above 100°C volatilization of low molecular weight species took place along with pyrolysis resulting to mass change. There was also shifting of the onset temperature of thermal degradation of the composites to lower values with increase of sap content due to low thermal stability of the acacia sap.

3.1.2 Decomposition temperature of the composites
The peak decomposition temperature of the bitumen-acacia sap composites were obtained from the maximum peak
temperature of the DTG curves shown in Figure 3.1. Bitumen has a high molecular mass (10000 to 100000) than acacia sap (10000 to 15000) [8] polymer, this resulted in decomposition of bitumen at higher temperature than the bitumen-acacia sap composites. The peak decomposition temperatures decreased with increase in acacia sap loading in the composites as shown in Table 3.1. This is due to low molecular weight and semicrystalline nature of the cellulose-acacia sap which makes them less temperature resistant. This is in agreement with results reported by other researchers [9]. The decomposition temperature of bitumen according to literature ranges from 440 to 650 °C [20] while that of cellulose-dry acacia sap from 250 to 350 °C [8].

3.1.3 Determination of Activation Energies

Figure 3.2 shows the kinetic curves of thermal degradation of bitumen-acacia sap composites. The solid lines have been fitted using the Broido model [1].

![Graph showing the kinetic curves of thermal degradation of bitumen-acacia sap composites.](image)

The activation energy ($E_a$) values were directly obtained from the slope of the linearly regressed line of ln(ln(1/x)) versus 1000/T at a constant heating rate of 5°C/min. There was a significant change in the activation energy values between the composites and the pure component. It can be inferred from values presented in Table 3.2 that the composites containing higher acacia sap concentration exhibit lower activation energy than composites with low acacia sap concentration. This shows that the thermal stability of bitumen-acacia sap composites decreased with increase in acacia sap content. The thermal stability of the bitumen-acacia sap composites was substantially reduced by the incorporation of semi crystalline acacia sap to the amorphous bitumen matrix. At lower acacia sap content, composites appear to be in a continuous phase and swollen by the miscible components of the bitumen and forms an interconnected three-dimensional structure but at higher polymer content polymeric network collapses due to poor compatibility and coalescence of polymer molecules resulting in phase separation. The value of activation energy obtained for the pure bitumen was close to the value reported in literature for the bitumen of 30 kJ/mol [2] using the Friedman’s technique.

<table>
<thead>
<tr>
<th>Table 3.2: Activation energies of bitumen-acacia sap composites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitumen-acacia sap composites</td>
</tr>
<tr>
<td>B100AS0</td>
</tr>
<tr>
<td>B75AS25</td>
</tr>
<tr>
<td>B50AS50</td>
</tr>
<tr>
<td>B37.5AS62.5</td>
</tr>
</tbody>
</table>

3.2. Rheological properties of bitumen-acacia sap composites

3.2.1. Storage Modulus

The storage modulus $E'$, is a measure of the rigidity (stiffness) and resistance to deformation of the sample. The storage modulus of the pure bitumen decreased with increase in temperature due to softening. It also shifted to the right with increase of frequency as shown in Figure 3.3 (a). At high frequency (shorter period) the sample behaves like an elastic solid while at low frequency (longer period) it’s rubbery. The storage modulus dropped suddenly at 300 K due to softening i.e. phase inversion.
The storage moduli of the bitumen-acacia composites are greater than that of bitumen as shown in Figure 3.4 (a), and increases with increase in acacia sap loading, this is because acacia sap stiffens the bitumen matrix. The composites also show a plateau at 305 K due to limited free volume which prevents molecular motion. The composites softened at higher temperatures than bitumen. This results from crystallization. A phenomenon attributed to physical hardening as a result of reorientation of some aromatic structures present in bitumen and crystallization of waxes possible to happen at lower temperatures. The storage modulus of the composites also reached a plateau at higher temperatures than bitumen; this is due to existence of molecular entanglements which makes the chains temperature resistant. These plateaus terminated at 320 K when the samples began to flow due to softening. These patterns of behaviour are consistent with the network structure which disperses when the polymer melts, and as has been described for several polymer-solvent systems, this is in agreement with work by other researchers [5].

3.2.2 Loss Modulus, E''
Loss modulus reflects the amount of mechanical energy dissipated by a material. It’s a relaxation process assigned to main chain fluctuations i.e. dynamic glass transitions. Figure 3.3 (b) show plots of the loss modulus against temperature for different frequencies of pure bitumen. The solid lines have been fitted using loss superposition model function [13].

\[
E''(T) = \sum_{j=1}^{2} A_j \exp\left\{-\frac{E_a}{R} - \frac{T^2}{T_m^2}\right\} \exp\left\{\frac{E_a}{k}\left(\frac{1}{T_m} - \frac{1}{T}\right)\right\}
\]

In this model function, A is a constant, k Boltzmann constant, T absolute temperature, T_m temperature at maximum loss modulus, E_a is the activation energy and refers to different processes which contribute to mechanical response.

From figure 3.3b, it is clearly seen that the relaxation process is narrow indicating narrow distribution of relaxation times. The maximum dissipation is observed at 3Hz. The loss modulus peaks shifts to the right (higher temperatures) as the frequency is increased. This shift is attributed to the fact that at low frequency, almost all the chains are able to follow movement of the oscillations. At higher frequency, however, it becomes very difficult for all the chains to follow the movement of the oscillations. A few, probably the ones with a shorter chain length, would be able to oscillate thus giving a shift of the loss modulus to higher temperatures. There is also sudden drop of the loss modulus
at 300 K indicating structural changes. This is due to softening of the bitumen as temperature rises. In addition, from Figure 3.4b; the loss modulus intensity for the composites increased with increase in percentage of acacia sap content indicating stiffening. Cellulose-acacia sap being a semicrystalline material, when mixed with bitumen (amorphous material) the crystallites impose chain constrains, which restricts the number of chains participating in the relaxation process, thus increasing the loss modulus, this is in agreement with literature [6].

The introduction of acacia sap changes the molecular environment and the molecular response to strains due to polar hydroxyl groups. The loss modulus peaks also shifts to higher temperatures with increasing acacia sap concentration. This shift is due to acacia sap introducing rigid phases resulting from molecular interactions. This produces a more rigid interface in the bitumen matrix. This restricts the number of chains participating. Cellulose-acacia sap being semicrystalline introduces some ordering of the chains thus making the response to be collective. This is because the chains cannot take up all the conformations that are theoretically possible. With the presence of crystalline phases, the molecular dynamics become more cooperative in nature thus giving a shift of the loss modulus. This observation is in agreement with reports from other researchers [3, 17, 19]. The curves also show that with increase in acacia sap content in the composites, phase inversion is delayed due to hydroxyl groups as more energy is needed to soften the stiff polymer matrix.

### 3.2.3 Time-temperature dependence of relaxation time

Figure 3.5: Time-temperature dependence of the relaxation process in bitumen-acacia sap composites

Figure 3.5 show that the time-temperature dependence of mean relaxation time for the pure bitumen and bitumen-acacia sap composites follows VFT law confirming that these are dynamic glass transition processes. The solid line has been fitted using the VFT model equation [15]

\[
\tau = A \exp \left( \frac{B}{T - T_o} \right)
\]

The fit parameters obtained are as shown in Table 3.3. The glass transition temperature \( T_g \) obtained from the VFT for pure bitumen was \( T_g = 321.5K \) or 48.5°C while the \( T_g \) obtained from the maximum loss modulus peak in Figure 3.3 at 1Hz = 288K or 15°C while the one reported in literature is 11.4°C [18]. The discrepancies in the glass transitions are associated with method used. The glass transition temperatures for the composites can also be obtained by adding 50°C to \( T_g \). From Figure 3.5, it can also be seen that the relaxation processes exhibited are glass transition processes, due to shifts; confirming that the molecular motions are cooperative. It can also be inferred from the results that as acacia sap loading increases the relaxation frequency is reduced. This is attributed to the induced chain stiffness by the sap and is in agreement with literature [3, 9].

### 3.3 CONCLUSIONS

An investigation on the mechanical and thermal properties of the injected drawn composites of bitumen and acacia sap has been presented. From the analysis of the results, the following conclusions were made: The thermal stability of the bitumen-acacia sap binders decreased with increase in acacia sap loading, this is evidenced by decreased activation energy values. Addition of acacia sap to bitumen binder led to increased values of the storage and loss moduli. The glass transition temperature was increased; this is evident by the shift of the glassy region to higher temperatures. Modification of bitumen binder with 25% acacia sap loading gave optimum mechanical properties.
3.4 RECOMMENDATIONS AND FURTHER WORK
Further studies should dwell more onto understanding morphological properties before applying the modifier in bituminous binding elements. The conclusion of this study covers utilization of acacia tree sap and 80/100 bitumen penetration grade. More research should be carried out by using different kinds of natural polymers and different grades of bitumen obtained from different crudes.

3.5 ACKNOWLEDGEMENT
We thank the laboratory technicians from the physics Department, Kenyatta University for providing materials and apparatus during experimental work.

REFERENCES


ABSTRACT

The Kenyan Government's Vision 2030 seeks to make Kenya a middle-level industrialized nation and improve the economic and social status of its citizens. The realization of this vision will be achieved with adequate human resource at the technology, technician and artisan levels. Technical Training Institutes are charged with the responsibility to train technicians and artisans. Concerns have been raised on the quality and quantity of the graduates coming out of these training institutions. The current study sought to investigate strategies that should be put in place to enhance the training in Technical Training Institutes. Descriptive survey research design was used for the study. Heads of academic departments and students were used for the study. Questionnaires and interview schedules were used for data collection. The study established that training was conducted with inadequate teaching staff and obsolete equipment. The researcher recommends that adequate staff should be hired in training institutions and programmes put in place to upgrade the skills and knowledge of trainers in the light of changing technology. Training facilities in the training institutions should urgently be upgraded. Thus findings of this study will benefit all stakeholders on the critical needs of Technical Training Institutes toward the realization of the Vision 2030.

Key words: Improving, Technical training, Human resource training

INTRODUCTION

In the Sessional Paper No. 2 of 1996, on industrial transformation by the year 2020, the government views industrialization as a means to accelerate the country’s economic development (GOK, 1996). However, this will remain elusive, as it requires enormous human resource support. It observes:

Kenya cannot industrialize unless the country has a sufficient reservoir of trained Indigenous human resource at all levels and especially in the technical fields GOK (1999, 43). This implies that human resource needs to be developed through formal training to impact relevant and desired skills. The Sessional Paper No. 2, also pointed out that Technical training Institutions have a big role to play in training technicians, craftsmen and artisans who are the actual workmen for the industrialization process. From the fore going, it can be said that TTI’s need to be given necessary attention if this industrial transformation by the year 2030 is to be realized. The 2003/2005 national development plan decries the imbalance in the labour force mix:

The current ratio of technologists to craftsmen to artisan is 1:3:12 as compared to an optimal of 1:5:30. The imbalance in labour force impacts negatively on development, which is a crucial to industrialization, GOK (2002, 58).

The implication of the above concerns is that TTI’s need to enhance the training of craftsmen and artisans. UNESCO (1995) observes that Kenya’s main challenge in technical and vocational education is the improvement of the quality of training at all levels to ensure relevant knowledge and skills to the employment requirements.

Statement of the Problem and Objectives of the Study

Technical skills are a necessary condition for Kenyans industrialization by vision 2030. These skills are offered by the TTI’s. Concerns have been raised on the quality and quantity of graduates coming from these training institutions. The current study sought to determine the availability of facilities and human resource for the training of human resource necessary to realization of vision 2030. The following objectives were formulated to guide the study:

i. To assess the adequacy of training facilities for human resource training need for the vision 2030.

ii. To determine the adequacy of teaching staff for human resource training for the vision 2030.

METHODOLOGY

This study was conducted using descriptive survey research. This design was appropriate for the study as it enabled collection of the facts on the status of training in TTI’s. It also allowed for collection and analysis of data in a manner
that combined relevance to the research objectives with economy in procedure. This study was carried out in eight TTI’s of Nairobi and Mount Kenya regions. Heads of Departments and students participated in the study. The research instruments that were used for data collection included questionnaires and interview schedule. The content validity of the research instruments was ensured through expert judgment. Reliability of the instruments was tested after piloting. A correlation coefficient of 0.849 and 0.921 were realized for the graduates and H.O.Ds questionnaires respectively. Data generated from the study was analyzed by use of descriptive statistics and presented in tables and figures.

RESULTS AND DISCUSSIONS

The sample constituting of Graduates and H.O.Ds was analyzed by gender. The male respondents were more (67%) than the female respondents (33%).

Trainers of TTIs

Trainers are a critical component of the training requirements. The GOK, (2005) emphasizes on the need for adequate staffing for the effective education at all levels of training. The study sought information on the adequacy of trainers in the departments. Majority of H.O.Ds felt that TTI’s operates with inadequate (73%) trainers.

Figure 1. Adequacy of Trainers in TTI

The trainers’ level of qualification is critical in determining the efficiency of the training process. Aduda (2003) observes that the trainer should possess higher qualification to effectively execute the training duties. The study sought information on the academic qualifications of TTI trainers. Table 18 presents findings on the trainers’ level of qualifications. Most of the trainers (32.1%) are either diploma holder or first-degree holders. About 22.2% and 13.6% of the trainers were said to have higher diploma and masters respectively. The study established that majority of the trainers were either diploma holders or first degree graduates. This is despite the fact that most TTI graduates left the institutions with a diploma qualification.

Table 18. Levels of Qualification

<table>
<thead>
<tr>
<th>Level</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diploma</td>
<td>26</td>
<td>32.1</td>
</tr>
<tr>
<td>Higher Diploma</td>
<td>18</td>
<td>22.2</td>
</tr>
<tr>
<td>First Degree</td>
<td>26</td>
<td>32.1</td>
</tr>
<tr>
<td>Masters</td>
<td>11</td>
<td>13.6</td>
</tr>
</tbody>
</table>

Facility Availability

The GOK (2005) observes that training facilities are critical if education in Kenya is to meet the technological market skill needs and move the country to the vision 2030. The availability of training facilities is critical to quality teaching and training. An item on the adequacy of training facilities was included in the H.O.Ds and graduates questionnaire. Table 24 presents findings on the H.O.Ds opinion on the adequacy of physical facilities. Majority of the H.O.D respondents (83.3%) indicated that training facilities were not adequate compared to only 16.7% of respondents who indicated that the physical facilities were adequate. This implies that the H.O.Ds felt that TTI’s operated with inadequate training facilities.
Table 24 H.O.D.’S View on Adequacy of Physical Facilities

<table>
<thead>
<tr>
<th>Response</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>8</td>
<td>16.7</td>
</tr>
<tr>
<td>No</td>
<td>40</td>
<td>83.3</td>
</tr>
</tbody>
</table>

The graduates’ opinion was also sought in reference to the adequacy of the physical facilities. Majority of the graduate respondents (63.1%) indicated that the training facilities in TTI’s were inadequate while 36.9% indicated that the facilities were adequate. This implies that majority of the T.T.I graduates felt that they were trained using inadequate training facilities. This data is captured on Table 25.

Table 25 Graduates Opinion on Availability of Facilities

<table>
<thead>
<tr>
<th>Response</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>62</td>
<td>36.9</td>
</tr>
<tr>
<td>No</td>
<td>106</td>
<td>63.1</td>
</tr>
</tbody>
</table>

Effect of Facility Availability on Training

The study sought information on the effects of the availability of training facilities to the T.T.I training. H.O.Ds were asked whether the availability of facilities in TTI’s affected the relevance of skill training to market skill needs. Majority of respondents (85.4%) indicated that availability of training facilities did affect the relevance of skills to market skill needs whereas 14.6% felt that facility availability had no effect on skill relevance. The information on the effects of facility availability to relevance of T.T.I training is presented on Table 27.

Table 27. Effects of Facility Availability on Training

<table>
<thead>
<tr>
<th>Response</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>41</td>
<td>85.4</td>
</tr>
<tr>
<td>No</td>
<td>7</td>
<td>14.6</td>
</tr>
</tbody>
</table>

State of Training Equipment

The study sought information on the state of training equipments in TTI’s. The H.O.Ds were asked to rate the state of training equipments ranging from obsolete to modern. Table 28 presents the H.O.Ds view and Table 27 presents the graduates view. At 47.9% the H.O.Ds felt that the training facilities are good, 22.9% were non-committal on the state of facilities, 14.6% rated the facilities as bad, 12.5% said the facilities were obsolete whereas only 2.1% of respondents rated the facilities as modern. Though a reasonable proportion of respondents rated the training equipments as good a greater proportion of respondents rated the equipments obsolete (12.5%) compared to the 2.1% who rated the equipments as modern. Modern referred to the training equipments being in tandem with the equipments used in the industries while obsolete referred to the situation where the training equipments were absolutely out of tune with the equipments used in industries and business organizations.

Table 28. H.O.D’s View on the State of Training Equipments

<table>
<thead>
<tr>
<th>State training equipments</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modern</td>
<td>1</td>
<td>2.1</td>
</tr>
<tr>
<td>Good</td>
<td>23</td>
<td>47.9</td>
</tr>
<tr>
<td>Neutral</td>
<td>11</td>
<td>22.9</td>
</tr>
<tr>
<td>Bad</td>
<td>7</td>
<td>14.6</td>
</tr>
<tr>
<td>Obsolete</td>
<td>6</td>
<td>12.5</td>
</tr>
</tbody>
</table>

The study also sought information on the state of training equipments from former trainees of TTI’s. Table 29 presents the graduates opinion on the state of training equipments. Graduate respondents (28%) rated the training equipments used in TTI’s as good, 23.2% rated the equipments as obsolete, 19.6% indicated the equipments to be bad, 19% held no opinion on the state of the training equipments whereas 10.1% rated the training equipments as modern. A larger proportion of the respondents rated the T.T.I training equipments as obsolete compared to the proportion that rated the training equipments as modern.

Table 29. Graduate’s View on State of Training Equipments

<table>
<thead>
<tr>
<th>State of training equipments</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modern</td>
<td>17</td>
<td>10.1</td>
</tr>
</tbody>
</table>
The study sought the respondents’ opinion on the need to modernize the training equipments. Respondents were asked to comment on the need to modernize the training equipments. Majority of the respondents 97.9% indicated that there was need to modernize the training equipments used in TTI’s. Only 2.1% felt that modernizing the equipments was not a priority. Table 29 shows the data by frequency and percentages. The study revealed that there was urgent need for TTI’s to modernize their training equipments.

Table 31. Need to Modernize Equipment

<table>
<thead>
<tr>
<th>Response</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>47</td>
<td>97.9</td>
</tr>
<tr>
<td>No</td>
<td>1</td>
<td>2.1</td>
</tr>
</tbody>
</table>

Effects of Bad or Obsolete Training Equipments to Relevance of Training

The study sought information on the effects of the obsolete training equipments to relevance of T.T.I training. An item on the graduate’s questionnaire inquired on the effects of bad or obsolete training equipments on the relevance of T.T.I training to market skill needs. Majority of respondents (90%) indicated that the facilities eroded the relevance of training to market skill needs whereas 10% of respondents indicated that the state of the training equipment did not have effect on the relevance of training to market skill needs. This data indicated that training equipments compromised the relevance of T.T.I taught skills to skill needs in industries and business organizations.

Table 35. Effect of Bad/Obsolete Equipment on Relevance

<table>
<thead>
<tr>
<th>Response</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eroded Relevance</td>
<td>81</td>
<td>90.0</td>
</tr>
<tr>
<td>Did not affect Relevance</td>
<td>9</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Challenges that Hinder Training in TTI’s

An open-ended question was included in the questionnaires and interview schedule that sought information on the hindrances that TTI’s faced in executing their mandate. Respondents were requested to list the perceived hindrances. Majority of the respondents (24.6%) indicated that training in TTI’s was hindered by obsolete training equipments used in TTI’s for training, 23% of the respondents identified obsolete curriculum to be an hindrance, 14% and 12.6% of the respondents indicated that T.T.I training was hindered by inadequate facilities and lack of refresher courses for teachers respectively, whereas 8.7% of the respondents identified inadequate personnel as an hindrance to T.T.I training. 8.3% of the respondents identified the absence of an attachment policy for T.T.I trainers and trainees as the hindrance to T.T.I skill training, 5.9% and 2.5% of the respondents identified inadequate funding and poor management of TTI’s as an hindrance to T.T.I training. Only 0.3% of the respondents felt that poor motivation among teachers was a hindrance to T.T.I training. The study established that TTI’s are hindered in the training Endeavour by a myriad of factors in the pursuance of their training objectives. For the training institutions to realize their objectives, TTI’s should urgently address the hindrances to training. The field data on the factors that hinder T.T.I training is presented on Table 99.

Strategies to Boost TTI Training

To enable the study propose a way forward on skill training in TTI’s an item was included in the questionnaires and interview schedule that sought the respondents suggestion on strategies that would help TTI’s improve the quality of training. Table 100 presents data on the proposed strategies. Majority of the respondents (23.7%) identified an update of training equipments as a viable option to boost skill training, 18.6% and 16.5% of the respondents proposed curriculum review and involvement of employers respectively in T.T.I training as viable options that would improve training in TTI’s whereas 11.6% and 10.0% of the respondents indicated that attachment of trainees with reputable firms and refresher courses for teachers as strategies that TTI’s should adapt to boost training.

A total of 7.4% of the respondents identified regular market survey and hiring of adequate and competent trainers each as a possible option to address training challenges in the TTI’s whereas 3.2% of the respondents proposed increased funding for TTI’s as method to improve skill training in the TTI’s. Only 1.5% of the respondents suggested motivation
of trainers in TTI’s as a strategy that could help TTI’s to achieve the training objectives and meet the expectations of employers in industries and business organizations in Kenya. Information on strategies that could boost T.T.I training is presented on Table 100.

**Table 99. Hindrances to TTI Training**

<table>
<thead>
<tr>
<th>Hindrances to T.T.I training</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obsolete Curriculum</td>
<td>211</td>
<td>23</td>
</tr>
<tr>
<td>Inadequate Facilities</td>
<td>129</td>
<td>14</td>
</tr>
<tr>
<td>Obsolete Equipments</td>
<td>225</td>
<td>24.6</td>
</tr>
<tr>
<td>Lack of Refresher/ Retraining Courses for Teachers</td>
<td>115</td>
<td>12.6</td>
</tr>
<tr>
<td>Inadequate Personnel</td>
<td>80</td>
<td>8.7</td>
</tr>
<tr>
<td>Poor Management of TTI’s</td>
<td>23</td>
<td>2.5</td>
</tr>
<tr>
<td>Lack of Attachment Policy</td>
<td>76</td>
<td>8.3</td>
</tr>
<tr>
<td>Inadequate funding</td>
<td>54</td>
<td>5.9</td>
</tr>
<tr>
<td>Poor Motivation of Teachers</td>
<td>3</td>
<td>0.3</td>
</tr>
</tbody>
</table>

**Table 100. Proposed Strategies to Boost TTI Training**

<table>
<thead>
<tr>
<th>Strategies to boost T.T.I training</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular market survey</td>
<td>80</td>
<td>7.4</td>
</tr>
<tr>
<td>Refresher courses for teachers</td>
<td>108</td>
<td>10.0</td>
</tr>
<tr>
<td>Curriculum review</td>
<td>201</td>
<td>18.6</td>
</tr>
<tr>
<td>Update training equipments</td>
<td>256</td>
<td>23.7</td>
</tr>
<tr>
<td>Involvement of employers in training</td>
<td>178</td>
<td>16.5</td>
</tr>
<tr>
<td>Hire adequate and competent trainers</td>
<td>80</td>
<td>7.4</td>
</tr>
<tr>
<td>Attachment of trainees with reputable firms</td>
<td>125</td>
<td>11.6</td>
</tr>
<tr>
<td>Increase funding</td>
<td>34</td>
<td>3.2</td>
</tr>
<tr>
<td>Motivate T.T.I trainers</td>
<td>16</td>
<td>1.5</td>
</tr>
</tbody>
</table>

**CONCLUSIONS**

1) Most TTI’s operates with inadequate staff. This compromises the quality of teaching and learning since the short fall in the number of trainers in addressed through Hiring part-time teachers, multi-grade teaching, and the students individualized learning engagements.

2) Technical training institutes operate with inadequate training facilities. Majority of the respondents indicated that TTI’s operated without adequate physical facilities.

3) Most of the training equipments found in TTI’s are not technologically in tandem with equipments found in industries and business organizations. The training equipments are inferior to the equipments used in industries and business organizations. This state of training equipments eroded the relevance of TTI’s taught skills to market skill needs.

4) Besides majority of the TTI trainers were diploma holders despite the fact that most of the T.T.I traineees were enrolled into diploma programs The study established that the current staffing in TTI’s compromised the quality of training and consequently this affected the quality of graduates upon employment in industries and business organizations.

**RECOMMENDATIONS**

1) The TTI’s should be adequately staffed with qualified trainers. A policy should be enacted to guide on the level of qualifications that a trainer should have to teach at each level of training.

2) The TTI’s should be equipped with modern training facilities and equipment to enable them achieve their function of quality graduates.

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Assessment of the current sources for financing educational activities in youth polytechnics in Imenti South District in Kenya

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Abstract
Despite the rationale for introduction of safety nets such as bursaries and constituency development fund in the education sector, there are increasing concerns over the limited finances in youth polytechnics to provide quality education and training. This is because, all educational institutions in Kenya face serious financial constraints due to failure by parents to pay fees promptly. The condition is made worse by introduction of structural adjustment programme and cost sharing policy in the 1980’s. This has given the youth polytechnics in Kenya a big blow because technical education is expensive due to tools and equipment required for education and training. The youth polytechnics are starved of funds and are operating on inadequate resources for both recurrent and capital expenditure. This study sought to assess the current sources of financing education in youth polytechnics in Imenti South District-Meru County. A descriptive survey design was adopted for a youth officer, 2 managers and 43 instructors in two youth polytechnics, giving a total of 46. Purposive sampling technique was employed and the sample size was 27 respondents, namely 1 youth officer, 2 managers and 24 instructors. Data collection used questionnaires, observations and interview schedules. The two main sources of finances for the youth polytechnics were parents and government subsidies. The income from Income Generating Activities and other sources came in third and fourth, respectively. The funds are insufficient for institutions recurrent and development expenditures. Thus the government should increase funding to the youth polytechnics, while youth polytechnics should venture into more Income generating activities to supplement the funding and also increase viability of their programmes.

Key words: Technical and vocational education, Income generating activities

Background
Education is a cornerstone of economic and social development, because it improves the productive capacity of societies and their political, economic and scientific institutions (GoK 2008, Schultz 1971). It helps to reduce poverty and mitigating its effects on population, improves health and nutrition and also increases the value and efficiency of the labor offered by the educated. As technology advance, new methods of production depend on educated, well-trained and intellectually flexible labor force. Additionally, education reform efforts in less industrialized countries such as Kenya have aimed at making education an effective vehicle for national development (UNESCO 2005). Governments, policy makers and civil society have emphasized that developing countries need to invest more in education and ensure that systems of education are efficiently managed, that limited funds allocated to the sector have maximum impact, and that cost-saving and cost-recovery measures are adopted (UNESCO 2003). Also, UNESCO 2003 reported that education is one of the largest sectors of the economy.

Kenya is no exception to this global trend of increasing allocation of resources towards education. However, technical vocational education and training and to a greater extent youth polytechnics are neglected. Since independence, education has taken the Lion’s share of national budget as observed in the KESSP document (GOK. 2005) this, has been geared towards meeting the economic demand and for manpower development. These efforts have seen increase in educational institutions and enrolment at all levels. Expanding educational systems appears to imply a proportional increase in resources, but governments are proving increasingly unable to cope with the higher costs (UNESCO 2005).
Nishimura et al. (1999) and Nyerere (2009) reported that there are inadequate facilities, obsolete equipments dilapidated changes in the industry and technology. All public training institutions will be provided with adequate and appropriate facilities and equipment to enable them more at the various categories of trained manpower for the economy. To add to that, the government was to ensure system, to provide greater opportunities for the training of primary and secondary school leavers and also to produce vocational and technical training institutions and their training programs to cater for the training demands of the 8-4-4 policy in 1988 the government agreed with the presidential working party about the need to expand and to streamline and running such institutions from one locality to another (Atchoarena 1996). After the launching of the cost sharing on local leadership and local prevailing economic conditions. As a result, there is a marked imbalance in developing any infrastructure and facilities and a low status overall (Ngome 2003).

The youth polytechnics are starved of funds and are operating on inadequate resources for both recurrent and capital expenditure. The funds they collect from students tuition fee fall short of running their programs efficiently, hence affecting the quality of their graduates and employability. RoK (2005) noted that ineffective coordination of training policies, disparities in training standards and the disproportionate production of skilled personnel in the economy have affected the development of the subsector which has been aggravated by inadequate funding. Mugumo (2005) in Daily Nation of 27/7/2005 reported that the sector-wide approach launched by the government intends to alleviate inadequate physical facilities for training and absence of modern equipment, low participation of the private sector in curriculum design and development, expensive training material and text books in youth polytechnics. More to that, lack of adequate training equipment coupled with poor terms of service and salary delays for instructors also affects running of youth polytechnics.

Financing Technical Vocational Education and Training (TVET) in Kenya

Technical Vocational Education and Training (TVET) programs in Kenya target to absorb the large proportions of students who cannot progress to secondary and higher levels of education. The Technical Vocational Education and Training (TVET) programs are offered in over (600) Youth Polytechnics; 21 Technical Training Institutes, 17 Institutes of Technology and 4 National Polytechnics (two of the National Polytechnics have become constituent colleges of Nairobi and Jomo Kenyatta universities). This study focused on youth polytechnics although only 350 youth polytechnics receive government’s assistance (Nyerere 2009). Of the more than 600,000 graduates of primary schools every year, only 55% i.e. 350,000 proceed to secondary schools (Government of Kenya 2006). The Waki report of 2008 and the 2007 post election crisis highlighted problems of a large population of unskilled, unemployed youth amidst growing poverty. The KESSP program of 2005 aims at mobilization of resources to rehabilitate facilities in public Technical Vocational Education and Training (TVET) institutions and especially youth polytechnics to ensure quality training. However, most of the strategies have not been implemented (Nyerere, 2009). Since independence, Technical Vocational Education and Training subsector has generated little attention and budget provision in Kenya resulting in poor infrastructure and facilities and a low status overall (Ngome 2003).

Financing of youth polytechnics has been a joint venture of the government, communities, parents, donors, religious organizations, nongovernmental organizations and other stake holders. The main source of finance is from tuition fees paid by the student trainees of these institutions (Nishimura and Orodho 2002). Also since ‘self help’ has been a key factor in education development in Kenya, the degree of success of a particular youth polytechnic depends very much on local leadership and local prevailing economic conditions. As a result, there is a marked imbalance in developing and running such institutions from one locality to another (Atchoarena 1996). After the launching of the cost sharing policy in 1988 the government agreed with the presidential working party about the need to expand and to streamline vocational and technical training institutions and their training programs to cater for the training demands of the 8-4-4 system, to provide greater opportunities for the training of primary and secondary school leavers and also to produce more at the various categories of trained manpower for the economy. To add to that, the government was to ensure all public training institutions will be provided with adequate and appropriate facilities and equipment to enable them undertake training more effectively and enable their graduates to be operationally effective and keep abreast with changes in the industry and technology.

Nishimura et al. (1999) and Nyerere (2009) reported that there are inadequate facilities, obsolete equipments dilapidated buildings, lack of refresher courses for lecturers and drastic budget cut followed by structural adjustment programs.
which adversely affected public Technical Vocational Education and Training (TVET) to a large extent. Moreover, the cut on recurrent budget has negatively affected the number of those qualifying, the pay, morale, and motivation of teachers and managers in youth polytechnics. Underfunding has led to poor service delivery, poor image and compromised training leading to technology shock of trainees in the labor market (Otieno 2009).

Koech report of 1999 noted that, parents continue to meet most of the cost of recurrent expenditure through payment of fees. This has affected enrolment and staffing at various youth polytechnics in the country. Also this situation has made education and training out of reach for a significant number of students. Further, Kibbogu (2001) noted that an increasing number of students have continued to drop out of school before completing the full education cycle; this is a scenario consisting of a serious drain and wastage on the countries budget. The main culprit cited is the private cost for education and training. World Bank (2002) notes that education is a powerful instrument for reducing poverty and inequality, health and social well being and laying the basis for a sustainable economic growth. Therefore, how will this be achieved with wastage rates going up and for those completing the training in our youth polytechnics being of wanting quality due to inadequate funding for their education and training?

Cost of Technical Vocational Education and Training in Kenya
According to Olembo (1986), education is a non-material good that cannot be free because to provide it, money is required for the training of personnel, employment of professionals, acquisition of land, buildings and teaching and learning material. As a durable good, education is costly; Ngerechi (2003) confirms this and observes that Technical Vocational Education and Training (TVET) is a very expensive undertaking in terms of equipment, physical facilities such as workshops, training materials and teacher’s salaries. However, it has a multiplier effect in that it benefits the government, society at large, the family and individuals (Kimenyi et al., 2002). It is a producer as well as a consumer good and still it is a commodity to sell in order to enhance one’s life and to be bought for the learner’s benefits. According to the children’s, act of 2001 education is one of the basic rights. Also articles 28 and 29 of the United Nation convention on the rights of the child (1989) states that, it is the right of every child to have access to education. Eshiwani (1993) observed that in its effort to provide education for all citizens; the government’s expenditure on education in Kenya continues to rise and requires both the parents and beneficiaries to contribute towards it. Since independence this has been done through ‘Harambee’ (fund raising activities) that helped to lower the government development expenditure on education. The presidential working party on education and manpower training for the next decade and beyond (Republic of Kenya, 1988) recommended the cost sharing policy. Parents and community were to supplement the government effort by providing with equipment and funds to procure teaching and learning materials. According to Kenya Education Sector Support Program (Republic of Kenya 2005), inadequate funding of the Technical Vocational Education and Training (TVET) sub-sector has aggravated the situation. Hence, this has led to inflexible and outdated curriculum, mismatch between the skills learned and the skills demanded by the industries, inadequate physical facilities for training coupled with lack of sufficient modern equipment and expensive training materials and textbooks.

METHODOLOGY
The study was carried out in the two youth polytechnics in Imenti South District of Meru County. Exploratory approach using a descriptive survey design. There are two youth polytechnics in Imenti South District according to the District youth officer as at January 2010. The study targeted 1 District Youth Officer, 2 youth polytechnic managers and 43 instructors in the two youth polytechnics. The researcher applied a purposive sampling technique where the District youth officer (1), the two youth polytechnic managers (2) and a total of twenty four (24) instructors from the two youth polytechnics especially those who head income generating and production units were selected. The entire sampling matrix yielded a total sample size of 27 respondents for the study. These respondents were best placed to furnish the researcher with relevant information regarding alternative financing mechanisms in the youth polytechnics in Imenti South District. The data for the study were collected using questionnaires, observation guide and interview schedule. The research instruments were piloted at Kiamakoro Youth Polytechnic which was not involved in the actual study.

FINDINGS AND DISCUSSIONS
The research findings revealed that the two main sources of finance for youth polytechnics are school fees (parents) and government subsidy. The income from IGAs and other sources come in third and fourth position, respectively. Furthermore, the researcher sought to find out how sufficient the current sources of finance were for the youth polytechnics. Out of the 26 respondents, 6 (23.1%) said that the finances were sufficient (Yes), while 20 (76.9%) said that the finances were insufficient (No) to smoothly run the training programme. Further findings revealed that the
majority 20 (76.9%) of the respondent agreed that the cited sources of finance were insufficient for the institutions recurrent and development expenditure. This is due to the fact that the youth polytechnics were not able to meet their budget estimates from the income realized. Hence there were budget deficits, stalled buildings, inadequate tools and low instructors’ salaries. However, the GoK (2005) in the KESSP document noted that youth polytechnics can provide more facilities and equipment if they can generate some income of their own from income generating activities. Inadequate funds impact negatively on provision of quality training in youth polytechnics in the district. Thus, majority of the youth polytechnics are in dire need of extra funds to effectively conduct their educational programmes. These findings are in line with the National Development Plan 2002–2008 (RoK, 2002), which cited inadequacy of funds as one of the challenges facing education provision in Kenya.

The findings also depicted clearly the prominence the issue of instructors’ remuneration as given 100%. This is one single factor that affects the morale or determines how hardworking the instructors are in their institutions to offer quality training. This implies if instructors have a scheme of service and are guaranteed upward job mobility, they will be highly motivated to carry out their duties. Diversification of income generating activities and starting production units got 20 (76.92%) and 21 (80.77%) respectively of the 26 respondents. Cost saving and effective measures got 15 (57.69), Fighting corruption in management of IGAs 16 (61.53%), Seek contracts 12 (46.15%) and enroll more trainees 10 (38.46%). Others were CDF/LATF assistance 8 (30.77%), donor funding 6 (23.08%), offer more programmes 4 (15.38%) and lastly, organize harambee which got 3 (11.54%).

The study concluded that there is need for the government to increase funding to the youth polytechnics and also the youth polytechnics will have to diversify their source of income to be able to achieve their targeted goals. The findings shed some light in financing education in that youth polytechnics can devise innovative ways to generate extra income for smooth running of their programmes. This will be in tandem with UNESCO (2004) which proposes that schools should generate extra income through hiring school facilities to the community for example, halls, vehicles or play grounds. The findings also reveal that the respondents are aware of the potential of income generating activities and careful management of these projects to benefit all stakeholders and as such to fight graft, or embezzlement by having prudent management, accountability and well kept records of account.

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ABSTRACT

For a long time, there have been conflicting stand points with regard to Cartha edulis (Miraa). Miraa is a substance that affects the psychological and physiological functioning of the human body, and therefore, falls under the category of drugs of abuse like alcohol, cigarettes, marijuana and heroin, among others. The National Campaign against Drug Abuse Authority and other scholars have confirmed this. The dilemma of many people, however, is that whereas there are numerous negativisms emanating from Cartha edulis farming, trade and consumption, there are also immense social, religious and economic benefits derived and associated with the same. This study addressed the impact of Miraa on religion-socio-economic and educational spheres of the society, especially in the growing areas of Meru North. It was motivated by conflicting incidences encountered by Miraa farmers and traders who also happen to be members of churches located within the study area and the alleged income purported to be derived from the trade used for social and economic developments. There are both positive and negative contributions brought about by Miraa farming and trade upon the families, schools and churches within Meru North region. Although the negatives outweigh the positives in terms of both short and long-term intangible damages to individuals, family and society, there are strong social, religious and economic attachments to Miraa. For the last few decades, Miraa has assumed political dimension. Exclusive focus on negativism has overshadowed the potential financial, social, educational and religious gains associated with the product, because apart from the economic contribution, Miraa is also alleged to have cultural, religious, as well as medicinal values. These contentions strongly agree that Miraa creates a contextual foundation for communication. However, the negative implications of Miraa and which greatly affect the individual user, the institution of marriage, school and church cannot be ignored. Thus, Miraa has diverse negative effects, but it could also serve a better purpose and value if handled properly since it has certain social-cultural values, especially among the community where it is grown.

Key words: Socio-cultural, Religious, Economic impact, Demystification

INTRODUCTION

The trade in miraa commodity has been in existence for a very long time. It is hard to say exactly when the trade of this commodity started and became a commercial enterprise. It is even more difficult to find documented literature that can highlight the discovery and origin of this substance. Oral literature has it that miraa was discovered as a useful substance by shepherds while out with their flocks. As is custom of many shepherds to taste the plants which their flocks seem to like, miraa, a tree that seemed to be liked much by goats and sheep, was not exceptional. It was tasted and found to taste good. The taste of the substance triggered the interest of the shepherds and they gradually started chewing the twigs obtained from miraa trees. This caught the attention of many other people as the substance came to be a good stimulant (Hjort, 1974).

Initially, miraa was not traded but was a highly valued tree among the Ameru people especially those living in Meru North. It had great cultural value as far as the traditional marriage and male circumcision rites are concerned. During marriages, a prospective bridegroom would take a bundle of miraa called ncoolo in Kimeru language, to the prospective bride who in turn would give to her mother to give to the father. This served as a marriage proposal and engagement. In preparation for circumcision, miraa was valued because the candidate of initiation would give the bundle to the man of his choice who would serve as his guardian father during the seclusion period. However, it was old men and shepherds and not young people who generally chewed miraa originally. Gradually, chewing of the twigs attracted the attention of young peoples and somehow few women could chew a few twigs. Initially, old men could plant a few trees of miraa for the purposes mentioned above and so no trade was done. However as the number of chewers increased, the demand to plant more and more trees became inevitable to meet both the emerging consumption and exchange.
Mwaniki (1986) and Carrier (2003) content that miraa trees grew wild in forests originally. However it is in Nyambene hills in Meru County that commercially oriented miraa have been grown for several decades. Nyambene mountain range lies to the northeast of Mount Kenya and includes Igembe and Tigania sub communities. According to Kabeca (1986), miraa trade in Kenya could have started in the 1960s when people in Nyambene traded with the neighbouring Somaliland. Although other crop like tea and coffee were planted alongside miraa, the latter’s return per hectare were high UNDCP (1999) and Kabecha (1986).

Large scale trading is supposed to have been started by few locals after realizing the increasing demand of the substance. The transaction was first to the fellow locals and eventually to the outsiders such as people of the Somali origin and Arabs. Kangeta market, which was already serving as a centre for barter trade among the people of Meru North, Meru Central and the Agikuyu people who traded in sheep, goats and cattle became the first focal point. People of Somali origin also visited the market for business. This means there was a ready market to which the substance was introduced. Today, miraa which is also known as khat and maiirungu is grown in high altitudes in East Africa and Yemen. In Kenya, the plant is grown in Meru and specifically in Ntonyiri and Igembe regions in Meru North. These areas produce the largest quantity as well as the best quality of miraa worldwide. Most of the population living in these regions of the country major in growing and trading in this commodity which does well compared with most other cash crops due to lack of natural waters and inadequate rainfall for agricultural production. The over 350,000 people living in these areas are therefore, to a large extent dependent on the commodity for their basic needs.

The commodity is sold locally in the local trading centres within the growing areas to prominent business men who in turn transport the substance to major markets where some is even exported to foreign markets. Since there is no airstrip near the growing area, road transport is used. Because the commodity is highly perishable, the vehicles transporting the commodity are driven at very high speed risking the lives of not only those in the respective vehicles but also other road users. International destinations of miraa include Ethiopia, Djibouti, and Somalia. Miraa has been a controversial substance occasionally subjected to legal restrictions. It is currently illegal in Eretria, Tanzania, the US, Canada, New Zealand and until recently in June 2014, Europe.

The people of Meru North refer to miraa as the Green Gold of Nyambene. The trade has created many jobs not only for local people but also others who have migrated to the area due to its potential business. By extension, the trade also earns the country revenue. The income from miraa trade is used basically for construction of schools, churches and other community projects. This trade is the major economic contributor to the development of the region (Goldsmith, 1998). The growing importance of Miraa has been faced with a lot of heated local and national debates on its safety as a consumption product. Those opposed to its human use contend that it is a health hazard and its socio economic value should be substituted with other products.

Despite the aforementioned benefits accruing from miraa trade, the activity is faced by a number of complexities. Family conflicts are not uncommon because traders are forced to leave their families in order to collect money from business partners. Being away for long periods of time leads some men to engage in prostitution and drug abuse as the men have a lot of money. Miraa farmers are quite impatient and intolerance with those who steal from their Sambas. Normally those caught stealing miraa are either beaten mercilessly or are slashed with pangas, or handed over to the police. Maua Methodist Hospital receives many patients with injuries associated with miraa controversies. School dropout is another negative consequence of miraa trade. Young school going age prefer to venture into the trade to going to school because of the presumed easy money. As a result the illiteracy rate is very high in the growing area. Because of the amount of money associated with the trade, and the entry of people of Somali origin into the trade, illegal firearms are common. These complexities affect the individual farmers, families, schools, churches and the entire society in general.

STATEMENT OF THE PROBLEM
Miraa farming and trade, which features as the single most successful business in Meru North has attracted the attention of both the well to do and the illiterates in the society. It attracts people from far and wide who venture into the business. This is in spite of the diverse negative impacts it has on the individual, family, church and community. This research therefore sought to establish the religious, social, economic and educational significance of farming and trade of miraa in spite of the widespread negative suspicion associated with it.
OBJECTIVES OF THE STUDY
This research was guided by the following objective:

- Highlight both negative and positive implications of miraa on the family, school, church and community.
- Evaluate the view of the Church on the trade and the extent of the church’s involvement with miraa as a resourceful commodity
- Examine the impact of the trade on education development, enrolment and retention of learners.
- Based on the findings of the study, make necessary policy and intervention recommendations.

RESEARCH HYPOTHESIS
Ho1: There is a lot of money made through miraa farming and trade which make people dependent and dedicate more attention to the commodity at the expense of other economic activities.

Ho2: In spite of the enormous negativism associated with miraa farming and trade, its contribution to the general socio-economic and religious perspectives in the growing areas is significant.

Ho3: Miraa chewing is a passive, tolerated, psychoactive drug with potential to alter the psychological and physiological functioning of the human body.

JUSTIFICATION OF THE STUDY
This study is of great importance to the whole country because it created awareness on both the positive and negative impact of miraa farming and trade. The study is also important because there is very few documented literature on miraa commodity. This research, therefore, did not only contribute to the existing knowledge, but also added some insight into the academic debate on miraa. This is going to be significant because of the conflicting theories associated with the farming and trade of the commodity. The study is also significant because there are many individuals and institutions that directly or indirectly depend on Miraa farming and trade. Chuka University for example has since its inception, admitted many students whose main source of funding is miraa. Furthermore Chuka University’s Igembe Campus is situated in the heart of miraa growing zone with a number of miraa trees within the Campus. It is on record that families, schools and churches within the growing area survive on miraa through its economic and social-cultural contribution.

AREA AND SCOPE OF THE STUDY
The research was limited to Igembe and Ntonyiri in Meru North, and four locations, namely Kawiru, Athiru Ruujine, Antubetwe Kiongo, and Luciuti. Kawiru location is located on the lower part of Ntonyiri and boarders Athiru Ruujine to the west, Antubetwe Kiongo to the north, Meru National park to the east and Kiengu location in Igembe to the south. The area is approximately 13 kilometres from Maua town and next to Chuka University Igembe Campus. This area is relatively warm with the lower part described as semi-arid and receiving very low rainfall throughout the year. There are no natural rivers and water for domestic and animals is scarce. The population according the 2009 census is 35,000 persons with the early middle age and school going age going children forming the greatest percentage. Agriculture forms the main economic activity in the area with miraa production taking the lead. Other crops include millet, sorghum, pigeon peas, maize and beans. Livestock keeping is also practiced.

The research focused on miraa commodity. It is also known by other names as khat, mairungu, Catha, qat, quat, Abyssinian tea, African tea, salad. It is a shrub with a slender trunk, which has a smooth thin bark. Its leaves are lancet-shaped, about 5-10 cm long and about 3-6 cm wide. The young leaves are crimson brown or reddish green in colour but change to yellow green as they age. In areas with frost the shrub may attain a height of about 1.5 metres but in areas with more rainfall it may grow to be about 20 feet. However for the purpose of easy plucking the shrub is usually trimmed so that it is between 1.5 and 2.5 metres high. The edible parts of the plant are the young shoots and leaves although the bark can too be used. However, to protect the shrub from drying up the barks are not removed. This young shoots and leaves contain a chemical known as cathinone that stimulates the chewers.

LIMITATIONS AND ASSUMPTION
The research encountered several limitations. There is limited documented literature and similar research on the subject focus on the negative only. Majority of respondents were illiterate and necessitated the help of their children to put the information in the questionnaire. This limitation may have affected the reliability and validity of the data. It was assumed that respondents will provide truthful and honest responses to the items in the questionnaire.
**METHODOLOGY**

The study used the *ex-post facto* design. This was appropriate for this study because the impact of *miraa* on religion, education and socio-economic fabrics of society were being investigated after they have already taken place. The factors that impact on the trade were independent variables which could not be manipulated by the researchers. This justified the choice of the design since the researchers were trying to establish the possible causes and effect relationship between dependent and independent variables in an existing situation.

This study was carried out in Meru North of Eastern of Eastern Kenya. The area was chosen because the major activity in the area is farming especially growing of *miraa* plant (*Caratha endulis*) whose herbs are chewed and acts as brain stimulant. Other activities are animal production, trade and to some extent tourism. The target and accessible population constituted elders, farmers, traders, and church members and pastors. A sample size of 34 persons was sampled for the interview. The data for this research was collected using questionnaires, and an observation schedule. There were five sets of questionnaires, one for elders, the second for farmers, the third for traders, the fourth for church members and the fifth for pastors. Questionnaires were selected on the strength that they are more commonly used in quantitative research as their standardized, highly structured design was compatible with that design. Questionnaires are appropriate for such studies since they collect information that is not directly observable as they inquire about feelings, motivation, attitudes and experiences. During visits to the selected areas, the researchers made observations on the situation in the sampled locations and paid particular attention to the religion- socio-economic activities. The purpose of making personal observation was to obtain additional and collaborative data which enhanced the data gathered through questionnaire. Personal observation enabled the researchers to take note of social-economic activities in the neigh hoods.

**Validity and Reliability**

The researchers ensured the instruments were valid by ensuring that the content, predictive, concurrent and construct validity were accurate. In addition, reliability of the instruments were tested through the Spearman’s Rank Order Correlation Coefficient (r) and a correlation of 0.869 for elders questionnaire, 0.834 for farmers, 0.792 for traders, 0.782 for church members and 0.781 for pastors’ questionnaire was obtained. Instruments were considered reliable.

The acquired data by the researchers was both quantitative and qualitative data and was analyzed using the Statistical Package for Social Sciences (SPSS) version 18 a popular software programme utilized by social and behavioral scientists. Descriptive statistics was used in analyzing data.

**RESULTS AND DISCUSSION**

The study sought information on how *miraa* commodity came into use and for what reasons it was used. The response was varied with some respondents reporting that it was by shepherds as a useful substance. As to the reasons why it was used, table 1 gives the summary. Older people and specifically men chewed *miraa* in the evening or while on journey. On whether *miraa* has any cultural values all the respondents agreed on the affirmative. Cultural values included opening marriage dialogue during circumcision or on becoming an elder and when settling disputes. On the contribution of *miraa* trade to the family, church and community, all respondents agreed that it contributes positively. The contribution included paying school fees 16.6%, buying food and other basic needs for the family 15.3%, buying plots and improving them, 16.4%, contribution towards community development programmes 12.1%, meeting personal needs18.2 and home improvement 5.1%.

<table>
<thead>
<tr>
<th>Reason for using <em>miraa</em></th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>To keep one busy and attentive at night while guarding flock and family</td>
<td>6</td>
<td>17.64</td>
</tr>
<tr>
<td>Reduce temptation of eating children food</td>
<td>6</td>
<td>17.64</td>
</tr>
<tr>
<td>Stimulate thinking while settling disputes</td>
<td>10</td>
<td>29.41</td>
</tr>
<tr>
<td>Pass time while waiting for food</td>
<td>5</td>
<td>14.70</td>
</tr>
<tr>
<td>Give courage while on a journey</td>
<td>7</td>
<td>20.59</td>
</tr>
</tbody>
</table>

Table 1. Reasons for Using *Miraa*

<table>
<thead>
<tr>
<th>Acreage</th>
<th>Year of planting</th>
<th>Amount of money/month</th>
<th>Place of selling</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 acres</td>
<td>1980</td>
<td>Ksh. 40,000</td>
<td>While on shamba</td>
</tr>
<tr>
<td>0.5 acres</td>
<td>1980</td>
<td>Ksh. 10,000-20,000</td>
<td>Nairobi or Mombasa</td>
</tr>
<tr>
<td>2.5 acres</td>
<td>1973</td>
<td>Ksh. 7,000-20,000</td>
<td>Laare, Muringene or Kawiru</td>
</tr>
</tbody>
</table>
As can be seen, miraa farming and trade improves the living standards of family based on the average monthly returns. Compared with other crops grown in the area, miraa fetches more income compared with maize beans, mangoes, papaws, and avocados. Table 3 is a consolidated summary of this. On the negative impact of miraa trade, majority of the respondents agreed that in spite of the positive impact of the trade it affects individuals, family, church and community. Table 3 shows a consolidated summary of the negative effects of miraa on the community.

Table 3: Positive impacts of miraa

<table>
<thead>
<tr>
<th>Positive Impact on Families</th>
<th>Positive Impact on Schools</th>
<th>Positive Impact on churches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education of children, building permanent family houses, helping put up business that sustain families</td>
<td>Schools have built permanent structures as well as meet other financial needs</td>
<td>Churches have built permanent sanctuaries, bought plots, musical instruments as well as meet other needs</td>
</tr>
<tr>
<td>Provided food, clothing and shelter for families. It has also helped them to access medical facilities and fees for their children</td>
<td>Helped in facilitating permanent buildings and learning equipment</td>
<td>Church financial needs have stabilized greatly</td>
</tr>
<tr>
<td>Standard of education have been raised up in families.</td>
<td>Has helped greatly in all school development activities</td>
<td>Pastors stipends and other financial commitments have been meet regularly</td>
</tr>
<tr>
<td>Has helped provide food, clothing, shelter and education</td>
<td>General development programmes have been achieved</td>
<td>Construction of income generating projects like social halls, commuter vehicle and private schools</td>
</tr>
</tbody>
</table>

Table 3. Negative impacts on miraa

<table>
<thead>
<tr>
<th>Negative impact on families</th>
<th>Negative impact on schools</th>
<th>Negative impact on churches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creates laxity/idleness. Promotes primitive activities like consumption of local brews, domestic quarrels and marital unfaithfulness</td>
<td>High school dropout since most of the children feel they can make money by plucking miraa and become rich quickly</td>
<td>Churches have been left without youths, who engage in drinking and prostitution</td>
</tr>
<tr>
<td>Promoted drinking of beer and prostitution</td>
<td>School dropout cases is very high in the area</td>
<td>Churches are left without youths because most of them have plunged into drinking beer and prostitution</td>
</tr>
<tr>
<td>Poverty is created in families, which have leased their miraa plantations. Conflicts are also encountered due misappropriation of funds</td>
<td>Due to money gotten from plucking miraa, most children drop out of school to go and make money which ends up spoiling them even more</td>
<td>There is much absenteeism which drag church growth</td>
</tr>
<tr>
<td>There are family quarrels because the men have the say over the money gotten from miraa</td>
<td>There are many incidences of early and unplanned marriages which perpetuates the cycle of poverty</td>
<td>Most youths are illiterate and cannot contribute much in terms of ideas. Poor families also result to poor churches because the family is the smallest unit of any church</td>
</tr>
</tbody>
</table>

The research findings show that in spite of its positive contribution on the development of families, churches and community in general, miraa has had great negative impact upon these institutions. These findings concur with similar results (though in an urban setting) from a study commissioned by NACADA entitled the *Role of Parents in control of Alcohol and Drug abuse among their Children in Nairobi* in 2010 which found out that 70% of parents in Nairobi knew that substances of abuse are available in their neighborhoods. They cited alcohol, 88.1% as the most common followed by cigarettes83%, marijuana 77% and miraa 66.2%. This is an indication that there are considerable negative impacts on the wellbeing of people in such neighbourhoods. The study sought the views of the respondents on the role of miraa on religion. Nearly 99% of the respondents agreed that miraa contributes to religion positively. Table 4 shows this summary.
SUMMARY

The results of the discourses in this paper centered on four areas namely; the impact of miraa on the family, education, community and church. Basing the discussion on the family, the results reveal that although miraa has been a great and probably the single most source of income to most of the families in the area under study, miraa business has had negative repercussions on families. Some of the challenges that became evident include conflicts among family members, between spouses, separation and divorce, sexual unfaithfulness and the danger of contracting sexually transmitted diseases and HIV/AIDS, increased poverty and school dropouts.

Table 4: Effect of Miraa on Religion

<table>
<thead>
<tr>
<th>Effects on Church</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The church has been able to put up permanent structures</td>
<td>99%</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>The Church is able to maintain her minister</td>
<td>90%</td>
<td>10%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>The churches are financially stable</td>
<td>98%</td>
<td>2%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>More churches have acquired worship instruments including personal bibles</td>
<td>98%</td>
<td>2%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

It was found out that there are increased misappropriation of family funds, conflicts, and quarrels. The study established that 63.4% of families have one kind of family conflict associated with miraa. 54.7% of miraa traders engage in sexual unfaithfulness or have mistress across trading towns. This means that whereas these families have a source of income, part of it was not used in gainful ways. 80.8% of the families recorded average or below average in terms family welfare in spite of the large amount of miraa money that passes through the family hands. The implication is stagnated families, coupled with separation and divorce. The study established that often husbands spend the earned money with prostitutes or in bars and there are instances of wife battering, sexual unfaithfulness which culminates in separation and divorces. 98% of miraa money is controlled by men with women only waiting for handouts from their husbands or grown up sons who hardly care for the family needs.

The study further established that sexually transmitted diseases including HIV/AIDS are on the increase. 29.6% of children are orphaned due to HIV/AIDS. A lot of money is generated from the trade and this easy unplanned money tempts people to get involved in immoral acts. Although the trade earns families money, poverty was revealed as a common issue. Families lent out miraa farms to middlemen or commit most of family land to miraa plantation at the expense of other cash crops or food crops, 78% of cultivatable land reserved for miraa farming while only 22% for other facilities including homesteads. 80.8% of the families recorded average or below average in terms family welfare in spite of the large amount of miraa money that passes through the family hands. The implication is stagnated families, coupled with separation and divorce. The study established that often husbands spend the earned money with prostitutes or in bars and there are instances of wife battering, sexual unfaithfulness which culminates in separation and divorces. 98% of miraa money is controlled by men with women only waiting for handouts from their husbands or grown up sons who hardly care for the family needs.

Majority of the dropouts are boys who after circumcision become rebellious in school. Such boys demand share of parents’ property or they dropout in order to look for money from the lucrative miraa business. 94.4% of the school dropout were employed as casuals in miraa picking or did petty miraa trade. This situation is alarming considering the resources invested in education. This has perpetuated the illiteracy rate. Efforts to counteract this is normally not effective because farmers and business men entice especially boys to drop out since they are cheap source of labour and their light weight does not cause breakage to the delicate miraa tree branches.

Furthermore, research findings show that whereas miraa has contributed to the growth of the church as far as materialism is concerned (90.7%), the spiritual growth has deteriorated. This is evidenced by absenteeism from the church services, fellowships and low morality as denoted from poor Christians living. Although miraa trade brings about a lot of money, the study established that much of the money is used in immoral activities, excessive drinking, and prostitution at the expense of useful community projects. As a result, household roles have been left to women. In addition, the study asserted that incidences of early marriages are on the rise due to the fact that young boys get a lot of money that ultimately made them believe that they are independent and hence can start their own families. On the other hand, young girls are lured by big money and consequently enter unplanned early marriages.

Generally, the study found out that miraa owners have sensitive tempers when matters of miraa are at stake. They easily injure real or imagined intruders. As far as education is concerned, the study noted the dual effects of miraa. For instance on the positive and negative side, the trade is the main source of family income where majority of people utilized the same to pay school fees (college and university) a whole 97.4%. In addition education physical facilities
have also been established through the same source. However, on the negative side, it was revealed that unlike other societies in Kenya, the study area registers very high dropouts among boys. Indeed education standards are low and male enrolment from primary school through secondary school level is highly affected.

This study labored to create awareness on miraa trade, and revealed that the trade picked up slowly from a localized activity to an international trade today. Miraa has been singled out as the only cash crop that sustains people who live in Igembe and Ntonyiri areas due to lack of natural waters for domestic and agricultural activities. There is also insufficient rainfall for sustenance of other cash crops.

The research has further, created awareness on the importance and side effects of this commodity by looking into its contribution. For instance, it revealed that miraa fetched money that has helped families survive by enabling them buy water for domestic use, food and clothes as well as access medical services. It has also created job opportunities for most people in the area in addition to helping many start other businesses. Education of many children in the area has also been made possible through this trade. Miraa has also been embraced by the church whereby the church has acquired plots and built sanctuaries, buy musical instruments and support clergy. However, the study revealed that miraa is responsible for most family conflicts including quarrels, excessive drinking, prostitution, separation and divorce and contraction and spread of sexually transmitted diseases including HIV/AIDS.

The study moreover, suggested various ways and means of curbing the problems associated with or emanating from miraa trade. Some of the suggested solutions are education of children, developing other business opportunities, provision of water and encouraging experts to further study the commodity.

CONCLUSION

This study critically examined the impact of miraa trade based on religio-socio economic and educational perspectives among the Meru of Meru North region. The research emphasizes the importance and side effects of the commodity by looking into its contribution both on the positive and negative perspectives. Positively, it has earned money that has helped families in terms of food, medical, education, job creation and promotion of physical growth. On the other hand, there are negative impact such as family conflicts, exposure to vices like prostitution, diseases and school dropouts.

These findings concur with a survey done by the Government drug watchdog, National Campaign against Drugs Abuse, NACADA, (2007), which found out that in Khat growing areas cases of boys dropping out of school were rampant. Boys chose to work in khat plantations or sell the stimulant instead of going to school because in the farms they make money which by extension is used to lure girls out of school.

Although miraa was identified as the sole cash crop and with great social, economic and cultural contribution, it has nevertheless negatively affected the spiritual and social growth of the area of the study. This is due to the mishandling of the commodity largely because of failure to discover a way of making it serve better purpose like the alleged medical value and also its contribution to language decay as Kobia, (2014) has observed. It is the feeling of the researcher that as per as awareness created by the literature review and the field survey, miraa has got medicinal value which if developed, could make it more use.

RECOMMENDATIONS

Based on the data collected and the literature review, miraa causes problems. There is therefore an urgent need to critically approach the preoccupation of this community and the churches within this area. The study therefore puts forward the following recommendations.

- **General:** Based on this revelation, it would be imperative that further comprehensive and intensive study be done on this trade. In fact its social, cultural and economic role cannot be underestimated. Furthermore, the immense side effects of miraa which were beyond the scope of this discourse should be fully studied with a view to highlighting the same to the public domain as well as addressing the challenges thereof through a combined effort of the medical and psychologist professionals.

- **Education:** Education is key to progress. The fact that most of the governments employees from the area are from other regions prove that education is not taken seriously in this region. Education has been neglected and hope put on miraa. The community and churches in the area should join hands and put up boarding schools,
polytechnics. Boarding schools in particular will separate children from the daily interaction with miraa people who might encourage the children to join them. The community and the church can start bursaries to encourage school attendance.

- **Research Centre and Experts**: *Miraa* has medicinal value as was revealed by the research findings. However, these values cannot be of any positive use without the input of experts. A research centre would be the answer. The government can intervene and help put up such a centre in the miraa growing region.

- **Economic Stability**: *Miraa* has earned people in the area a lot of money. On the other hand, it is also true that people end up saving very little or nothing due to many expenses, which they could otherwise have avoided. With proper arrangement, the community can install water in the area which could not only serve domestic purposes but also agriculture, and commerce. Due to poverty caused by leasing miraa, farmers should manage their own miraa trees whenever possible. Formation of *miraa* associations to protect their rights as well as make savings to start other projects to alleviate poverty instead of over dependence on miraa. This could also help farmers obtain loans.

- **Social Welfare**: To curb the many conflicts and cases emanating from miraa trade, there is need for the church to include in her curriculum a programme on Christian Education with an aim of promoting everyone in the community and proper way of handling miraa.

- **Church’s Role**: The church can take a pro active role in the economic development of the community by improving education.

**SUGGESTION FOR FURTHER STUDY**
- Extent of other substance and drug abuse besides *miraa* in Igembe and Ntonyiri.
- Impact of *miraa* farming on education showing retention, repetition, and completion at all levels.
- Impact of boys drop out *vis-a-vis* the drop out of girls.
- The clinical medicinal values of *miraa* and possible side effects.

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INFLUENCE OF HOUSEHOLD SOCIOECONOMIC CHARACTERISTICS ON THE PREVALENCE OF ACUTE RESPIRATORY INFECTIONS AMONG CHILDREN IN NAKURU TOWN, KENYA

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ABSTRACT
Prevalence of Acute Respiratory Infections (ARI) in children under 5 years has been attributed to exposure to polluted indoor air from biomass combustion. In Kenya, ARI accounted for 67% of outpatient morbidity cases in children under 5 years, while in Nakuru Town, it accounted for 41%. The cause has been attributed to indoor air pollution from biomass use. Clear studies have not been done in urban areas to show if indoor air pollution from energy sources is an influential factor. In urban areas, household socioeconomic characteristics such as education level, income level, number of household members, sources of energy and the indoor structural characteristics such as ventilation vary. This study determined the influence of energy sources and household socioeconomic characteristics on prevalence of ARI among children. An observation, cross-sectional survey was conducted on 187 randomly selected households, comprising low-income and middle-income strata. In low-income homes, education (p=0.028), presence of carpet (no carpet) (p=0.007), hours spent indoor (p=0.004) and outdoor (p=0.006) had a significant impact on ARI in children. In middle-income homes, neither energy sources nor indoor socioeconomic characteristics influenced ARI presence in children. Exposure to outdoor and indoor environment, education level of caretakers and lack of carpet in low-income areas in urban centers were influential factors on the prevalence of respiratory illnesses affecting children under 5 years.

Key words: Respiratory Infections, Indoor Air Pollution, Urban, Children.

INTRODUCTION
Acute Respiratory Infection (ARI) is a respiratory tract infection that inhibits normal breathing function. It usually begins as a viral infection in the nose, trachea (windpipe), or lungs. Acute respiratory infections can be categorized as upper respiratory infections and lower respiratory infections. Upper respiratory infections occur in the upper tract of the respiratory system causing the common cold. Lower respiratory infections affects the lung(s) area primarily causing pneumonia or further lung abscess and acute bronchitis. Acute respiratory infections are contagious meaning that they can spread from person to person (DiMaria and Solano, 2012) and (WHO, n.d.). Children, older adults, and people with immune system disorders are at a high risk of contracting this disease. For persons and children from low-income homes, immunity problems will tend to be persistent due to the lack of proper nutritional contents and good healthcare accessibility. The World Health Organization (WHO) suggests that acute respiratory infections kill an estimated 2.6 million children under-5 yearly worldwide (DiMaria and Solan, 2012). In Kenya, Acute Respiratory Infections (ARI) accounted for 67% of outpatient morbidity cases in children under 5. Likewise, in Nakuru Town, ARI accounted 41% of the reported outpatient morbidity cases in children under 5.

Energy is an important commodity to all urban dwellers in Kenya because it is the main source of lighting and cooking. Most urban dwellers live below the national poverty line of KSH 2,913 per month per person (GoK, 2006), thus energy accessibility for cooking is limited to charcoal and paraffin. As for lighting, electricity grids are available, but due to high costs some urban dwellers are left to cope without. The urban poor in Kenya spent on an average 42% of their monthly income on paraffin for lighting and spent another 51% on charcoal for cooking purposes. Electricity usage for the urban poor remained at 7.7% because it was not a priority for them due to its unavailability or it being expensive. The urban non-poor households will spend 39.4% of their monthly income on charcoal, 37% will be spent on paraffin and Gas will cost about 9.6% of the monthly income. Electricity will consume 14.5% of the urban non-poor household income (GoK, 2006).

In urban areas such as Nairobi, Mombasa, Kisumu, and Nakuru, the number of household members varies between the urban poor and the urban non-poor. The urban poor will tend to have more people in their homes as opposed to the urban non-poor. About 46% of urban poor will have 4-6 members living in one home while another 24% will have 7+ members. On the contrary 54% of urban non-poor will have between 1-3 members while 36% of other urban non-poor may have 4-6 members (GoK, 2006). Crowding in the households will be inevitable for the urban poor unlike the urban non-poor due to their socio-economic standing. Around the world respiratory illnesses are also leading in lower income countries. In India, Mishra et al (1999) studied the relationship between the use of biomass cooking fuels and the prevalence of active tuberculosis. In this study, persons that were living in households that mainly use biomass for
cooking fuel had substantially higher prevalence of active tuberculosis than persons living in households that were using cleaner fuels. Fuel type was seen to have a large effect when the analysis was done separately for men (Odd Ratio=2.46: 95% Confidence Interval= 1.79-3.39) and women (OR=2.74: 95% CI= 1.86-4.05) and rural (OR= 2.65: 95% CI=1.74-4.03) and urban areas (OR 2.29; 95% CI=1.74-4.03).

Fuel type used showed a higher prevalence of active tuberculosis in Women and rural dwellers (Mishra et al., 1999). In China, Mestl et al (2007) through combined exposure-response function and current mortality and morbidity rates suggested that the burden of disease of China from indoor air pollution would decrease. For the burden of disease to decrease, outdoor air pollution needed to be reduced because it also served as a factor to respiratory diseases (Mestl et al., 2007). In Central Kenya, Ezzati and Kammen, 2001 found that ARIs were increasing concave functions of average daily exposure to PM$_{10}$ above 1000-2000 ug/m$^3$. They suggested that public health programs should focus on reduction of exposure to below 2000 ug/m$^3$, which will provide substantial health benefits (Ezzati and Kammen, 2001). Indoor air pollution has proven to be a major environmental health hazard for South African children. Studies done in South Africa have shown a strong and relatively consistent association between indoor air pollution and acute lower respiratory infections (ALRI) in children, regardless of the relatively small-scale nature of the epidemiological evidence. Children living in households that rely on polluting fuels such as wood fuels are more than 2 to 4 times likely to suffer from an ALRI as compared to children living in homes that rely on electricity. This consequentially results in up to 1,400 annual deaths in children under five (Barnes et al., 2009).

MATERIALS AND METHOD

The study was conducted in four areas of Nakuru Town, Kaptembwo, Kiratina, Shaabab and Langa-Langa. Nakuru as a Town is located 160 kilometers northwest of Nairobi, 0.2833° South and 36.0667° East along the Kenya-Uganda highway, at an altitude of 1800 meters. (Nyasani, 2009). This research was an observation and cross-sectional household survey where a comparative analysis of urban households was conducted. The sample of households cut across different socioeconomic categories of urban homes. The target population consisted of children under the age of 5 and their mothers or primary caretakers. A multi-staged sample design with a non-random first stage followed by a random second stage was used. Stage one consisted of non-random selection of low-income and middle-income areas for studying. Stage two consisted of random selection of households for studying. Purposive sampling was used across transect lines and selection of study candidates was done using the snowballing method.

The 187 homes sample size was obtained from the following formula.

\[
n = n'N / N-1+n' \text{ Where:} \\
n = \text{sample size} \\
N = \text{accessible population} \\
n' = \text{sample size for simple random sampling with replacement} \\
\]

But, \(n'=Z\alpha/2/d^2 \times P (1-P)\)

\(Z \alpha/2 = \) degree of confidence taken as 1.96 at 95%

\(d = \) level of statistical significance taken as 0.05

\(P = \) proportion of the target population estimated to have the characteristic being measured ALRI (taken as 0.4 at 40%).

<table>
<thead>
<tr>
<th>Stratum 1: Low Income Areas</th>
<th>Location</th>
<th>Households</th>
<th>Proportion (%)</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaptembwo</td>
<td>23,200</td>
<td>85</td>
<td>104</td>
<td></td>
</tr>
<tr>
<td>Kiratina</td>
<td>4,239</td>
<td>15</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>27,439</td>
<td>100</td>
<td>122</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stratum 2: Middle Income Areas</th>
<th>Location (Githima)</th>
<th>Households</th>
<th>Proportion (%)</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaabab (Githima)</td>
<td>5,182</td>
<td>35</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Langa Langa</td>
<td>9,674</td>
<td>65</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>14,856</td>
<td>100</td>
<td>65</td>
<td></td>
</tr>
</tbody>
</table>

Source: GoK, 2009 and Nyasani 2009

Data was collected by the means of a questionnaire and an observational schedule. The Questionnaire was used to collect data on the socioeconomic aspects of the household such as education level, household size, income level, energy
source and the child’s health status. The observation schedule was used to collect data on the physical characteristics of the home such as housing type, flooring type, roofing type and ventilation. For ventilation analysis a likert scale was used, ranging from strongly disagree to strongly agree. The definition for the scale was done after the pretesting of the questionnaire where ventilation characteristics were surveyed as follows:

1. No chimney. No hood. One door. One window- strongly disagree.
3. No chimney. No hood. One door. Two or more windows- neither agree or disagree.
4. No chimney. No hood. Two or more doors. Two or more windows- agree.
5. Chimney or hood. Two or more doors. Two or more windows- strongly agree.

Multiple Linear Regression analysis was used to explain the relationship between the explanatory variable (ARI) and response variables (energy sources and household indoor socioeconomic characteristics). This was to show if there was a significant impact of energy sources and household indoor socioeconomic characteristics on respiratory illnesses in children under 5.

RESULTS
In low-income homes key variables such as the main source of cooking fuels (p=0.927), source of lighting (p=0.115), and poor ventilation (p=0.958) showed no significant impact on the presence of respiratory illnesses in the children. The significant regression equation model was as follows at 95% confidence level:

\[ \text{ARI} = 3.02 - 0.105 \text{education} - 0.169 \text{hours spent indoors} - 0.0778 \text{hours spent outdoors} - 0.0473 \text{carpeting} \]

An increase in the level of education reduces the chance of getting ARI by 0.105. Increasing the hours spent indoor decreases the prevalence of ARI by 0.169 and decreasing the hours spent indoor increases the prevalence of ARI by 0.169. An increase in the hours spent outdoor decreases the prevalence of ARI by 0.0778 and decreasing the hours spent outdoor increases the prevalence of ARI by 0.0778. An increase in the presence of carpeting decreases the prevalence of ARI by 0.0473 while a decrease in the presence of carpeting increases the prevalence of ARI by 0.0473.

Table 14: ANOVA (low income)

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>14</td>
<td>2.41261</td>
<td>0.17233</td>
<td>1.99</td>
<td>0.025</td>
</tr>
<tr>
<td>Residual error</td>
<td>106</td>
<td>9.19070</td>
<td>0.08670</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>120</td>
<td>11.6033</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S = 0.294457, R-Sq = 20.8%, R-Sq(adj) = 10.3%.

In middle-income homes, key variables such as cooking fuels (p=0.750), source of lighting (p=0.065) and ventilation status (p=0.338) showed no significant impact toward ARI. The p-values were at 95% confidence level. The regression equation was reduced to the following non-significant model: \[ \text{ARI} = - 1.84 + 0.778 \text{home classification} \]

Home classification was based on whether the home had a foundation or had no foundation. In middle income homes 91% (n=59 homes) of the homes had permanent foundation. The equation model suggests that a decrease in the type of home classification by a unit, then you increase the prevalence of ARI.

Table 15: ANOVA (middle income)

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>14</td>
<td>2.9851</td>
<td>0.2132</td>
<td>1.42</td>
<td>0.181</td>
</tr>
<tr>
<td>Residual error</td>
<td>49</td>
<td>7.3743</td>
<td>0.1505</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>63</td>
<td>10.3594</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S = 0.387938, R-Sq = 28.8%, R-Sq(adj) = 8.5%.
DISCUSSION

The results show that the model was significant at p=0.025 implying that the independent variables in the regression model significantly contributed to the dependent variable (ARI). The R-Square implies that the model was erroneous by 20.8%. The significant impact of education on ARI suggests that low income home caretakers are unaware of the environmental hazards that their children are exposed to inside and outside the home. According to Habitat for Humanity Australia, Dampness affects some countries more than others due to prevailing climate conditions. Studies have confirmed that the association between damp homes and a higher prevalence of poor health. Damp houses have a higher incidence of dust mites and mold (spores) causing or exacerbating respiratory conditions such as asthma, wheezing, aches and pains, diarrhea, nausea and headaches. This explains the high rates of respiratory illnesses in children from homes without carpeting on the floor.

In Low income areas, 62% of children spent 8 or more hours outdoors in a day while 41% spent 13-16 hours outdoors a day. The increase in hours spent outdoors by low-income children decreases the presence of ARI, which suggest that a reduction in ARI prevalence will be due to the children being in a controlled environment where their exposure to indoor environmental pollutants is limited. Like wise, an increase in hours spent indoors will reduce the prevalence of ARI because the children will be away from the hazardous environmental conditions such as rampant air pollution in low income areas associated with dust weather, roadside biomass use and vehicular emissions. Furthermore, Urban slums may be located near major roads, factories, or dumpsites, for instance, exposing residents to higher levels of air pollution or to the risks of industrial accidents (Mutunga 2004). In Nakuru town, Kaptembwo being part of the low-income study areas is located behind industrial area in Nakuru Town where emissions from the factories may be a possible cause to respiratory illnesses in children. But overall the dry and dusty weather that was prevailing in Nakuru Town contributed largely to the outdoor pollution that was an influential factor to children being sick. The poor health status of children could be explained by the continuous exposure to environmental hazards and lack of good hygiene practices as well as the absence of health services in the area (Oxfam GB, 2009). A balance in number of ours spent indoors and outdoors is key to ensuring that children reduce prevalence of ARI.

The table 2 ANOVA shows that the regression equation model for middle incomes was insignificant (p=0.181). The R coefficient of determination (R-sq) implies that the model was erroneous by 28.8%. This insignificance of the model may show that the children are brought up in a friendlier, cleaner and controlled (gated communities) environments. Thus the variables listed in the study have no significant impact on their respiratory health. Middle-income children also spend similar amounts of times indoor and outdoors as low-income children. 53% of children spent 8 or more hours a day outdoors while 40% of children spent 13-16 hours in a day at home. External factors such as Air Bourne contraction cannot be ruled out as a cause of ARI presence in middle-income children due to social and public interactions (such as school) with children from low-income homes. The school going children from middle-income homes could in turn affect the children at home. The environment that most children in middle-income areas lived in was a controlled environment, gated community flats or gated homes where they were limited to straying off to the streets where much of the air pollution was concentrated.

CONCLUSION AND RECOMMENDATIONS

Based on the findings of this study, we concluded that in urban areas household energy sources are not significantly influential toward the prevalence of ARI in children. Findings of this research showed that in low-income neighborhoods, the level of education of the caretaker, the hours spent indoors, the hours spent outdoors and carpeting significantly influenced the presence of ARI in children under 5. In middle-income areas neither energy sources nor indoor socioeconomic characteristics had an impact on the presence of ARI in children under 5. This only seemed to suggest that the presence of ARI in middle-income children was as a result of possible interactions in public places away from home between middle income and low-income children.

At home, majority of middle income children played in controlled environments as they mostly lived in gated communities that restricted their movements toward roads and streets where solid and liquid wastes and pollution from dust, vehicular emissions and roadside biomass usage were present. Unfortunately low-income children roamed freely outside their plots and were exposed to extremely hazardous conditions that included exposure to solid and liquid wastes and air pollutants from roadside biomass usage, vehicular emissions and a dry dust weather. The interaction between low and middle-income children occurred in schools. The results of this study justify that Children living in urban areas are highly active outside their homes. The environment outside their homes, contain majority of the hazards that expose them to infections and illnesses. Children under 5 should therefore be restricted to playing in their...
homestead compounds or plots to keep them from the polluted outdoor environment outside their homes. The hours the children play outside and spend inside should be balanced such as to ensure they are not over exposed to one environment that could increase their illness prevalence. Recommendations:

1. Landlords of single unit homes should be responsible for ensuring that all the homes they build should have a secure roof hatch/latch window where tenants can open if they decide to cook in the home or just to let fresh air into the home. This will result in a much more conducive internal environment.

2. In low-income homes, charcoal was the main source of energy. Most of the homes did not have a cleaner alternative other than kerosene. Middle-income homes used cooking gas as an alternative energy source. Policy makers should discourage charcoal and promote green energy alternatives such as efficient eco-charcoal from recycled plant and animal waste. Price manipulation for electricity and gas should be dealt with for the sake of low-income families.

3. Throughout this study, a lot of caretakers in low-income homes were poorly sensitized on the environmental hazards that affect their children such as allowing their children to play roadside where a lot of dangers and pollution existed. Community based organizations (CBO) and women self-help groups in low-income areas should be briefed and sensitized on environmental hazards their children are exposed to.

4. Children living in urban areas are highly active outside their homes. The environment, which are outside their homes, contain majority of the hazards that expose them to infections and illneses. Children under 5 should be restricted to playing in their homestead compounds or plots to keep them from the polluted outdoor environment outside their homes. The hours children play outside and spend inside should be balanced to ensure they are not over-exposed to one environment that could increase illness prevalence.

5. In this study, ARI was prevalent among low and middle-income children under 5. What seems to be the primary source of the ARI is the environmental conditions and factors that the children are exposed to outside their homes. Weather has seemed to be one of the major factors of ARI prevalence in children. Other factors are outside air pollution and airborne contamination through interactions with other children. Clinical officers in schools and clinics should be trained properly to diagnose ARI and be clear and precise on preventative measures and inquire on the child’s environment.

REFERENCES


INVESTIGATION INTO THE STATE OF DISASTER PREPAREDNESS IN SCHOOLS IN KENYA

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Masinde Muliro University of Science and Technology

ABSTRACT
Disasters of various kinds have been witnessed in learning institutions in Kenya for many years. Indeed, disasters disrupt the education process and undermine quality of education. This study investigated preparedness of learning institutions in fighting instances of fire outbreaks. It was based on a survey conducted in 12 Counties in Kenya and targeted all learners in primary and secondary schools, teachers, school administrators, Boards of Management/School Management Committees, Chiefs, Sponsors and education officials. Descriptive survey research design was used. The research instruments used in collecting data were questionnaires and interview guides. Piloting of the instruments was done and validated for reliability in three Counties selected randomly. The pilot Counties were not part of the main study. Quantitative data were analyzed using SPSS while qualitative data were analyzed thematically. Education is hampered in learning institutions because the personnel were not sufficiently prepared to handle disasters or emergency situations, as 61% of the respondents had not attended drill demonstrations on disaster management. Only 39% of the respondents had been exposed to demonstrations on disaster management. The study makes recommendations at both the policy and programmatic levels. It is expected that these findings will provide insightful reference that policy makers, education officials, school administrators, teachers and stakeholders can rely on in regard to disaster preparedness and management in learning institutions. Strategies to contain disasters are crucial in helping ensure quality education in schools.

1.1. Background to the study
Disasters in society can influence the pattern of academic performance in learning institutions. When disasters take a violent dimension, it disrupts the fabric of society in political, economic and social areas (Rugumamu and Gabla, 2003). Achoka (2007), defines disaster as a state of incompatibility. Achoka further compares disaster to the traffic light that shines green to alert you to move on yet at the same time it shows red warning you to stop. According to Wario (2006), violent conflicts have been the cause of distress across many schools, communities and countries in the world. They lead to human anguish through loss of lives and property. In relations to schooling, such trends cause adverse effects on curriculum delivery and supervision in learning institutions leading to poor performance in examinations because, learning and supervision can only be well achieved in a harmonious environment (Wekesa, 1993; Rue, 1982). Therefore, a disaster can be generally understood as a natural or human-caused event, occurring with or without warning. It causes death, injury or disease, damage to property, infrastructure or the environment, which exceeds the ability of the affected society to cope using only its own resources. Disaster preparedness encompasses the body of policy and administrative decisions and operational activities which pertain to the various stages of a disaster at all levels.

Safety awareness and preparedness in schools are becoming major concern in the wave of violence and arson. In the recent past, there have been perpetual reports on violence and fire outbreaks across the schools in the country. These reports are evidence that schools are not immune to destructive violence. Apparently, there exists constant fear among the leaders and a growing need to address the issue of safety in depth. According to Indiana Education Policy Centre (2000:2); school violence prevention demands that we be prepared for the eventuality of violence. Schools that are safe and responsive have plans and procedures in place to deal with violent and disruptive behaviour.

According to Begun (2001), most violent situations can be avoided if training of social skills becomes part of proactive safety procedures. The School administrators have a responsibility to ensure that the school environment is conducive for learning (Day and Golench, 1995). They can accomplish this by working through an establishment of clear rules and procedures; thus school policy takes an important role in safety procedures.
The question here is whether schools are adequately prepared to deal with issues of disasters that include the evolving threats to school security, comprehensive school safety planning and leadership, school security assessments, school security strategies and issues including board meeting and administration office security. Other areas include athletic and large event security, bomb and grenade threats and suspicious devices, cell phones and text messaging, gangs, hotlines and anonymous reporting, private and independent schools, school police, school security staffing, student involvement in school safety planning, transportation security, uniforms and dress codes, zero tolerance, managing bullying; preparing schools for terrorism; managing school safety on tight budgets; parents and school safety; early warning signs of violence; assessing and managing threats; lessons learned from school crisis Incidents; emergency preparedness planning and preparation; emergency response and crisis management; managing media and parent Communications on school safety and crisis issues.

The statement of Problem
The issue of disasters and safety standards in schools or educational settings will continue being a major factor in the management of education world over. This is evident from the numerous scholarly works that attempt to address this issue. In Kenya, the issue of students’ safety and security has attained greater significance especially following the unprecedented levels of school fire breakouts and unrest witnessed in the country frequently. In 2008, student unrest was reported in learning institutions resulting into the death of three students. In 2012, there were 28 cases of fire breakout in schools resulting in 14 deaths. This was happening at a time when the country had just witnessed serious political violence in the name of post-election violence. Many schools have continued to suffer property destruction and loss of lives. In 2012, the following schools had incidences of fire disasters destroying school property and in some incidences causing death: Malindi High School – Malindi District, fire caught deputy principal’s house at night claiming his life, wife, 6 children; Emmanuel High School in Uasin Gishu County, the school boy’s dormitory caught fire at night.

In addition, Kathigiriri mixed boarding school girl’s dormitory in Meru County caught fire destroyed the whole dormitory and pupil’s property. The most critical one was in Homa Bay County where in August 2012 fire broke out in a dormitory at Asumbi primary boarding school burning to death eight pupils that were in the dormitory. Only one pupil survived. The fire was suspected to have been caused by electric upsurge. In all these fire incidences the probable cause of fire is attributed to electrical fault and other unknown reasons. It is in the interest of this study to establish the level of disaster preparedness in learning institutions in Kenya.

The general objective of the study was to establish whether schools were well prepared to deal with disasters. The study will enrich the theoretical foundations on which disaster preparedness and conflict management is to be carried out. The findings of this study will contribute to the existing fund of knowledge pertaining to disaster preparedness in schools, practice and theory. Literature was reviewed based on the following themes:

i) Disaster preparedness and safety management practice,
ii) Manpower training and development,
iii) Effect of disaster on schools.

Findings on Disaster Preparedness
The purpose of this study was to establish whether schools were well prepared to deal with disasters. The specific objectives were to determine the nature and types of disasters encountered in schools; to establish whether training on disaster preparedness is carried out in schools in Kenya; to establish measures employed by headteachers and principals in ensuring disaster preparedness in schools; to evaluate the effects of disasters on schools in Kenya and to find out the challenges facing schools in disaster management.

Major Responses on Safety Standards in Schools
The general trend of safety standards in schools was of concern. The selected categories of safety standards surveyed included: availability of the Kenya Power and Lighting Certificate (KPLC), availability of functional fire extinguishers, perception of risks, and impact of disasters and levels of training as a mark of preparedness.

Responses on availability KPLC certificate
It was observed that 92% of the surveyed schools did not possess the certificates. This, in effect, is a pointer to possible risky power connections which are a major cause of frequent fire outbreaks in schools. On fire out breaks, 53.9% of the respondents in the sampled schools rated it as ‘most severe’. Availability of KPLC Certificate was: Not Available = 92%. Available = 8%.
Responses on serviceability of fire extinguishers

It was noted that only 43% of the schools surveyed had actually serviced the fire extinguishers. The rest (57%) had never renewed or serviced the gadgets since installation. Again, this is a pointer towards the risky disposition the learning institutions in Kenya are exposed to. There is need to cushion them from the risk of fire outbreaks.

Perceived Major Disaster Risks

The research identified six perceived major disaster risks namely; floods, fire, famine/drought, strong wind, inter-communal violence, and school strikes. The opinion of the respondents on occurrence of these disasters in the last five years was gauged on the 1-3 Likert Scale: most severe (1), severe (2) and less severe (3).

The findings were as follows:

<table>
<thead>
<tr>
<th>Type of disaster</th>
<th>% Most severe</th>
<th>% Severe</th>
<th>% Less severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floods</td>
<td>25.0</td>
<td>8.3</td>
<td>66.7</td>
</tr>
<tr>
<td>Fire</td>
<td>53.9</td>
<td>26.9</td>
<td>19.2</td>
</tr>
<tr>
<td>Famine/drought</td>
<td>16.7</td>
<td>25</td>
<td>58.3</td>
</tr>
<tr>
<td>Strong winds</td>
<td>33.3</td>
<td>16.7</td>
<td>50</td>
</tr>
<tr>
<td>Intercommunal Violence</td>
<td>9.0</td>
<td>45.5</td>
<td>45.5</td>
</tr>
<tr>
<td>School strikes</td>
<td>18.2</td>
<td>31.8</td>
<td>50</td>
</tr>
</tbody>
</table>

This means that the most severe disaster in schools was fire as majority (53.9%) of the respondents pointed out that fire caused the most unwarranted disasters in schools. This therefore implies that issues to do with fire need to be addressed urgently in learning institutions. The problem of fire breakout was said to be followed closely by the menace of strong wind (33.3%) and floods at (25%). These percentages are high hence schools that encounter these disasters were likely not to perform well in academics.

Impact of Disasters on Schools

On impact of disasters on schools, the respondents were exposed to seven variables which included: deaths, students’ transfer, disease outbreak, injuries to individuals, and closure of schools, emotional trauma, sexual abuse/exploitation, infrastructural damage, and lessons disruption.

The responses were as follows:

<table>
<thead>
<tr>
<th>Impact of disaster</th>
<th>% Most severe</th>
<th>% Severe</th>
<th>% Less severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deaths</td>
<td>66.6</td>
<td>16.7</td>
<td>16.7</td>
</tr>
<tr>
<td>Sexual abuse exploitation</td>
<td>33.3</td>
<td>16.7</td>
<td>50</td>
</tr>
<tr>
<td>Students transfer</td>
<td>54.5</td>
<td>18.2</td>
<td>27.3</td>
</tr>
<tr>
<td>Disease outbreak</td>
<td>50</td>
<td>8.3</td>
<td>41.7</td>
</tr>
</tbody>
</table>
Injuries to individuals & 42.9 & 7.1 & 50 \\
Emotional trauma & 30.8 & 38.4 & 30.8 \\
Infrastructure damage & 38.1 & 19.0 & 42.9 \\
Lessons disruption & 34.4 & 9.4 & 56.2 \\

Looking at the bar graph carefully, majority (66.6%) of the respondents indicated that the disasters encountered had severe impact that resulted into death of students or injuries of the individuals.

Disaster Awareness
On disaster awareness it was observed that pupils/students, teachers and local community were sensitive to the occurrence of disasters in their environment.

The responses were as follows:

Table 3: Disaster Awareness

<table>
<thead>
<tr>
<th>Type of respondents</th>
<th>% - Aware of disasters and know what to do</th>
<th>% - Not aware of disasters and do not know what to do</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Pupils/students</td>
<td>41</td>
<td>59</td>
</tr>
<tr>
<td>Local community</td>
<td>43</td>
<td>57</td>
</tr>
</tbody>
</table>

Figure 3: Bar Graph Showing Disaster Awareness
The bar graph reveals that majority of the respondents were not aware of what to do in case of a disaster. This was worrying because in an event of a disaster, many people were not prepared in anyway on how to deal with it.

Levels of training as a mark of preparedness.
On levels of training as a mark of preparedness, it was observed that 52% of the respondents indicated that they had received basic training in disaster prevention. Out of the respondents who indicated that they had received any training in disaster management, 72% had only attended demonstration sessions in disaster management; 16% had gone to certificate level, 7% had attained diploma level, and only 2% had attained Bachelors and Masters Degrees in Disaster Management.

CONCLUSION
From the findings above, it is concluded that learning institutions were not sufficiently prepared to handle disasters or emergency situations as they may occur from time to time. This premise is informed by the fact that schools do not have contingency plans to mitigate disasters like floods, fire outbreak, and wind, among others. It is, therefore, incumbent upon the national government and County governments throughout the forty seven (47) regions to urgently address disasters of various kinds in learning institutions throughout the country.

RECOMMENDATIONS
It is therefore, recommended that a seven pronged response plan which includes the following action points should be put in place by the Ministry:
i) Policy: Develop a coherent disaster/emergency preparedness policy and implement it at national, county and sub-county levels. The policy should generate and encourage proactive leadership and prudent use of local resources in handling disaster related issues at grassroots levels.

ii) Sensitization: Urgently organize a sensitization programme for all directorates in the Ministry and key education stakeholders on issues pertaining to Disaster and Emergency preparedness. This initiative will promote ownership of emergency programmes in both central and county governments.

iii) Capacity building: Build the capacity of all levels of education sponsors, managers and administrators in all the 47 Counties. This initiative should be continuous and it should be able to empower all actors and facilitate rapid response to emergencies in rural areas.

iv) Rapid Response Teams: Establish county-level rapid response teams/committees in all 47 Counties to handle regional emergency situations.

v) Funding: Establish a County emergency fund to cater for disasters through rapid response teams mentioned in No. 4 above.

vi) Networking: The Ministry and County officers alike should coordinate synergized responses to emergency situations through coherent networking with international and national humanitarian organizations like UNOCHA, UNICEF, Save the Children, Red Cross, Fire Brigade Department, among others.

vii) KPLC: The Kenya Power and Lighting Company should urgently survey the state of electrical wiring in schools and make appropriate recommendations.

WAY FORWARD

a) Directorate of Policy, Partnerships and East African Community
i) Develop an education policy on disaster/emergency preparedness in learning institutions to be implemented at national, county and sub-county levels.

ii) A clear coordination framework on disaster/emergency management response should be formulated.

iii) Networking: Should network with other stakeholders including international and national humanitarian agencies like UNICEF, UNOCHA, Save the Children, Red Cross and Fire Brigade for assistance.

b) Directorate of Quality Assurance and Standards
i) Officers at all levels should be trained on how to detect functional and malfunctional fire extinguishing equipment and materials e.g sand, water, hand held cylinders, etc.

ii) The Directorate should review and upgrade the safety standards manual to address issues related to adequacy of equipment and responsiveness.

c) Directorate of Basic Education/Secondary and Field Services
   (i) Should operationalize the rapid response teams through coordination at all levels

   (ii) Capacity building for BOMs/SMCs, Principals, Head teachers and even students on disaster preparedness and management should be held

   (iii) Funding: a pool of emergency funds should be established to cater for disasters by the rapid response teams

   (iv) A way should be found to encourage the culture of openness, transparency, dialogue (communication), democratization in schools and the community to reduce tensions that trigger vandalism and arson.

d) Education Secretary’s Office
i) Sensitization - the office should urgently organize a sensitization programme on disaster preparedness findings for all the Directorates and the counties, sub-counties and key education stakeholders.

ii) The office should liaise with KPLC to undertake a survey on the status of electrification, safety and durability in basic education.

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RELATIONSHIP BETWEEN PSYCHOLOGICAL INTERVENTION REQUIREMENTS AND MATHEMATICS ACHIEVEMENT COUNSELLING NEEDS AMONG SECONDARY SCHOOL STUDENTS IN MAARA DISTRICT, KENYA

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ABSTRACT
Mathematics achievement among secondary school students facilitates pursuit of critical economic blue print careers deemed necessary to transform Kenya into an industrialized middle income country. The dismal mathematics achievement among Kenyan students may delay attainment of Vision 2030. Closing the gap in mathematics achievement may require design of appropriate, comprehensive and intensive academic counselling programmes geared towards optimizing arithmetic competencies among students. School counsellors may benefit from a knowledge base regarding the need for psychological intervention about counselling needs related to Mathematics achievement; a premise upon which this study was conceived. Descriptive survey research design was adopted, and target population was 12,823 respondents, comprising 452 teachers and 12,371 students in 48 secondary schools. Purposive sampling and simple random sampling techniques were used to obtain a sample size of 378 respondents, mainly form-three students, Heads of Mathematics and Counselling Departments. Data collection used three sets of questionnaires whose validity and reliability was enhanced through opinion and expert judgment, while a pilot study was conducted in Meru South District. A significant difference between psychological interventions and Mathematics achievement counselling needs existed. Psychological interventions with respect to mathematics counselling needs were vital in an attempt to enhance achievement in Mathematics. Measures should be taken to improve access to and demand for mathematics psychological interventions, and concerted efforts by all education stakeholders in meeting counselling needs related to the subject’s achievement among secondary school students.

Key words: Counselling needs, Mathematics, Psychological intervention.

1. INTRODUCTION
Mathematics achievement among secondary school students in Kenya determines an individual’s opportunities for further education and career prospects. This is because qualification for entry into a variety of strategic professional courses at colleges and universities is based on mathematics achievement at the Kenya Certificate of Secondary Education examinations. As a result, education stakeholders in the country have focused on strategies aimed at enhancing mathematics achievement among students in order to facilitate steady supply of professionals in the fields of Science, Technology, Engineering, Statistics and Medicine deemed to transform Kenya into an industrialized middle income country by the year 2030. For instance, the Kenyan Government in conjunction with the Government of Japan have initiated a nationwide in service programme for all mathematics and science teachers in the country to encourage a student centered and activity oriented content delivery process (SMASSE, 1998). However, learning of mathematics is not only influenced by teaching techniques but also affected by a myriad of psychological, social, physical and intellectual challenges experienced by the students themselves. Some of these challenges may be mediated through school counselling programmes instituted to help students achieve optimal personal growth, acquire positive social skills and values, set appropriate career goals and realize potential to become productive members of the community.
appropriate chores, choosing right activities and addressing stress within the family (Michael and Allan, 2005). Once

Parents may be taught how to use their child’s strengths and weaknesses to modify family patterns like selecting

problem and the parents retake control of the family. Therefore family therapy may help students from distressed families gain control of the

potential and talents are properly natured. There are many families in distress and without any one to point them in the

in order to help them understand challenges facing students in mathematics study. This will ensure that the student's

effectively assist such a student unless the entire family is involved. Additionally, economic and psycho social pressure

weaknesses and find ways of coping in an effort to improve achievement in the subject.

Thus, slow learners in mathematics can naturally benefit from group counselling as they learn to acknowledge personal

difficulties who have worked through the problems. Group members also feel free to care about each other because

Free interaction among members in group counselling provides support and comfort in such a way that difficulties

In group counselling people benefit from shared experiences because it brings persons with similar issues together. It is also comforting for each member of the group to know that others also experience their predicaments. Further, group counselling saves time since several clients are dealt with simultaneously. The purpose of group counselling is to provide information to members, clarify changes they must make to improve their condition and avail the necessary resources to initiate those changes (KIE, 2003). Bringing students of similar mathematics ability or problems together in group counselling can facilitate discovery of better and efficient methods of dealing with the issues. Therefore, regular mathematics achievement counselling services are vital for alleviating persistent negative attitude towards the subject among students and should be done in time before the students give up on studying mathematics altogether (Kipronoh, 2011). Such psychological interventions should be a continuous process until visible progress is observed. The free interaction among members in group counselling provides support and comfort in such a way that difficulties are resolved and alternative behaviours learned (KIE, 2003). This is because during group therapy people realize they are not suffering alone and that there is hope and help. It is also comforting to meet other people with similar difficulties who have worked through the problems. Group members also feel free to care about each other because of the climate of trust within the group. The psychological safety in the group allows the expression of those feelings which are often difficult to express outside the group and members begin asking for necessary support (Donna, 2009). Thus, slow learners in mathematics can naturally benefit from group counselling as they learn to acknowledge personal weaknesses and find ways of coping in an effort to improve achievement in the subject.

Family therapy involves the whole family because family members influence each other and therefore getting everyone involved in counselling can have a much stronger effect (Ricky, 1990). A student’s academic problems such as poor concentration, declining grades and anxiety may be a reflection of conflicts at home. School counsellors may not effectively assist such a student unless the entire family is involved. Additionally, economic and psycho social pressure imposed on the family deny parents time with their children for necessary guidance in personal, social, educational and career development (Chireshe, 2006). Therefore, school counsellors should provide counselling services to parents in order to help them understand challenges facing students in mathematics study. This will ensure that the student’s potential and talents are properly natured. There are many families in distress and without any one to point them in the right direction for assistance. Therefore family therapy may help students from distressed families gain control of the problem and the parents retake control of the family.

Parents may be taught how to use their child’s strengths and weaknesses to modify family patterns like selecting

appropriate chores, choosing right activities and addressing stress within the family (Michael and Allan, 2005). Once

the parents have the information about the child and the concept of intervention, the family may move ahead creatively
working out their own problems. Hence, students’ lack of mathematics resources and dire need for private tutoring may be addressed during family therapy. Home environment has a significant influence on a child’s academic achievement since the language spoken at home, expected educational level, family background, gender and home educational resources significantly influence a student’s level of mathematics achievement (Ismael and Awang, 2007). This is so because there is a positive correlation between students’ attitude towards mathematics and the parents’ attitude towards the subject (Kipronoh, 2011). Students’ fear and negative attitude towards mathematics are passed on from parents, neighbours and older siblings (SMASSE, 1998). Therefore, to change students’ attitude towards mathematics requires development of an encouraging home environment in terms of conversations on the subject, games and home learning resources which can best be achieved through family therapy.

Continued dismal achievement in mathematics among secondary school students in Kenya regardless of existence of counselling services is an indicator of either students do not seek help or the school counsellors are not aware of the specific intervention required by the students. Therefore, benefits regarding students’ mathematics achievement that may accrue from the various forms of counselling may not be visible or optimized without school counsellors’ knowledge about the specific aspects that require psychological intervention. Hence, knowledge about the relationship between psychological intervention requirements and mathematics achievement counselling needs may aid school counsellors in designing appropriate and comprehensive counselling programmes aimed at enhancing achievement in the subject among the students.

2. Statement of the Problem
Mathematics achievement among most secondary school students in Kenya and particularly Maara District is way below the minimum requirement for admission into various strategic professional courses at the postsecondary school level of education. This means that most of these students stand to miss out on careers of choice thus hampering personal development and the achievement of the country’s vision 2030 whose back bone is advancement in science and technology. Closing the gap in mathematics achievement may require among other strategies design of appropriate, comprehensive and intensive academic counselling programmes to optimize arithmetic competencies. School counsellors may benefit from a knowledge base of psychological intervention about counselling needs related to mathematics achievement among secondary school students. To fill this gap, this study sought to determine the relationship between psychological intervention requirements and mathematics achievement counselling needs among secondary school students in Maara District in Kenya.

3. Objectives of the Study
The main objective of this paper was to determine the relationship between psychological intervention requirements and mathematics achievement counselling needs among secondary school students in Maara District in Kenya.

4. Theoretical Framework
This study was guided by the client centered theory of counselling developed in 1950s by Carl Rogers. According to Rogers (1951) client centered theory states that human beings have an inherent tendency of self-actualization which helps them meet their needs, develop a positive attitude towards self and interact effectively with other people in the society. Further, Rogers asserts that an environment that is conducive encourages one towards self-actualization. This kind of environment can be created by use of client centered theory whose purpose is to increase a person’s feelings of self-worth, reduce the level of incongruence between the ideal and actual self and then help an individual become more of a fully functioning person. Lester and Cheryl (1990) purport that a client centered therapist functions mainly as a facilitator of personal growth by helping the client to discover capacities for problem solving. This creates a helping relationship in which the client experiences the freedom to explore areas in life that are now denied to awareness or distorted. Therefore, learners can be trusted to discover significant problems related to students’ existence and academic work. Rogers (1951) posits that client centered theory operates according to three basic principles which reflect therapist’s attitude towards the client. These principles include: therapist being genuine with the client, providing the client with unconditional positive regard and eventually showing empathetic understanding to the client. The client centered theory was relevant to this research because students can only appreciate mathematics if: (a) The environment both internal and external to self is conducive to the learning of the subject and (b) The students are helped to explore the subject and discover its nature and importance which may both be either denied to their awareness or distorted.

5. METHODOLOGY
Descriptive survey research design was adapted for the study whose target population constituted 12,823 respondents comprising of 452 teachers and 12,371 students in 48 secondary schools within Maara District in Kenya. Purposive sampling and simple random sampling techniques were used to obtain a sample size of 378 respondents mainly form three students as well as Heads of Mathematics and Counselling Departments from the schools. A permit for conducting
the research was obtained from the National Council of Science and Technology while permission for data collection was granted by the principals from the respective schools. Required data were collected via three sets of questionnaires whose validity was enhanced through opinions and expert judgment of the university supervisors while a pilot study was conducted in Meru South District in order to improve on the reliability of the instruments. To determine the reliability of the instruments, Chrobanch’s Alpha Coefficient was computed resulting in reliability coefficients that were more than 7.0 which was considered as the threshold for the research. Percentages, Means and Chi Square Test were employed for data analysis which was enabled by use of the Statistical package for Social Sciences version 17.0. Eventually, the results of data analysis were presented on tables and discussed.

6. RESULTS
Items on the questionnaires were designed to determine the relationship between psychological intervention requirements or counselling help requirements and mathematics achievement counselling needs among secondary school students. The respondents were asked to indicate the extent of mathematics achievement counselling help required by students in given areas of mathematics achievement counselling needs on a five level likert scale. The levels on the likert scale included: No Help, Little Help, Undecided, Much Help and A lot of Help valued as 1 through to 5 respectively.

6.1 Demographic Characteristics
Demographic information of the respondents was sought in order to disclose the nature of the research respondents. There were 47% male and 53% female student participants. This gender difference was attributed to the simple random sampling technique used in selecting form three students who were streamed according to subjects of specialization. The range of students’ age was 4 years with the majority comprising 49% being 17 years old. Concerning the heads of mathematics departments, data obtained indicated that 87.8% were male while only 22.2% were female. This finding supports the views of Steinberg (2007) who suggests that girls associate mathematics with masculinity because of a lack of substantial number of successful female mathematician role models. Majority of the heads of mathematics departments comprising 44.4% were within the age bracket 51 years to 60 years, 33.3% were within 41 years to 50 years age bracket while 22.2% were aged 31 years to 40 years. This means that most of the heads of mathematics departments were experienced in the profession. With respect to professional qualifications, 77.8% of the heads of mathematics departments held a bachelor’s degree while 22.2% had a diploma in education. The heads of counselling departments’ data analysis results revealed that 88.9% were female while 11.1% were male. This implies that much of the counselling work is delegated to female teachers possibly based on the belief that females are better at nurturing than the males. Majority of the heads of counselling departments comprising 55.6% were within the age bracket 41 years to 50 years, 33.3% were within 31 years to 40 years whereas 11.1% were aged 21 years to 30 years. Technically, most of the heads of counselling departments comprising 77.8% had no special training in guidance and counselling while 22.2% were trained at the certificate level.

6.2 Students’ Opinions on Counselling Help Requirements
The study inquired about students’ opinions on the extent of counselling help required with regard to stated mathematics achievement counselling needs. A Chi Square Test was carried out to determine differences in the expected and observed frequencies among the following groups of responses: No Help, Little Help, Undecided, Much Help and A lot of Help. Table 1 displays the data analysis results.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Chi-Square</th>
<th>df</th>
<th>Asymp. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family support with private tuition</td>
<td>243.750</td>
<td>4</td>
<td>.000</td>
</tr>
<tr>
<td>Making mathematics notes</td>
<td>264.472</td>
<td>4</td>
<td>.000</td>
</tr>
<tr>
<td>Persistent poor mathematics performance</td>
<td>209.528</td>
<td>4</td>
<td>.000</td>
</tr>
<tr>
<td>Mastery of mathematics concepts and formulas</td>
<td>213.556</td>
<td>4</td>
<td>.000</td>
</tr>
<tr>
<td>Developing interest in mathematics</td>
<td>144.167</td>
<td>4</td>
<td>.000</td>
</tr>
<tr>
<td>Concentration during mathematics lessons</td>
<td>53.306</td>
<td>4</td>
<td>.000</td>
</tr>
<tr>
<td>Coping with too many mathematics assignments</td>
<td>77.722</td>
<td>4</td>
<td>.000</td>
</tr>
<tr>
<td>Interpreting mathematics questions</td>
<td>186.722</td>
<td>4</td>
<td>.000</td>
</tr>
<tr>
<td>Clear presentation of mathematics test items</td>
<td>152.528</td>
<td>4</td>
<td>.000</td>
</tr>
</tbody>
</table>

The estimated Chi Square Test statistic was significant at the 0.05 level. The computed P-Value was 0.000. Since the
P-Value < 0.05, the null hypothesis was rejected. Hence, it was concluded that a statistically significant relationship existed between counselling help requirements and mathematics achievement counselling needs among secondary school students. This means that counselling services would enhance mathematics achievement among secondary school students. Further analysis was performed to determine the students’ mean perceptions on requirements of mathematics counselling help. This was necessary in order to establish the pattern of the results obtained from the Chi Square Test Statistics. Table 2 shows the results of the data analysis.

<table>
<thead>
<tr>
<th>Statement</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family support with private tuition</td>
<td>360</td>
<td>4.00</td>
<td>1.193</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Making mathematics notes</td>
<td>360</td>
<td>4.04</td>
<td>1.229</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Persistent poor mathematics performance</td>
<td>360</td>
<td>3.88</td>
<td>1.347</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Mastery of mathematics concepts and formulas</td>
<td>360</td>
<td>4.01</td>
<td>1.144</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Developing interest in mathematics</td>
<td>360</td>
<td>3.62</td>
<td>1.419</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Concentration during mathematics lessons $p = e^{-(b-\mu)a}$</td>
<td>360</td>
<td>3.19</td>
<td>1.446</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Coping with too many mathematics assignments</td>
<td>360</td>
<td>3.45</td>
<td>1.296</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Interpreting mathematics questions</td>
<td>360</td>
<td>3.82</td>
<td>1.257</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Clear presentation of mathematics test items</td>
<td>360</td>
<td>3.64</td>
<td>1.241</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

According to the data analysis results on Table 2, it appears that guidance and counselling can considerably improve secondary school students’ mathematics achievement. This is inferred from the students’ mean perception on the relationship between counselling help requirements and the stated mathematics achievement counselling needs. The estimated means ranged between 3.19 and 4.04 which were greater than the average mean of 3 out of a possible maximum mean of 5 and minimum mean of 1. Therefore, guidance and counselling teachers should focus on helping students to acquire family support with private tuition, make mathematics notes, improve the persistent poor mathematics performance, master mathematics concepts and formulae, develop interest in mathematics, concentrate during mathematics lessons, cope with too many mathematics assignments, interpret mathematics questions and clearly present mathematics test items.

An item was included in the students’ questionnaire inquiring about additional counselling help deemed necessary to enhance mathematics achievement. Thematic analysis of the students’ responses pointed out the following themes:

i. Advocate for more frequent mathematics quizzes and tests.
ii. Help students to stop fearing mathematics.
iii. Advice mathematics teachers to become friendly to students.
iv. Advocate for more mathematics exchange programmes.
v. Encouraging those students who have given up on mathematics.
vi. Overcoming negative peer pressure in mathematics study.
vii. Shielding form one students against discouragement and intimidation about mathematics success from the older students in schools.
viii. Encourage the students to be positive about mathematics study groups.

6.3 Mathematics Heads’ Opinions on Counselling Help Requirements

The heads of mathematics departments were asked to give opinions about the extent of counselling help that students required in relation to mathematics achievement. A Chi Square Test was administered to determine differences in the expected and observed frequencies among the following groups of responses: No Help, Little Help, Undecided, Much Help and A lot of Help. Table 3 represents the Chi Square Test data analysis results.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Chi-Square</th>
<th>df</th>
<th>Asymp. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building positive attitude towards mathematics</td>
<td>5.444</td>
<td>1</td>
<td>.020</td>
</tr>
<tr>
<td>Skills in organizing test item solutions</td>
<td>5.444</td>
<td>1</td>
<td>.020</td>
</tr>
<tr>
<td>Importance of mathematics in career choice</td>
<td>5.444</td>
<td>1</td>
<td>.020</td>
</tr>
<tr>
<td>Effective participation in discussion groups</td>
<td>5.444</td>
<td>1</td>
<td>.020</td>
</tr>
<tr>
<td>Overcoming gender stereotypes in mathematics</td>
<td>8.000</td>
<td>2</td>
<td>.018</td>
</tr>
<tr>
<td>Intrinsic motivation in mathematics education</td>
<td>5.444</td>
<td>1</td>
<td>.020</td>
</tr>
</tbody>
</table>
Negative peer pressure in mathematics study 5.444 1 .020
Time management during mathematics test 5.444 1 .020
Advocating for parental support in mathematics 8.000 2 .018

The Chi Square statistic was tested at a 0.05 level of significance. Information on Table 3 shows that the Chi Square values lie between 8.000 and 5.4444 with the P-Value ranging from 0.018 to 0.020. Since the P-Value < 0.05, then the null hypothesis was rejected. This means that there was a statistically significant relationship between the observed and expected frequencies for the extent of counselling help required on the indicated mathematics achievement counselling needs among secondary school students. Therefore, it can be inferred from the Chi Square Test results that counselling help was required to meet the mathematics achievement counselling needs among secondary schools students. The mean perceptions of heads of mathematics departments’ opinions on the extent of counselling help required by students in relation to stated mathematics achievement counselling needs was determined. The purpose of this analysis was to verify the trend of the Chi Square Test results represented on Table 3 above. Table 4 shows the mean perceptions of the opinions of heads of mathematics departments about the extent of counselling help requirements on students’ mathematics achievement counselling needs.

The information on Table 4 shows that the means ranged between 3.89 and 4.89 out of a possible maximum of 5 and minimum of 1. Since the means were all above the average mean of 3, then it can be concluded that mathematics counselling help was vital in improving achievement in the subject among secondary school students. The results of the heads of mathematics departments’ mean perceptions suggested a dire need for students to be assisted in building a positive attitude towards mathematics, enhancing skills for organizing test solutions, understanding the importance of mathematics in career choice, participating effectively in mathematics discussion groups, developing intrinsic motivation in mathematics education, overcoming mathematics gender stereotypes, resisting negative peer pressure in mathematics study, managing time during mathematics tests and advocating for parental assistance in mathematics study.

Table 4. Mean perceptions of mathematics heads’ opinions on counselling help requirements

<table>
<thead>
<tr>
<th>Statement</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building positive attitude towards mathematics</td>
<td>9</td>
<td>4.89</td>
<td>.333</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Skills in organizing test item solutions</td>
<td>9</td>
<td>4.11</td>
<td>.333</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Importance of mathematics in career choice</td>
<td>9</td>
<td>4.89</td>
<td>.333</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Effective participation in discussion groups</td>
<td>9</td>
<td>4.11</td>
<td>.333</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Overcoming gender stereotypes in mathematics</td>
<td>9</td>
<td>4.56</td>
<td>1.014</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Intrinsic motivation in mathematics education</td>
<td>9</td>
<td>4.89</td>
<td>.333</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Negative peer pressure in mathematics study</td>
<td>9</td>
<td>4.89</td>
<td>.333</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Time management during mathematics test</td>
<td>9</td>
<td>4.11</td>
<td>.333</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Advocating for parental support in mathematics</td>
<td>9</td>
<td>3.89</td>
<td>.782</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>

Heads of mathematics departments were also asked to indicate other mathematics achievement counselling needs among secondary school students. The following themes were extracted from the opinions of the heads of mathematics departments in response to the question:

i. Students to be encouraged to consult mathematics teachers.
ii. Students to be shown how to ask for clarification during lessons.
iii. Advocate for provision of mathematics learning resources such as calculators, geometrical instruments, graph boards, text books and graph books.
iv. Influence the students to develop a more positive attitude towards mathematics and the mathematics teachers.
v. Help the students to see the need to write personal notes on mathematics concepts and relationships.
vi. Students need tips on how to avoid procrastination in their mathematics study.
vii. Emphasis to be placed on the need for good performance in mathematics during career counselling.

6.4 Counselling Heads’ Opinions on Counselling Help Requirements
The research sought opinions of the heads of counselling departments about the extent to which counselling help was required by students with regard to the stated mathematics achievement counselling needs. A Chi Square Test was
conducted to determine differences in the expected and observed frequencies among the following groups: No Help, Little Help, Undecided, Much Help and A Lot of Help. Table 5 displays the results of Chi Square Test on opinions of the heads of counselling departments about the extent of counselling help requirements on students’ mathematics achievement counselling needs.

Table 5. Counselling heads’ opinions on counselling help requirements Chi-Square test results

<table>
<thead>
<tr>
<th>Statement</th>
<th>Chi-Square</th>
<th>df</th>
<th>Asymp. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setting attainable mathematics study goals</td>
<td>8.000</td>
<td>2</td>
<td>.018</td>
</tr>
<tr>
<td>Conflict with mathematics teaching techniques</td>
<td>8.000</td>
<td>2</td>
<td>.018</td>
</tr>
<tr>
<td>Developing a mathematics study programme</td>
<td>5.444</td>
<td>1</td>
<td>.020</td>
</tr>
<tr>
<td>Reduction of mathematics anxiety</td>
<td>8.000</td>
<td>2</td>
<td>.018</td>
</tr>
<tr>
<td>Understanding the nature of mathematics</td>
<td>8.333</td>
<td>3</td>
<td>.040</td>
</tr>
<tr>
<td>Procrastination in mathematics revision</td>
<td>5.444</td>
<td>1</td>
<td>.020</td>
</tr>
<tr>
<td>problems at home affecting performance</td>
<td>8.000</td>
<td>2</td>
<td>.018</td>
</tr>
<tr>
<td>Effective mathematics test taking skills</td>
<td>8.000</td>
<td>2</td>
<td>.018</td>
</tr>
</tbody>
</table>

The Chi Square Test statistic was tested at a 0.05 level of significance. Information on Table 5 indicates that the Chi Square values lied between 5.444 and 8.333 with the P-Values ranging between 0.018 and 0.040. Since P-Value < 0.05, the null hypothesis was rejected. This means that there was a statistically significant relationship between the observed and expected frequencies for the extent to which counselling help was required on the indicated mathematics achievement counselling needs among secondary school students. The inference from the results is that there was demand for mathematics counselling services among secondary school students. To confirm the pattern of responses, mean perceptions of heads of counselling departments’ opinions on counselling help requirements in mathematics achievement among secondary school students was determined. Table 6 shows data analysis on mean perceptions of the heads of counselling departments’ opinions on counselling help requirements among students.

Table 6. Mean perceptions of counselling heads’ opinions on counselling help requirement

<table>
<thead>
<tr>
<th>Statement</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setting attainable mathematics study goals</td>
<td>9</td>
<td>4.56</td>
<td>1.014</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Conflict with mathematics teaching techniques</td>
<td>9</td>
<td>3.89</td>
<td>.782</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Developing a mathematics study programme</td>
<td>9</td>
<td>3.78</td>
<td>.667</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Reduction of mathematics anxiety</td>
<td>9</td>
<td>4.56</td>
<td>1.014</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Understanding the nature of mathematics</td>
<td>9</td>
<td>3.56</td>
<td>1.236</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Procrastination in mathematics revision</td>
<td>9</td>
<td>4.89</td>
<td>.333</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Problems at home affecting performance</td>
<td>9</td>
<td>3.89</td>
<td>.782</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Effective mathematics test taking skills</td>
<td>9</td>
<td>4.56</td>
<td>1.014</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>

The information on Table 6 shows that the mean perceptions of heads of counselling departments’ opinions on counselling help requirements ranged between 3.56 and 4.89 out of a possible maximum of 5 and minimum of 1. Since the obtained means were all above the average mean of 3, then it was inferred that mathematics counselling services were essential for improving achievement in the subject among secondary school students. This means that students needed help in setting attainable mathematics study goals, resolving conflict with mathematics teaching techniques, developing a mathematics study programme, reducing mathematics anxiety, understanding the nature of mathematics, avoiding procrastination in mathematics study, coping with problems at home affecting mathematics performance at school and developing effective mathematics test taking skills. When suggesting additional counselling help required in mathematics achievement among secondary school students, heads of counselling departments felt that:

i. Intrinsic motivation to study the subject was fundamental and should be instilled in the students.

ii. Support groups for low achievers were considered necessary to alleviate the poor mathematics grades among secondary school students.

iii. Some heads of counselling departments advocated for a mathematics rich school and home environment rendering students a diversity of mathematics formulae, games, objects and concepts.

7. DISCUSSION
A statistically significant relationship between psychological intervention requirements and mathematics students’
counselling needs was noted from the data analysis results. This suggests that mathematics achievement counselling needs existed among secondary school students and necessary counseling measures should be taken into account in order to meet these needs hence enhance achievement in the subject. These findings support views of American School Counsellor Association (2006) that school counselling programmes can help students realize academic achievement. Therefore, there is need for psychological intervention in enhancing mathematics achievement among secondary school students. Addressing students’ issues of attitude, study methods and test taking skills in mathematics education may enhance development of intrinsic motivation to study and curb the persistent dismal achievement in the subject.

This research indicated that most students required parental support in terms of extra mathematics tuition and there were also home based issues that interfered with mathematics achievement at school. According to Ricky (1990) a student’s academic problems may be a reflection of conflicts at home. Once such conflicts are resolved, the student’s optimum academic achievement may be realized. Therefore, helping students to cope and resolve home based conflicts affecting academic achievement can best be done through family therapy. SMASSE (1998) emphasizes that students’ mathematics anxiety and negative attitudes towards the subject are passed on from parents, neighbours and older siblings. Therefore, changing students’ anxiety and negative attitude towards mathematics may involve enriching the home environment in terms of positive conversations on the subject and ensuring adequate mathematics learning resources in the home.

The findings also revealed that students were deficient of social skills in the mathematics class exemplified by ineffective participation in group discussions, fear of asking for clarification when in doubt and lack of teacher consultation. Group counselling provides an appropriate environment for nurturing social skills. Donna (2009) asserts that the free interaction among group member provides support and comfort in such a way that difficulties are resolved and alternative behaviours learned. Moreover, the psychological safety in the group allows the expression of those feeling which are often difficult to express outside the group and members begin to ask for support. Therefore, group counselling can help in creating a favourable mathematics class social environment.

Heads of counselling departments advocated for support groups for the slow learners in mathematics. According to KIE (2003) group counselling brings people with similar issues together which is comforting for each member of the group to know that others also experience similar predicaments. Moreover, bringing students of similar mathematics ability together can facilitate discovery of better and efficient methods of tackling diverse problem areas. The purpose of group counselling is to provide information to group members, clarify changes that must be taken to improve the condition and avail the necessary resources to effect the changes. Information about issues of setting appropriate study goals, developing effective study groups, avoiding procrastination, following through personal study timetable and managing time during examinations can be passed to students in group counselling. Therefore, slow learners can naturally benefit from group counselling as they acknowledge their weaknesses and find ways of coping in the effort to improve mathematics achievement.

7. CONCLUSION AND RECOMMENDATIONS
It was concluded that psychological interventions with respect to mathematics achievement counselling needs were vital in an attempt to enhance achievement in the subject among secondary school students. Thus:

i. Measures should be put in place to improve access to and demand for mathematics psychological interventions among secondary school students.

ii. Concerted effort should be made by all education stakeholders to meet the counselling needs related to mathematics achievement among secondary school students.

iii. School counsellors should sensitize secondary school students about the importance of utilizing mathematics counselling services in order to improve performance.

iv. Mathematics teachers should appropriately refer students requiring mathematics counselling help.

REFERENCES


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ABSTRACT
Challenges of everyday living experienced by students’ in the institutions of higher learning leave many of them devastated, not able to make realistic personal decisions and choices. Although counselling services are usually provided in various Kenyan universities, there seem to be noticeable students’ unconstructive behaviour. University guidance and counselling services have a role of assisting students understand and learn how to deal with their intrapersonal issues and problems. This study determined whether there are differences in efficacy of guidance and counselling services among Kenyan universities on development of students’ personal competence. The study employed ex post facto research approach and utilised casual-comparative design. Purposive, proportionate and stratified random sampling techniques were used to select the respondents. Quantitative data was collected using a questionnaire that was administered to 369 third and fourth year full-time undergraduate students enrolled in three public and three private universities in Kenya. Qualitative data collection used interviews conducted among 10 student counsellors and a focus group discussion involving 36 peer counsellors from the universities studied. Data analysis used Statistical Package for Social Sciences and inferential statistical techniques which included one-way Analysis of Variance. The hypothesis of the study was tested at significant level of 0.05. There were significant differences in the efficacy of guidance and counselling services on development of students’ personal competence among the studied universities. Universities need to establish clear policies and structures that would improve and strengthen guidance and counselling services hence contributing to students’ growth in personal competence.

Key words: Counselling, Efficacy, Guidance, Personal

INTRODUCTION
The globalization and rapid pace at which new knowledge is being created and utilised are among the recent developments which pose challenge to university education. Generally, university education is based on the philosophy that students are mature enough to take the fullest responsibility for their behaviour. There is the understanding that university education helps students acquire knowledge, skills and values that enhance self-management. Biswalo (1996) argues that, although university undergraduate students are young adults, most of them remain in a suspended state of semi-immaturity and dependence, compared with persons of the same age who do not go to college but begin careers. Thus, the need for guidance and counselling services in institutions of higher learning cannot be overstated. Globally it is evident that students in educational institutions have personal needs that call for guidance and counselling services which if unattended could lead to numerous disciplinary issues and wastage. The development of personal competency means that the students have suitable knowledge on how to deal with personality maladjustments such as unhappiness, annoyance and anger, inability to meet needs and get aspirations into fruition. Gelabert (2007) points out some factors that may hinder personal growth which include stress and anxiety neurosis, excessive frustration, lack of knowledge and partial or total failure. Students have problems related to themselves, their parents and family, loneliness, failure, feelings of inadequacy and sometimes inferiority. The expansion of higher education moves along with the modern advancement associated with changing life styles and complexities of life (Ngombe, Mwiria, Wawira and Wesonga, 2003). Thus the students in educational institutions are searching, quite ardently for values that would
give meaning to life after training. The students become disenchanted when they have difficulty relating their education to their personal development. Effective Guidance and counselling services are therefore definitely very crucial in the universities. These services need to be rendered in the best way possible in order to help students cope with the modern life complexities and the various challenges that may affect their development of personal competences.

Biswalo (1996) notes that higher educational institutions have a two-fold crucial responsibility: to nurture students who have varying abilities, capacities, interests and unlimited potential; and to prepare these individuals to become effectively functioning members of their changing societies. Moreover, Mutie and Ndambuki (2004) points out that most of the students in the universities comprise adolescents or young adults as well as adult students. Atwater (1984) argues that the adolescent stage of life is marked by emotional development that includes mood swings, enthusiasm, tenderness, cruelty, curiosity and apathy. It is marked with increase in crimes and delinquency. University students both individually and collectively could eschew violence as a way of solving their problems in favour of dialogue. Ndondo (2004), points that some students engage in antisocial behaviour such as drug and alcohol abuse and irresponsible sexual behaviour, which leads to decline of moral integrity, because they lack knowledge on how to effectively spend and manage their personal leisure time. The provision of counseling service may need to be based on a complete understanding and acceptance of students personal experiences.

University guidance and counselling services are meant to assists, students develop various competencies that help them adjust to different situations and make appropriate personal decisions in life. Biswalo (1996) points out that for most students, the period in the university represent unique personal challenges. It is actually a time of significant personal growth and decision – making regarding one’s values, interpersonal and intrapersonal relationships, career and other life goals all within a stressful student academic environment. The challenges often encountered by the students include: academics, interpersonal relationships and sexuality, family problems, financial challenges, self identify issues, feelings of loneliness, low self-esteem and depression or anxiety (Sikoliia and Lutomia, 2002). As highlighted in the Vice- chancellor’s report (2000), when students face personal challenges, they may express their dissatisfaction in any of the following ways: withdrawal, drug abuse, demonstrations, riots or anxiety. Thus the need to examine the efficacy of students counseling services in a university.

As noted by Ndondo (2004) students may become disenchanted when they have difficulty relating their education or training to the rest of their lives. This makes guidance and Counselling services vital in education institutions which according to help individuals to understand and use personal opportunities they have. Makinde (1984) points out that there is need for the institutions to guide the young people about making right choices of educational tracks they have to follow in order to realize their goals. Therefore working with university students effectively requires specialized knowledge. The provision of university guidance and counselling services would enable students develop personal competencies that can prevent occurrence of undesirable behaviours and academic wastage among students and probably some of their personal problems may be highly reduced.

The objective of study was to determine whether there are differences in the efficacy of guidance and counselling services among Kenyan universities on development of the students’ personal competence. The following hypothesis was tested at 0.05 level of significance: HO: There is no statistically significant difference in the efficacy of guidance and counselling services among the Kenyan universities on development of students personal competence. Limitation of the study was that some respondents expressed only the socially acceptable views. During the collection of the qualitative data some of the respondents interviewed were defensive when asked questions relating to their area of service. To overcome this, the researcher assured them of confidentiality. In this study, it was assumed that the students in both public and private universities had more or less similar characteristics. Guidance and counseling services were provided in both categories of the universities. This was to allow comparison among the universities.

**METHODOLOGY**

The study applied causal- comparative research design. As explained by Cohen and Swerdlik (2005), in this approach the researcher does not manipulate the variables under study but instead examines the variables in their existing condition. In this study, the variables of interest included counselling services as the independent variable and student personal competence as the dependent variable. The casual- comparative design was therefore appropriate for this study because it allowed for comparisons of groups. This enabled the researcher to make comparisons between the public and private universities in the efficacy of guidance and counselling services based on student development of personal competence. The target population of this study were the undergraduate students in public and private
universities in Kenya. Six universities (three public and three private) were selected using purposive sampling technique for the actual study. Two universities (i.e. one public and one private) were chosen for piloting the research instruments. From an accessible population of 19,169 third and fourth year students a sample of 377 was selected. The sample size of the students was distributed among the six (6) universities using proportionate sampling. The other respondents in the study included ten university student counsellors (six from public universities and four from private universities) who were purposefully selected. The researcher observed that most of the private universities studied had only one student counsellor. In addition, there was a focus group discussion involving thirty six (36) peer counsellors from the universities studied. Thus, the total number of respondents was four hundred and fifteen. The researcher used three instruments to solicit data from the respondents who included third and fourth year undergraduate students, universities students’ counsellors and peer counsellors. The study used triangulation method of data collection. The three data collection tools included the students’ questionnaire, Peer counsellors focus group discussion and the student counsellors’ interview schedule.

The instruments (questionnaire, focus group discussion, and interview schedule) were reviewed by the researcher’s supervisors and other research experts from two other universities (one public and one private). This was to ensure content validity and face validity. The data collected from the pilot study was used to compute the reliability of the instruments. Cronbach’s coefficient alpha method was used to determine internal consistency of the items. This method is appropriate owing to the fact that it requires only one administration of the test (Cohen and Swerdlik, 2005). In the study, the items were considered reliable if they yielded a reliability coefficient of 0.70 and above. In this study, the reliability coefficient of the items in the questionnaire was 0.8459 for the adequacy of counselling resources and 0.9663 for personal competence. These reliability tests were for both public and private universities and were considered desirable for consistency levels. Both qualitative and quantitative data analyses were done. Qualitative analysis was used in this study because the research was based on an interpretive naturalistic approach. Some of the items in the questionnaire were analysed quantitatively and inferential stastics which included ANOVA was used to allow comparisons among universities.

RESULTS AND DISCUSSION
Efficacy of guidance and counselling services in universities on students development of personal competence
The analysis of the set hypothesis was done first by computing the mean scores and standard deviation as indicated on Table 1. For confidentiality, codes U1, U2, U3, U4 and U5 were used for the universities.

<table>
<thead>
<tr>
<th>University</th>
<th>N</th>
<th>Mean</th>
<th>S.D</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1</td>
<td>149</td>
<td>32.36</td>
<td>10.26</td>
<td>12.00</td>
<td>61.00</td>
</tr>
<tr>
<td>U2</td>
<td>30</td>
<td>34.57</td>
<td>11.72</td>
<td>12.00</td>
<td>48.00</td>
</tr>
<tr>
<td>U3</td>
<td>32</td>
<td>35.53</td>
<td>10.95</td>
<td>13.00</td>
<td>48.00</td>
</tr>
<tr>
<td>U4</td>
<td>39</td>
<td>29.54</td>
<td>10.95</td>
<td>12.00</td>
<td>48.00</td>
</tr>
<tr>
<td>U5</td>
<td>94</td>
<td>22.09</td>
<td>6.49</td>
<td>12.00</td>
<td>36.00</td>
</tr>
<tr>
<td>U6</td>
<td>21</td>
<td>25.48</td>
<td>10.69</td>
<td>12.00</td>
<td>37.00</td>
</tr>
</tbody>
</table>

From the Table 1 the minimum and the Maximum column show the range of scores in personal competence in each university. The descriptive statistics reveal that some mean differences existed in development of student personal competence among the six universities. One way ANOVA was then done to find out whether the mean differences were significantly significant.

<table>
<thead>
<tr>
<th>Sum of squares</th>
<th>df</th>
<th>Mean Squares</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Competencies</td>
<td>Between Groups</td>
<td>8642.500</td>
<td>5</td>
<td>1728.500</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>34054.552</td>
<td>359</td>
<td>94.859</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>42697.052</td>
<td>364</td>
<td></td>
</tr>
</tbody>
</table>

From the ANOVA results given on Table 2, it was evident that there were statistically significant differences in the efficacy of guidance and counselling services on development of the students personal competence among the universities. The computed P=0.000 was less than the set alpha value (0.05). The null hypothesis was rejected. The
multiple comparison tests were done in order to reveal where the differences in students personal competence among the universities occurred as indicated on Table 3.

The Post Hoc test in Table 3 shows where there are significant mean differences in students personal competence among the various universities. The results show the universities where the mean differences are significant and where the differences are not significant. The efficacy of guidance and counselling services on development of students’ personal competence among the universities seem to vary. For instance, the mean difference on students personal competence between U5 and U3 is -13.4355. This difference is significant. This also shows that the mean on personal competence for U3 is higher than the mean for U5. This may imply that the outcome of guidance and counselling services could be more productive on development of students personal competence in U3 than U5. Development of students’ personal competence means that they are able to deal with personal problems such as anger, anxiety or excessive frustrations that can lead to personality maladjustments. Moreover, Corey (1996) adds that it is the duty of the institutions guidance and counselling services to restore mental health in order to enable clients to cope with personal problems. This means that the students are assisted to understand their feelings, attitudes and emotional dispositions. Thus the student is able to better understand himself or herself in relating to his present and future decision and problems. Thus the efficacy of the counseling services refers to whether the counselee/student is assisted to learn to deal more effectively with himself/herself and the reality of his environments. There is growth and positive change through an exercise of self understanding. Personal matters needing counseling include boredom, confusion, sense of inferiority, frustration, loneliness, shyness, worry, sadness, unfulfillment, hate and rejection. The findings on Table 3 show that there is a significant difference in the efficacy of guidance and counseling services on the development of guidance and counseling services among the universities. Personal counseling services equips a student with skills for development of self-esteem and positive self-evaluation hence contributing to her/his success and happiness.

**Table 3. Post hoc tests (multiple comparisons LSD) table of the mean differences in the development of the students personal competence among the universities**

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>(I) University of references</th>
<th>(J) Other universities</th>
<th>Mean Differences (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal competencies</td>
<td>U1</td>
<td>U2</td>
<td>-2.2110</td>
<td>1.9490</td>
<td>.257</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U3</td>
<td>-3.1755</td>
<td>1.8976</td>
<td>.095</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U4</td>
<td>2.8172</td>
<td>1.7518</td>
<td>.109</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U5</td>
<td>10.2600(*)</td>
<td>1.2828</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U6</td>
<td>6.8795(*)</td>
<td>2.7019</td>
<td>.003</td>
</tr>
<tr>
<td></td>
<td>U2</td>
<td>U1</td>
<td>2.2110</td>
<td>1.9490</td>
<td>.257</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U3</td>
<td>-.9646</td>
<td>2.4751</td>
<td>.697</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U4</td>
<td>5.0282(*)</td>
<td>2.3652</td>
<td>.034</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U5</td>
<td>12.4709(*)</td>
<td>2.0423</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U6</td>
<td>9.0905(*)</td>
<td>2.7711</td>
<td>.001</td>
</tr>
<tr>
<td></td>
<td>U3</td>
<td>U1</td>
<td>3.1755</td>
<td>1.8976</td>
<td>.095</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U2</td>
<td>2.4751</td>
<td>1.8765</td>
<td>.095</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U4</td>
<td>5.9928(*)</td>
<td>2.3237</td>
<td>.010</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U5</td>
<td>13.4355(*)</td>
<td>1.9933</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>U4</td>
<td>U1</td>
<td>10.0551(*)</td>
<td>2.7332</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>-2.8172</td>
<td>1.7518</td>
<td>.109</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U3</td>
<td>-5.0282(*)</td>
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<td>2.3237</td>
<td>.010</td>
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<tr>
<td></td>
<td></td>
<td>U6</td>
<td>7.4427(*)</td>
<td>1.8551</td>
<td>.000</td>
</tr>
<tr>
<td></td>
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<td>U1</td>
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</tr>
<tr>
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<tr>
<td></td>
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<td>-12.4709(*)</td>
<td>2.0423</td>
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<tr>
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<td>-13.4355(*)</td>
<td>1.9933</td>
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</tr>
<tr>
<td></td>
<td></td>
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<td>-7.4427(*)</td>
<td>1.8551</td>
<td>.000</td>
</tr>
<tr>
<td></td>
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<td>U1</td>
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<td>2.3508</td>
<td>.151</td>
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<td></td>
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<td>9.0905(*)</td>
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<tr>
<td></td>
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<td>10.0551(*)</td>
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<td></td>
<td></td>
<td>U6</td>
<td>3.3804</td>
<td>2.3508</td>
<td>.151</td>
</tr>
</tbody>
</table>

* The mean difference is significant at the 0.05 level.

Counsellors work in areas ranging from problem prevention to remediation and treatment. The effective counsellor can be distinguished from ineffective counsellors by the nature and quality of relationship skills used. Clients of ineffective counsellors become worse, whereas clients of effective counsellors improve. Competence in the execution of attending, responding and initiating skills determines a counsellors effectiveness. There is a relationship between personality characteristics and effectiveness in counselling. The quality of the therapeutic bond is determined by the counsellors personal characteristics such as the ability to communicate empathy and concern to the clients and willingness to be vulnerable and open. The interpersonal skills include communicating empathy, respect concreteness,
confrontation, and self-disclosure. For the efficacy of counselling services in assisting students develop their personal competence, the support of the administration is vital. Moreover, for an educational programme to succeed there is need for all role players and stakeholders to do their part. In an educational institution the administration provides the necessary facilities and resources. Guidance and counselling services on the other hand are vital because they help the students cope with life challenges in the university setting. Thus Mohanty (2003) states that counsellors must function as institutional integrators so that student and university goals may be accomplished. The stakeholders of education institutions including the Ministry of Education Science and Technology are aware of the need for students counselling services today (GOK,1999). The government of Kenya is therefore concerned and thus recommends Guidance and counselling to feature in teacher education (Mutie and Ndambuki, 2004). The GOK (1999) points out the need for administration in learning institutions to create and maintain the right atmosphere for co-operation and support of Guidance and Counselling with the aim of strengthening these service. As Biswalo (1996) notes, the universities in Kenya, have made considerable progress in setting up administration structures and programmes for provision of guidance and counselling services. However, as highlighted in the Vice- chancellor’s report (2000), counselling services seems not to be making much impact in dealing with students’ challenges in the higher learning institutions. Therefore, it appears that total and enlightened commitment on the part of policy and decision makers is necessary and need to definitely surmount the problems that could be thwarting the counselling services. This would enhance the efficacy of guidance and counselling services putting them on the right track in Kenyan universities and assisting the students develop holistically.

The Vice-Chancellor’s report (2000) on causes of disturbances/riots in public Universities points out that guidance and counselling services are necessary in the universities. In most cases students’ usually regard themselves as the very reason for existence of the university. Hence they make certain demands on the institution. Thus as noted by the GOK(1999) students need to be aware of their rights and regulations governing their conduct in the educational institutions. A substantial number also lack courage or self esteem needed to seek explanations or dialogue with significant others (Pelt 1988). Adults including lecturers believe that adolescence/young adults need direction and control which is often resented because the later feel that they should be treated like grownups. In addition the parents of students with undesirable behaviour also require counselling. This will enhance change of behaviour of the students even at family set up where they belong. Thus in the universities the student counsellors need to be competent. Lutomia and Sikolia (2002) points out that individual and group counselling among the students are necessary in an educational institution. The group or individual counselling may be conducted through interviews, informal discussions, reports, lectures, dramatic films, case conferences, career meetings and excursions. However as noted by Mohanty (2003) for any counselling techniques to show worthwhile results, there must be adequate understanding and rapport between the counsellor and client or students. All this is meant to enhance efficacy of guidance and counseling services in a university set up.

CONCLUSION
The main aim of the study was to determine the efficacy of guidance and counselling services on development of students personal competence among public and private universities in Kenya. From the findings of this study, significant differences were reported on development of the students personal competences among public and private universities. The students in private universities seemed to have higher positive growth of their competencies through assistance of guidance and counselling services compared to those enrolled in public universities. It can therefore be concluded that difference in student behaviour witnessed in the two types of universities was due to the state of students’ development of their personal competence. Thus, Biswalo (1996) points out that universities need effective students guidance and counselling services that can assist the students with the knowledge about the world of work, choice of courses, academic habits and besides because some campuses are mercilessly assailed by drug and alcohol abuse, unplanned pregnancies, depression and other numerous personal problems.

RECOMMENDATIONS
It was found that significant differences existed in efficacy of guidance and counselling services in development of student personal competence among the selected universities with students showing different levels of development of personal competence. Based on the findings of this study the following recommendations were made:

i. The university managers need to strengthen these services for holistic development of the students. University management could provide adequate physical and human resources that are crucial in promoting the provision of guidance and counselling services.

ii. There is also need for the university management to encourage and involve students in management decision
making processes especially in issues that are likely to negatively affect their lives in the university. Thus the students feel that they are part of stakeholders in the university management system.

iii. The provision of guidance and counselling services in the area of human development should be enhanced. This is in consideration to the challenges associated with adolescent and young adulthood stage of life in which majority of the undergraduate students belong.

iv. The Commission for Higher Education and the managers of public and private universities need to organize for workshops and conferences in order to exchange ideas on how strengthen students guidance and counseling services in the universities. Participation of the student counsellors in workshops or conferences will keep them abreast with the new developments emerging in the area of counselling.

REFERENCES


MATHEMATICAL ANALYSIS OF A COMPREHENSIVE HIV AIDS MODEL: TREATMENT VERSUS VACCINATION

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ABSTRACT
A comprehensive deterministic HIV/AIDS transmission model incorporating social behaviour, treatment, vaccination, stages of infection, age structures, discrete time delay and vertical transmission is presented and rigorously analyzed. Two age structures were considered with group one consisting of children aged (0 - a) years and group two consisting of adults aged (a) years and above. This study investigated whether a trade-off exists between vaccination and treatment. Numerical simulations showed that treatment that does not reduce infections is worse than when the treatment is not applied at all. However, when coupled with effective counseling, then it is very effective in combating the spread of the disease and finally eliminating it. A trade off seems to exist between vaccination and treatment and therefore careful consideration should be made because a combination of the two could be counterproductive or helpful depending on implementation.

1.0. INTRODUCTION
Mathematical models and Computer simulations are useful experimental tools for building and testing theories, assessing
quantitative conjectures, determining sensitivities to changes in parameter values and answering specific questions. The magnitude and severity of the problem of HIV/AIDS became increasingly evident in the early 1990’s with a prevalence rate of about 12 percent in Africa (Workshop on HIV/AIDS, 2003). In some communities i.e in Uganda a whole generation was wiped out (UNAIDS, “Africa fact sheet”, March 2000). The first simple HIV Mathematical epidemic model goes back to Anderson (Anderson, R. M. et al, 1986). By then behaviour change was recognized as the major way of combating the spread of HIV/AIDS epidemic given that there was no treatment or vaccine to the virus. After the discovery of Anti-retroviral treatment, modeling of HIV/AIDS was directed towards incorporating behaviour change and effects of treatment. Incorporating treatment and social behaviour posed a challenge to HIV/AIDS mathematical modeling because treatment acts both in the positive and negative direction. It reduces the infectiousness of an infected individual reducing the probability of transmission from an infective to a susceptible. On the contrary anti-retroviral therapies increase the lifespan of the HIV infectives and as such they can infect more people if the treatment does not reduce infectiousness with no change in social behaviour. These directions included the models by Valesco - Hernandez and Hsieh who concluded that only significant reductions in the transmission probability can contain the spread of the epidemic (Valesco H. and Hsieh, 1994 ). Such reductions could be through adoption of safer sexual practices or through reductions in viral load due to treatment. A model by Ying -Yen and Cook on behaviour change and treatment of core groups and its effects on the spread of HIV/AIDS showed that behaviour change and treatment can eradicate the disease however if the treatment and behaviour change levels do not reach critical values, detrimental effects could be realized resulting from slower progression to AIDS without sufficiently lower transmission rates resulting in increased spread of HIV infection (Ying – Yen and Cooke, K, 2000). Raw modeled the effect of combination of anti-retroviral treatments with different levels of unsafe sex on HIV incidence in Australia when effective anti-retroviral treatments first became widely available in Australia. The results suggested that decreases in HIV incidences through large decreases in infectiousness as a result of combination anti-retroviral treatment could be counterbalanced by much more modest increases in the levels of unsafe sex (Raw et al, 2001 ). The struggle for a safe and effective vaccine has been on going for over twenty years but still remains a difficult target, however Recent studies done in Thailand hinted that some vaccine for some strain of the virus could be on the way with an efficacy level of about 30 percent (BBC News: bbc.co.uk ). Wells A.W , in his paper, "even imperfect vaccines could be valuable", suggested that vaccines against the AIDS causing virus could save money, extend lives and prevent deaths even if these vaccines are only moderately effective in preventing or treating the infection (Wells A.W, 1998 ). Vaccination reduces the number of susceptible in the population whereas treatment increases the lifespan of the infective which may lead to an increase in the rate of infection. A trade - off seems to exists between vaccination and treatment and therefore a combination of the two could be counterproductive or helpful.

This study have developed a comprehensive deterministic HIV/AIDS transmission model incorporating counseling, treatment, vaccination, stages of infection, Age structures, discrete time delay and vertical transmission. It is our view that this study represents the very first practical realistic comprehensive model harmonizing the existing models into a single model that can be used to study most aspects of HIV and AIDS without presenting conflicting findings thus attempts to investigate the possibility of a trade off between vaccination and treatment.

2.0 Preliminaries

The population is divided into two age groups. Group I comprises of the sexually Immature children aged (0 - a) years and group II comprises of sexually mature and active adults aged (a) years and beyond. It is group II that is responsible for the spread of the epidemic through sexual activity and for the spread in children through infected mothers (Vertical Transmission).

2.1 Assumptions

1. Transmission of HIV from an infective to a susceptible is through heterosexual mode and vertical transmission.
2. There is random mixing of individuals within the population.
3. AIDS cases has full blown symptoms and are easily noticeable and are not sexually interacted with and as such, they don't transmit the virus and do not give birth to new borns.
4. Individuals in group I comprise of sexually Immature children aged (0-a) years and do not transmit the disease.
5. The removed class are sexually interacted with but are not infectious and are immuned.
6. Treatment is done in the adult group only.
7. The vaccine acts both as the "Leaky type" and the "All or Nothing type" of vaccine. The "Leaky type" of vaccine protects everybody vaccinated partially, while the "All or Nothing" type protects a fraction of those vaccinated fully leaving the rest completely susceptible.
2.2 Parameters and Notations Used in the Model

\( W(t) \) - denotes the number of susceptible children at time \( t \). \( H(t) \) - The number of infected children at time \( t \). \( U(t) \) - The number of AIDS Cases at time \( t \) in group I. \( S(t) \) - The number of susceptible adults at time \( t \). \( V(t) \) - The number of vaccinated adults at time \( t \). \( R(t) \) - The number of removed adults covered by the vaccine at time \( t \). \( X(t) \) - The number of infective adults at time \( t \). \( Z(t) \) - The number of infected adults who receive treatment at time \( t \). \( A(t) \) - The number of full blown AIDS Cases in group II at time \( t \). \( P(t) \) - The total population size at time \( t \).

2.3 The Parameters used in the model and how they are obtained

\( m \) - The rate at which the HIV infected children progress to AIDS in group I obtained from the average incubation period of HIV in children.

\( d \) - The disease related death rate obtained from the number of years it takes one who has shown full blown AIDS symptoms to die of the disease.

\( \mu \) - Natural death rate referring to the number of deaths in a year per 1000 people.

\( \alpha \) - The proportion of susceptible adults assumed to be vaccinated taken arbitrary.

\( \delta \) - Vaccine efficacy, assuming the “All or Nothing type of vaccine”. Obtained by getting the product of the vaccine efficacy (assuming the leaky vaccine) and the proportion of the susceptibles vaccinated. It represents the proportion of the vaccinated completely covered by the vaccine.

\( \varepsilon \) - Proportion of the infectives receiving treatment.

\( \eta \) - The rate at which the infectives who do not receive treatment progress to HIV/AIDS calculated from the average incubation period of HIV in adult infectives.

\( \lambda \) - Rate at which those treated progress to AIDS. (both the normal and vaccinated infectives) calculated from the average incubation period of treated adult infectives.

\( b \) - The per capita birth rate calculated as a ratio of the average live births per year to the general population size.

\( g \) - Natural child mortality rate calculated as a ratio of the average number of children below 15 years who die per year to the total population below 15 years.

\( v \) - Proportion of babies born with HIV from HIV infected mothers.

\( b_1 \) - Per capita birth rate of the adults calculated as a ratio of the average live births per year among the adults to the general population size of the adults excluding AIDS cases.

\( a \) - Years at which an individual becomes sexually mature.

\( \beta_1 \) - The per partnership transmission probability of a normal infective who is not treated. Obtained from the prevalence of the disease in a given area and their sexual behaviour patterns.

\( \beta_2 \) - The per partnership transmission probability of an infective who is treated and counseled.

\( c_1 \) - The average number of new sexual partners acquired per unit time by those infected but not yet counselled and treated.

\( c_2 \) - The average number of new sexual partners acquired per unit time by those treated and counselled.

\( \theta \) - The proportion of the vaccinated protected by the vaccine assuming the “leaky type of vaccine”.

2.4 Age Structures

Group I consists of children of age (0 - \( a \)) years which has three compartments namely \( W(t), H(t) \) and \( U(t) \). The differential equations for group I takes the following form:

\[
\frac{dW(t)}{dt} = b_1 N(t) - gW(t) - b_1 v(X(t) + Z(t)) - e^{(-\mu a)}b_1 N(t - a)
\]

\[
\frac{dH(t)}{dt} = b_1 v(X(t) + Z(t)) - (g + m)H(t)
\]

\[
\frac{dU(t)}{dt} = mH(t) - (d + g)U(t)
\]

Group II consists of adults aged (\( a \)) years and beyond. It has six compartments comprising of \( S(t), V(t), R(t), X(t), Z(t) \) and \( A(t) \). The differential equations takes the following form:-
2.5 Analysis of the Disease Free Equilibrium (D.F.E)

We analyze the stability of the Disease Free Equilibrium, (D.F.E) in group II since it is this group that is sexually active and responsible for the spread. We also assume that the AIDS cases $A(t)$ in the population can easily be identified from the full blown symptoms and are not associated with sexually and as such are not involved in the spread of the diseases though their projection will be investigated numerically to identify the impact they have on the population.

We set the proportions as follows: $a(t) = \frac{P(t)}{N(t)}$, $x(t) = \frac{X(t)}{N(t)}$, $z(t) = \frac{Z(t)}{N(t)}$, $r(t) = \frac{R(t)}{N(t)}$.

Note: $a(t) + x(t) + z(t) + \lambda(t) = 1$

We set $e^{-\sigma a} = \rho$

The equations of 1, 2, 3, 4, 5, with $e^{-\sigma a} = \rho$ becomes

\[
\begin{align*}
\frac{dN(t)}{dt} &= -\sigma a N(t) - (2.5) \\
\frac{dx(t)}{dt} &= (\beta + \frac{\rho}{N(t)})x(t) - (\mu + \sigma) x(t) - (4.5) \\
\frac{dz(t)}{dt} &= (3.5) \\
\frac{dV(t)}{dt} &= -(\mu + \sigma) V(t) - \rho V(t) \\
\frac{dR(t)}{dt} &= \rho (\frac{N(t)}{N(t)} - x(t)) + \frac{\rho}{N(t)} - \mu R(t) \\
\frac{dB(t)}{dt} &= \mu B(t) + \lambda (t) \\
\frac{dP(t)}{dt} &= (b_1 - \mu) N(t) - g(W(t) + U(t) + H(t) - \mu A(t)) \\
\end{align*}
\]

With $P(t) = N(t) + W(t) + H(t) + U(t) + A(t)$, $N(t) = S(t) + V(t) + R(t) + X(t) + Z(t)$ and $b_1 = b \frac{N(t)}{N(t)}$.
3.0 Threshold Quantities
The Threshold for many epidemiology models is the basic reproduction number \( R_0 \) defined as the average number of secondary infections produced when one infected individual is introduced into a host population where everyone
is susceptible. For many deterministic epidemiology models, an infection can get started in a fully susceptible population if and only if \( R_0 > 1 \). The basic Reproduction number \( R_p \) is often considered as the threshold quantity that determines when an infection can invade and persist in a new host population. The reproduction number could be obtained by inspection if we have only one infective class. If the number of infective classes are two or more, then the technique due to Diekmann, called the next generation matrix is more appropriate (Diekmann, 1990).

3.1 The next generation matrix
We have 2 infected compartments \( m = 2 \), in group II givenbelow:

\[
\begin{align*}
\frac{dx(t)}{dt} &= (\beta_1 c_1 x(t) s(t) + \beta_2 c_2 s(t) z(t)) + ((1 - \theta) (\beta_1 c_1 v(t) x(t) + \beta_2 c_2 v(t) z(t))) \\
&\quad - (\epsilon + \eta) x(t) - \rho b_1 w_1 x(t) + \eta x(t)^2 + \lambda x(t) z(t) \\
\frac{dz(t)}{dt} &= \epsilon x(t) - (\mu + \lambda) z(t) - \rho b_1 w_1 z(t) + \mu z(t) + \eta x(t) z(t) + \lambda z(t)^2
\end{align*}
\]

\( F \) is given by the matrix:

\[
\begin{pmatrix}
\beta_1 c_1 & \beta_2 c_2 \\
0 & 0
\end{pmatrix}
\]

and

\[
V = V_i^- - V_i^+ = \begin{pmatrix}
(\epsilon + \eta) x(t) + \rho b_1 w_1 x(t) - \eta x(t)^2 - \lambda x(t) z(t) \\
(\lambda) z(t) + \rho b_1 w_1 z(t) - \epsilon x(t) - \eta x(t) z(t) - \lambda z(t)^2
\end{pmatrix}
\]

The (D.F.E), point of the system has coordinates \([s^*(t), v^*(t), r^*(t), x^*(t), z^*(t)] = [1, 0, 0, 0, 0] \)

The derivatives of \( F \) and \( V \) at \([1, 0, 0, 0, 0] \), are given by:

\[
F' = \begin{pmatrix}
\beta_1 c_1 & \beta_2 c_2 \\
0 & 0
\end{pmatrix}
\]

\[
V = \begin{pmatrix}
(\epsilon + \eta + \rho b_1 w_1) & 0 \\
-\epsilon & (\lambda + \rho b_1 w_1)
\end{pmatrix}
\]

Using the wolfram research mathematica software

\[
V^{-1} = \begin{pmatrix}
\frac{1}{(\rho b_1 w_1 + \epsilon + \eta)(\rho b_1 w_1 + \lambda)} & 0 \\
\frac{1}{(\rho b_1 w_1 + \epsilon + \eta)(\rho b_1 w_1 + \lambda)} & \frac{1}{(\rho b_1 w_1 + \lambda)}
\end{pmatrix}
\]

\[
F * V^{-1} = \begin{pmatrix}
\frac{\beta_1 c_1}{(\rho b_1 w_1 + \epsilon + \eta)} + \frac{\epsilon + \beta_1 c_1}{(\rho b_1 w_1 + \epsilon + \eta)(\rho b_1 w_1 + \lambda)} & 0 \\
0 & \frac{\beta_2 c_2}{(\rho b_1 w_1 + \epsilon + \eta)} + \frac{\epsilon}{(\rho b_1 w_1 + \epsilon + \eta)(\rho b_1 w_1 + \lambda)}
\end{pmatrix}
\]

the eigen values of \( F * V^{-1} \) is given as

\[
\lambda_1 = 0
\]

\[
\lambda_2 = \frac{\beta_2 c_2}{(\rho b_1 w_1 + \epsilon + \eta) + \frac{\epsilon}{(\rho b_1 w_1 + \epsilon + \eta)(\rho b_1 w_1 + \lambda)}
\]

\[
\rho(F * V^{-1}) = R_0 = \left(\frac{\beta_1 c_1}{(\rho b_1 w_1 + \epsilon + \eta)} + \frac{\epsilon}{(\rho b_1 w_1 + \epsilon + \eta)(\rho b_1 w_1 + \lambda)}\right)
\]

Hence if

\[
\left(\frac{\beta_1 c_1}{(\rho b_1 w_1 + \epsilon + \eta)} + \frac{\epsilon}{(\rho b_1 w_1 + \epsilon + \eta)(\rho b_1 w_1 + \lambda)}\right) > 1
\]

the infection will invade and persist in a host population of susceptibles.
4.0 Numerical simulations of the Model

We present numerical simulations of the model to illustrate some of the analytical results above using the following default parameter values with reference to Kenyan statistics.

- **b = 0.03664** - The birth rate referring to the number of live births in a year per 1000 people. The value used is obtained from the Kenya demographics profile 2010. The value of 0.04 used is adjusted to ensure that the ratio of the adults and those under 15 years is at steady state.
- **μ = 0.00973** - Natural death rate referring to the number of deaths in a year per 1000 people. Obtained from the Kenya demographics profile 2010.
- **g = 0.015** - Natural under 15 child mortality rate estimated to be 1.5 times higher than the natural death rate.

**Parameter Values**

- **v = 0.3** - Proportion of babies born with HIV from HIV infected mothers.
- **m = 0.2** - The rate at which the HIV infected children progress to AIDS in group I.
- **d = 0.4** - The disease related death rate calculated from the number of years it takes one who has shown full blown AIDS symptoms to die of the disease.
- **β1 = 0.019** - The probability of getting an infection from a new sexual partner.
- **c1 = 9.9** - The rate at which an individual acquires new sexual partners per year.
- **β1 = 0.1881** - is the force of infection of the infectives who are not treated and counseled obtained from the Kenya National Aids Control Council Report of 2007.
- **δ = 0.12** - Vaccine efficacy, assuming the “All or Nothing type of vaccine”.
- **η = 0.125** - The proportion at which the normal infectives who do not receive treatment progress to AIDS, calculated from the average incubation period of HIV in treated adult infectives.
- **λ = 0.08** - Rate at which those treated progress to AIDS, calculated from the average incubation period of HIV in treated adult infectives.
- **α = 0.44** - The proportion of the infectives who receive treatment.
- **a = 15** - Age at which one becomes sexually mature.
- **a = 0.4** - The proportion of the susceptible vaccinated given by getting the product of the vaccine efficacy assuming the leaky vaccine and the proportion of the susceptible vaccinated.
- **θ = 0.3** - The proportion of the vaccinated protected by the vaccine assuming the “leaky type of vaccine”.
- **η = 0.125** - The proportion of the vaccinated who are not treated and counseled.
- **θ = 0.12** - Vaccine efficacy, assuming the “All or Nothing type of vaccine”.
- **η = 0.125** - The proportion of the vaccinated who are not treated and counseled.
- **a = 15** - Age at which one becomes sexually mature.
- **δ = 0.12** - Vaccine efficacy, assuming the “All or Nothing type of vaccine”.

**Figure 1**

4.1 Population model

To develop a population model when the disease is not incorporated, we set all the disease parameters to zero. We draw the graph of the population proportions with time to investigate whether our parameter values gives us steady state solutions of the population proportions. We need the steady state solutions as a background to study the effects of HIV/AIDS on the stable states. Using the birth rate of 0.04, the graph of the population proportions appears as shown in Figure 1.

**Figure 1: Graph of population proportions against time.**

4.2 Treatment of adult infectives with no behavioral change and no change in infectiousness

We investigate the effects of treatment which does not reduce infectiousness or which is counterbalanced by reckless sexual practices. The parameter α is the proportion of infectives who receive treatment. Different parameter values for treatment are simulated and the results are shown in Figure 2.
The increase in the disease prevalence level with treatment may be due to the fact that treatment lengthens the lives of the infectives and as such those who would have died of AIDS do become healthier and continue to spread the disease if they are not counseled or the counseling has no effect in changing their social behaviour.

4.3 Treatment of adult infectives with behavioral change and change in infectiousness

This reflects the current state of HIV/AIDS in Kenya where 44 percent of HIV/AIDS infectives receive treatment and counseling. According to medical research, treatment alone reduces infectiousness by 50 percent. In Kenya, no data exist to estimate by which percentage treatment coupled with counseling (zero grazing, condom use and circumcision) reduces infectiousness. We again simulate the prevalence of the disease with time for $\beta_2c_2 = 0.0905$ (reducing infectiousness by 50 percent), $\beta_2c_2 = 0.07524$ (reducing infectiousness by 60 percent), $\beta_2c_2 = 0.03762$ (reducing infectiousness by 80 percent) and $\beta_2c_2 = 0.01881$ (reducing infectiousness by 90 percent) as shown in Figure 3.

We observe that at the estimated current force of infection of $\beta_1c_1 = 0.1881$, coupled with treatment alone that reduces infectiousness by 50 percent, the disease will die out in about 200 years time. We thus conclude that counseling and treatment that reduces infectiousness is very effective in controlling the spread of the disease.

4.4 Speculative studies

This area is based on speculative studies in the event that an effective HIV/AIDS vaccine is found which currently is not there though the latest findings in Thailand indicated that some vaccine for some strain of the HIV/AIDS virus has been obtained with an efficacy level of 30 percent. It is not known however that the vaccine acts as the "Leaky type" or as the "All or Nothing type" or both. We assume here that 40 percent of the susceptible are vaccinated and the vaccine acts both as the "leaky" type and the "All or Nothing" type of Vaccine. We begin by investigating the effects of treatment alone without vaccination then simulate for vaccination alone without treatment in a single graph to determine which of them would be more effective assuming that treatment alone reduces infectiousness by 50 percent, i.e $\beta_2c_2 = 0.09405$. The simulations are shown in Figure 4.
Figure 4: Graph of prevalence against time.

This model suggests that vaccination alone without treatment is more effective in controlling HIV spread using the vaccination and treatment parameters above.

4.5 The trade-off between vaccination and treatment

In the second step we simulate vaccination alone, treatment alone and a combination of the two within a single graph to determine whether a trade-off exists between vaccination and treatment. In this case we again assume that treatment reduces infectiousness by 50 percent as shown in Figure 5.

Figure 5: Graph of prevalence against time

We note that a trade-off seems to exist between vaccination and treatment using our parameter values for treatment and vaccination. We observe that vaccination alone is still more effective than a combination of treatment and vaccination implying that treatment would be counterproductive when applying vaccination.

4.6 Threshold Parameters

We set to numerically investigate the thresholds of the disease transmission rates beyond which treatment and vaccination is counterproductive by incorporating counseling in treatment. We assume here that counseling and treatment reduces infectiousness by 70 percent i.e. $\beta_2c_2=0.05643$. The graph appears as shown in Figure 6.
We observed that treatment and counseling that reduces infectiousness by 70 percent is equivalent to applying vaccination alone.

5.0 CONCLUSION AND RECOMMENDATIONS

We formulated a comprehensive HIV/AIDS transmission model with reference to the Kenyan situation and according to this model, we observed the following:

• If there is no intervention even at the current reduced rates of HIV/AIDS infection, our model predicts that we might get a lower proportion of adults in the population than those who are 15 years and below which would mean that we have more dependants than the workforce in the country.

• Treatment that does not reduce infectiousness is worse than when the treatment is not applied at all, however when coupled with effective counseling, then it is very effective in combating the spread of the disease and finally eliminating it.

• Our speculative studies for vaccination showed that careful considerations should be made when a combination of vaccination and treatment is to be applied because a combination of the two could be counterproductive or helpful depending on how it is implemented.

This study provides an in-depth mathematical analysis of a practical comprehensive HIV/AIDS transmission model for the transmission dynamics of HIV/AIDS with special reference to Kenya. It should be noted however that deterministic Mathematical modeling is more useful in predicting trends of diseases usually over longer periods of time but might not be very accurate in the short run because of changing circumstances.

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EMERGENCE OF NON-COMMUNICABLE DISEASES AND THEIR ECONOMIC IMPACT: A CASE STUDY OF KENYA

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ABSTRACT
Non-Communicable Diseases (NCDs) are the leading global causes of death, compared to all other causes combined. In Africa, NCDs are rising rapidly and are projected to exceed communicable, maternal, perinatal, and nutritional diseases by 2030. Kenya is faced with an impending epidemic of chronic diseases, with NCDs contributing about 32% total mortality rates. From 2005-2007, NCDs contributed over half of the top 20 causes of morbidity and mortality in Kenya. This study determined the leading causes of NCDs, economic impact of NCDs at household level and some recommended solutions to NCDs in Kenya. It used literature review and purposive interview targeting some stakeholders in healthcare industry and service provision. The leading causes of deaths due to NCDs included cardiovascular diseases (13%), cancers (7%) and diabetes (4%). Kenya recorded 779.6 and 575 NCDs mortality of male and female, respectively, per 100,000 deaths. Many chronic diseases contribute high economic and health cost towards treatment. They reduce productivity and drain resources of individuals, thereby aggravating poverty. Thus, country health-care systems should undertake interventions for individuals already with NCDs or at high risk of developing them.

Key Words: Economic, Healthcare, Mortality, Non-Communicable diseases

INTRODUCTION
Non Communicable Diseases (NCDs) are defined as diseases of long duration, generally slow progression and they are the major cause of adult mortality and morbidity worldwide (WHO, 2005a). Four main diseases are generally considered to be dominant in NCD mortality and morbidity: cardiovascular diseases (including heart disease and stroke), diabetes, cancer and chronic respiratory diseases (including chronic obstructive pulmonary disease and asthma). A key set of diseases not included on the list are mental illnesses – including unipolar depressive disorder, alcohol use disorders and schizophrenia, all major contributors to the economic losses stemming from NCDs. Also excluded are sense disorders such as glaucoma and hearing loss, digestive diseases such as cirrhosis, and musculoskeletal diseases such as rheumatoid arthritis and gout. These conditions impose private and social costs that are also likely to be substantial. Some diseases like musculoskeletal diseases can severely diminish one’s capacity to undertake manual labour, such as farming, which is the dominant productive activity in rural settings that are home to 50% of the world’s population. Moreover, the term NCD is something of a misnomer because it encompasses some diseases that are infectious in origin. In the social sphere, NCD risks are also shared – eating, drinking and smoking habits are powerfully influenced by social networks and thus defines lifestyle diseases.

Overview of the five major NCDs
Cardiovascular disease (CVD) refers to a group of diseases involving the heart, blood vessels, or the sequelae of poor blood supply due to a diseased vascular supply. Over 82% of the mortality burden is caused by ischaemic or coronary heart disease (IHD), stroke (both hemorrhagic and ischaemic), hypertensive heart disease or congestive heart failure (CHF). Over the past decade, CVD has become the single largest cause of death worldwide, representing nearly 30% of all deaths and about 50% of NCD deaths (WHO, 2011a). In 2008, CVD caused an estimated 17 million deaths and led to 151 million DALYs (representing 10% of all DALYs in that year). Behavioural risk factors such as physical inactivity, tobacco use and unhealthy diet explain nearly 80% of the CVD.

Cancer refers to the rapid growth and division of abnormal cells in a part of the body. These cells outlive normal cells and have the ability to metastasize, or invade parts of the body and spread to other organs. There are more than 100 types of cancers, and different risk factors contribute to the development of cancers in different sites. Cancer is the second largest cause of death worldwide, representing about 13% of all deaths (7.6 million deaths). Recent literature estimated the number of new cancer cases in 2009 alone at 12.9 million, and this number is projected to rise to nearly 17 million by 2020

Chronic respiratory diseases refer to chronic diseases of the airways and other structures of the lung. Some of the most common are asthma, chronic obstructive pulmonary disease (COPD), respiratory allergies, occupational lung diseases and pulmonary hypertension, which together account for 7% of all deaths worldwide (4.2 million deaths).
Diabetes is a metabolic disorder in which the body is unable to appropriately regulate the level of sugar, specifically glucose, in the blood, either by poor sensitivity to the protein insulin, or due to inadequate production of insulin by the pancreas. Type 2 diabetes accounts for 90-95% of all diabetes cases. Diabetes itself is not a high-mortality condition (1.3 m deaths globally), but it is a major risk factor for other causes of death and has a high attributable burden of disability. Diabetes is a major risk factor for cardiovascular disease, kidney disease and blindness.

Mental illness is a term that refers to a set of medical conditions that affect a person’s thinking, feeling, mood, ability to relate to others and daily functioning. Sometimes referred to as mental disorders, mental health conditions or neuropsychiatric disorders, these conditions affect hundreds of millions of people worldwide. In 2002, 154 million people suffered from depression globally, 25 million people from schizophrenia and over 100 million people suffered from alcohol or drug abuse disorders (WHO, 2011a). Close to 900,000 people die from suicide each year.

LITERATURE REVIEW
NCDs are currently the leading causes of death, disability and disease worldwide, except in sub-Saharan Africa. And WHO and the World Bank project that, while the major NCDs in 2001 accounted for nearly 60 percent of all deaths, this toll will rise to 73 percent by 2020(WHO,2012). Deaths from cardiovascular disease are predicted to rise from 17.1 million in 2004 to 23.4 million from 2030. Deaths from cancer are predicted to increase from 7.4 million in 2004 to 11.8 million in 2030. Non-communicable diseases were responsible for 68% of all deaths globally in 2012, up from 60% in 2000. The 4 main NCDs are cardiovascular diseases, cancers, diabetes and chronic lung diseases. Communicable, maternal, neonatal and nutrition conditions collectively were responsible for 23% of global deaths, and injuries caused 9% of all deaths. Similarly, according to the Global Burden of Disease analysis, which compares the burden of different diseases on the basis of Disability-Adjusted Life Years (DALYs), the burden from NCDs is expected to rise from the 46 percent recorded in 2001 to 57 percent by 2020. This means that the rank order of the global disease burden in 2020 will also substantially change: Ischaemic heart disease will become the leading cause of disease burden, followed by cerebrovascular and chronic obstructive lung disease, among other conditions. At the same time, many of the infections and nutrient deficiencies, including those that affect child survival, have already decreased, and will become even less prevalent. In 2005, an estimated 35 million people worldwide died from chronic diseases; this is double the number of deaths from all infectious diseases (WHO 2005). The world is experiencing an epidemic of non-communicable diseases (NCDs).

NCDs are an under-estimated cause of poverty and a barrier to economic development. Kenya, like most developing countries, is faced with an impending epidemic of chronic diseases, with non-communicable diseases contributing to about 32 per cent of total mortality rates (WHO, 2002). From 2005 - 2007, non-communicable diseases contributed over half of the top twenty causes of morbidity and mortality in Kenya (MOH, 2007). NCDs also contribute to half of the top ten leading causes of morbidity in the country (MOH, 2007). In 2002 mortality from communicable diseases was 68.2 per cent, while NCDs contributed over 31.8 per cent of total mortality (WHO, 2005). In 2007 non-communicable diseases contributed over 33 per cent of total mortality. Some of the causes of the rise in NCD fatalities are thought to be the following: a change in lifestyle – as the population surges towards urbanization, and away from rural areas; unhealthy eating habits; reduced physical activity as more motorized transport is used; and an increase in smoking and alcohol consumption.

Non Communicable Diseases risk factors
Non-modifiable risk factors refer to characteristics that cannot be changed by an individual (or the environment) and include age, sex, and genetic make-up. Although they cannot be the primary targets of interventions, they remain important factors since they affect and partly determine the effectiveness of many prevention and treatment approaches. A country’s age structure may convey important information on the most prevalent diseases, as may the population’s racial/ethnic distribution.

Modifiable risk factors refer to characteristics that societies or individuals can change to improve health outcomes. WHO typically refers to four major ones for NCDs: poor diet, physical inactivity, tobacco use, and harmful alcohol use (WHO, 2011).

Poor diet and physical inactivity. The composition of human diets has changed considerably over time, with globalization and urbanization making processed foods high in refined starch, sugar, salt and unhealthy fats cheaply and readily available and enticing to consumers – often more so than natural foods (Hawkes, 2006; Kennedy, Nantel,
and Shetty, 2004; Lieberman, 2003; WHO, 2002). As a result, overweight and obesity, and associated health problems, are on the rise in the developing world (Cecchini, et al., 2010). This spreading of the fast food culture, sedentary lifestyle and increase in bodyweight has led some to coin the emerging threat a “globesity” epidemic (Bifulco and Caruso, 2007; Deitel, 2002; Schwartz, 2005).

**Tobacco.** High rates of tobacco use are projected to lead to a doubling of the number of tobacco-related deaths between 2010 and 2030 in low- and middle-income countries. Unless stronger action is taken now, the 3.4 million tobacco-related deaths today will become 6.8 million in 2030 (NCD Alliance, 2011). A 2004 study by the Food and Agriculture Organization (FAO) predicted that developing countries would consume 71% of the world’s tobacco in 2010 (FAO, 2004). China is a global tobacco hotspot, with more than 320 million smokers and approximately 35% of the world’s tobacco production (FAO, 2004; *Global Adult Tobacco Survey - China Section*, 2010). Tobacco accounts for 30% of cancers globally, and the annual economic burden of tobacco-related illnesses exceeds total annual health expenditures in low- and middle-income countries (American Cancer Society and World Lung Foundation, 2009).

**Alcohol.** Alcohol use has been causally linked to many cancers and in excessive quantity with many types of cardiovascular disease (Boffetta and Hashibe, 2006; Ronksley, Brien, Turner, Mukamal, and Ghali, 2011). Alcohol accounted for 3.8% of deaths and 4.6% of DALY’s in 2004 (GAPA, 2011). Evidence also shows a causal, dose-response relationship between alcohol use and several cancer sites, including the oral cavity, pharynx, larynx, oesophagus, liver and female breast (Rehm, et al., 2010).

**NCD Mortality Today**

Today, coronary heart disease is the leading cause of death worldwide, responsible for 30 percent of all deaths; meanwhile, 79 percent of all chronic disease mortality is occurring in developing countries, according to WHO. In fact, for adults under the age of 70 in India, China and sub-Saharan Africa, the probability of dying from heart disease is already greater than for their Western peers. And developing countries face double jeopardy. Infants who survive malnutrition, infection and low birth weight appear to be predisposed to reduced stature, Type II diabetes, and a host of respiratory, musculoskeletal and cardiovascular conditions in adulthood. Urbanization is a major culprit in the NCD epidemic. More than half of the world’s population is expected to be urban by the next decade, with about 70 percent of this urban population – more than 2 billion people – residing in developing countries, according to a 2002 report by B. M. Popkin.

As economies develop, populations tend to migrate to urban areas. As seen in North America, Latin America, Central and Eastern Europe, and Asia, urbanization and affluence precipitate the adoption of the mistakenly called “affluent diet,” which is high in meat, fat and sugar, and often accompanied by a lifestyle involving alcohol consumption, cigarette smoking and little physical activity. While this transition and prosperity tend to reduce malnutrition, such diets and lifestyle pose their own health risks.

**The Double Risk: The “Affluent Diet” and Sedentary**

In fact, world trends in the past half-century demonstrate that as gross national product (GNP) rises, cereal consumption decreases and the intake of animal protein, animal fats, and added fats and alcohol increases. While the urban diet is generally more diverse than the rural diet and contains more micronutrients and animal proteins, it also has much less plant foods and fibre, and much more refined carbohydrates, processed foods, and saturated and total fat. In developing countries, NCDs tend to emerge at a younger age and initially appear among the affluent, as they are the first to embrace a “Western” lifestyle. Obesity and Type II diabetes are good examples of the challenges presented by NCDs around the globe. Almost one-sixth of humanity – 1 billion adults – are overweight, at least 300 million of whom are obese, according to 2003 WHO data. Today, more than 60 percent of American adults are overweight, with half of them obese, and obesity rates in American children have trebled over the last two decades, revealed a 2005 U.S. Department of Agriculture/Department of Health and Human Services report. Overweight and obesity pose a major risk not only of Type II diabetes, but also of cardiovascular disease, hypertension and stroke, and several forms of cancer. They lead to an overall reduction in the quality of life, and an increased risk of premature death. Even in many historically agrarian lower- and middle-income countries such as Mexico, Egypt, India and South Africa, obesity, Type II diabetes and cardiovascular diseases currently affect 25 to 50 percent of the population, according to studies by I. Aboderin and colleagues, and Popkin. Once predominantly a disease of the old, Type 2 diabetes has been increasing in all WHO regions, and striking younger people. And WHO projects that of the more than 300 million diabetics estimated by 2025, three-fourths will inhabit the third world.
**Disease Burden**

Although research on the global economic effects of non-communicable diseases is still in a nascent stage, economists are increasingly expressing concern that NCDs will result in long-term macroeconomic impacts on labour supply, capital accumulation and GDP worldwide with the consequences most severe in developing countries (Abegunde and Stanciole, 2006; Abegunde et al., 2007; Mayer-Foulkes, 2011; Nikolic, Stanciole, and Zaydman, 2011; Suhrcke, Nugent, Stuckler, and Rocco, 2006).

Globally, the labour units lost owing to NCD deaths and the direct medical costs of treating NCDs have reduced the quality and quantity of the labour force and human capital (Mayer-Foulkes, 2011). In the United States, men with chronic disease worked 6.1% fewer hours and women worked 3.9% fewer hours (Suhrcke, Stuckler, and Rocco, 2006). Pronk et al. found that a “healthy” lifestyle in the US working-age population reduced healthcare costs by 49% in adults aged 40 and above (Mayer-Foulkes, 2011).

For the developing world, a US Institute of Medicine (IOM) report on the macroeconomic impacts of cardiovascular disease and chronic diseases in a number of countries (Fuster and Kelly, 2010) suggests that the economic impact of CVD and related chronic diseases (such as diabetes and COPD) is large. Estimates ranged from an annual US$ 3 billion for direct medical costs of obesity-related diabetes, coronary heart disease, hypertension and stroke in China to US$ 72 billion for treatment of and productivity losses due to five chronic conditions in Brazil.

The rising tide of NCDs is increasingly affecting the quality of life of younger individuals who are of working-age. Consequently, the economic impact of NCDs is significant due to the combined burden of high healthcare costs of treating these diseases and lost economic productivity due to illness and premature deaths. In South Africa, whilst infectious diseases still predominate in terms of both morbidity and mortality, lifestyle related NCDs are becoming more prevalent, resulting in approximately one third of all deaths per annum. Data from medical schemes in South Africa confirm the increasing problem posed by NCDs. Since 2008, there has been a significant increase in the number of medical scheme members living with one or more chronic conditions. The cost of treatment of chronic diseases has also risen significantly over the past five years.

**NCDs Socio-Economic effect on Kenya**

Kenya is experiencing increase in diabetes, heart disease, cancer, chronic lung, neurological, psychiatric diseases and injury even before communicable diseases like malaria, HIV and tuberculosis have been brought under control resulting in “double burden of diseases”. The following graphs show estimated mortality proportion by Sex in 2004.
METHODOLOGY AND OBJECTIVES OF THE STUDY
This paper seeks to find the leading causes of NCDs in Kenya as well as the economic impact of NCDs at household level and finally study some of the recommended solutions to NCDs in Kenya. The paper uses secondary literature review with key words defining the various sections and sub-sections of the case study. Reviewing of WHO publications, professional society journals and websites Centre for Disease Control and presentations from National NCDs Centre of Kenya. The researcher also sought the opinions and views of some of the stakeholders in healthcare service industry and service providers.

FINDINGS
This papers’ finding was basically based on qualitative results by establishing some of the associated economic impact of NCDs at household level. Non communicable conditions represent an increasingly significant burden of ill health and death in the country and include cardiovascular diseases, cancers, and respiratory diseases, digestive diseases, psychiatric conditions, and congenital anomalies, amongst others. They represented 50–70% of all hospital admissions and up to half of all inpatient mortality in Kenya. This is because an aging population and lifestyle changes linked with economic development increase the risk factors for NCDs such as heart disease, cancer, chronic obstructive pulmonary disease and diabetes. The true picture of the national burden of NCDs (their social, economic and health costs) is still unclear, where diabetes contributed about 27.3 per cent of the total admissions. The cost of NCD at household level can be divided into two types:

Direct costs:- are those costs related to the treatment and management of the diseases e.g. running of clinics and hospitals, salaries for healthcare personnel, medications, rehabilitation where available, and medical supplies and testing, the patient’s time used to seek care.

Indirect costs include:- loss of income results from lost productivity or employment due to major disabilities, such as stroke or heart failure. The loss of future earnings from assets that are sold off for chronic and/or catastrophic care, loss of income from other family members who must provide care. Households and individuals also bear indirect costs when they are affected by NCDs. These costs mainly include time and productivity loss by patients and caregivers because of the illness as well as income lost by patients and family members. Whereas there is no doubt that these indirect costs can pose a substantial burden on households, there are numerous methodological challenges in measuring this burden adequately

RECOMMENDATIONS
Prevention avoids the high cost of NCDs. Behavioural change mechanisms like creating NCDs awareness through community participatory approaches like empowering health workers through training, community screening to allow early detection of NCDs, creating linkages with corporate organizations and the promotion of healthy nutritional lifestyle. Since NCDs are not being addressed, chronic diseases have not received the priority attention in public health policies and programmes, commensurate with their disease burden. Over emphasis of communicable disease prioritising infectious diseases such HIV/AIDS is an alarm that NCDs should also be given priority.

<table>
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<tr>
<th>Illness</th>
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<th>Economic consequences</th>
<th>Coping strategies/ Social resources</th>
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<td>Non- Communicable</td>
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<td>Diseases</td>
<td>Indirect Cost</td>
<td>Loss of working time of person who is ill and giving care</td>
<td>Intra- and inter- household labour substitution</td>
<td>Reduced well-being and increased financial vulnerability for individuals and households</td>
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<td>Loss of income of person who is ill and caregivers (due to absenteeism, missing business appointments, etc.)</td>
<td>Hiring other labour and other strategies</td>
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<tr>
<td>Direct Cost</td>
<td>Financial costs of health care (consultation, medicines, laboratory, hospitalization, etc.)</td>
<td>Reducing/delaying consumption of non-health goods and services (food, education, electricity, leisure, etc.)</td>
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<td>Other financial costs related to seeking care (transportation, special dietary regimes, etc.)</td>
<td>Use of savings</td>
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<td>Sale of assets</td>
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<td>Other strategies to cope with financial costs (assistance from others, etc.)</td>
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Figure 3: Framework Analysis of Economic effect of NCDs on Households
Monitoring NCD and their determinants provides the foundation for advocacy, policy development and global action. Monitoring is not limited to tracking data on the magnitude of and trends in non-communicable diseases, it also includes evaluating the effectiveness and impact of interventions and assessing progress made.

CONCLUSION
It is important to reiterate that, for several reasons, the various methods for estimating the economic burden of NCDs yield results that are not comparable to each other. It is equally important to highlight the fact that implementing each of these methods required us to make numerous assumptions – assumptions that can be challenged and that we cannot test. Nevertheless, the results presented here give a sense of the magnitude of the economic burden of NCDs. Further refinement of methods, and better data, will be needed to obtain a more reliable sense of the cost of NCDs. Understanding these costs is crucial in judging the priority of addressing NCDs. However, what comes out clearly in the paper is that prevention of NCDs would go a long way in prolonging the lives of people. Some of the lifestyles causes of NCDs include smoking, leading an inactive life, poor eating habits. Behaviour change would play a key role in addressing these issues and therefore better lives which would include investment of resources which would otherwise go to treat NCDs!

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ABSTRACT
The education system in Kenya has undergone tremendous changes over the last decade ranging from the introduction of Free Primary Education, changes in the secondary school curriculum, increased school enrollment, creation of more universities and colleges and the introduction of Information Communication Technology (ICT). Of these reforms, the most notable is how ICT is revolutionizing education through E-learning, Digital Content and specialised computer packages for teaching. Of late, Geography seems to be recapturing its place as a discipline by demonstrating its relevance to the world of everyday reality and towards the development of understanding of both social and natural sciences. At the centre of this is Geographic Information Systems (GIS) which is creating avenues to cultivate a spatial perspective within diverse curricula and by extension encourage a return of geography in institutions which lack it as a formal course of study. As a tool, GIS can be used for display, inquiry and analysis in problem-based learning. It is therefore envisaged as an invaluable resource for use in extending a learners’ understanding of Geography by allowing for the visual illustration and manipulation of major concepts of the discipline. Despite the increased growth of GIS in Kenya, its use in teaching and improving quality of Geography education in secondary schools is minimal, if any. This paper provides the rationale and background for calling attention to: build awareness for GIS in schools by reviewing the current state of Spatial Information Education in Kenya, roll out GIS in institutions, and challenges and opportunities of promoting Geospatial Technologies in learning by emphasizing the importance of interdisciplinary collaborative partnerships between the event sponsors and the research community.

Key words: Awareness, Collaborative Partnership, Geography, GIS, Problem-based learning, Spatial Perspective

INTRODUCTION
As Kenya strives to become a middle income nation by the year 2030, Science and Technology are now receiving mainstream attention with focus shifting to the use and adoption of Information and Communication Technology (ICT) in all human activity and specifically in Education. In a world where data-rich visualizations, location-based services and geospatial tools are everywhere thing, spatial literacy is becoming a marketable asset. At the core of all these is geography which has played a major role in advancing spatial literacy termed as the ability to visualize and interpret location, distance, direction, relationships, movement and change through space. The Concepts of Space are central not only within geography but also in Physical sciences, natural sciences and social sciences. Geographic Information Systems (GIS) is generally viewed as an excellent information technology tool for promoting higher-order thinking skills such as decision making and problem solving (Longley et al. 2005). GIS is a system of hardware and software used for storage, retrieval, mapping, and analysis of spatially referenced geographic data and therefore is an important technology tool for teaching geography (Kerski 2003; Wiegand 2001).

The inquiry based nature of GIS application is lauded as offering real-world contexts in which students may develop geographical knowledge and skills (West, 1998; Turner and Beeson, 2003). GIS creates the environment for real world learning, which can be both multidisciplinary and interdisciplinary therefore extending its potential for use in teaching of a variety of disciplines. The irony in the Kenyan case however, is that the current approaches do not foster a spatially infused learning where Geography and Geographic Information Systems are integrated together to help visualize knowledge, solve problems and understand relationships within a spatial context. However, the ongoing reforms in Kenya’s education system provide an opportunity to integrate GIS technology into schools given its importance in the teaching-learning process. Even with this opportunity, the challenge is how can we create the need and Awareness for GIS in Secondary schools where it remains a relatively new idea? To address this question the paper will give an overview of the current state of spatial information education, the prospects of rolling out GIS and finally a look at the challenges and opportunities of incorporating GIS into secondary school curriculum.
State of Spatial Information Education in Kenya

Education is primarily the responsibility of the state with the respective government through the ministry of Education (MOE) providing the necessary regulations, curriculum and policy for both public and private schools. All schools are expected to adhere to the approved syllabus and curriculum irrespective of whether they are public or private institutions. Schooling in Kenya consists of pre-primary education (4-6years age), Lower primary (Class 1 -3) Upper Primary (Class 4-8), Secondary level (Form 1-4) and Tertiary level (4years). Since the year 2003, primary education was made free and universally accessible to all people. On the other hand, secondary education has been made affordable and form the bulk of elementary basic education in the country. The study of geography is an important part of education as it provides students with a holistic view of the world, combining the natural and social sciences. Students taking geography gain the understanding, knowledge, and skills necessary to make sense of complex issues facing humanity in this 21st Century such as climate change, drought, aging populations, urban growth, ethnic conflicts, and globalization (National Committee for Geography, 2007). Geography in Kenya however is not compulsory and therefore lacking in many secondary schools and in those schools offering it, minimal number of students enrolling for the subject is discouraging. In primary schools, geography is rendered as social studies contextualizing on the general social environment and human activities on that space. In all these cases, learning is usually theoretical and lacks objective-field work research restricting students to excursions which deny them problem-solving skills, spatial thinking and an opportunity to participate in society.

In higher education, the situation is somehow different since geography has a higher profile especially in the country’s oldest universities where formal academic geography departments have been set up and degrees in geography offered. Despite the fact that geography can foster spatial information education in the region, it has been neglected in many of the existing pioneer universities. For example, only five out of more than twenty universities operating in Kenya offer either BA or B Sc degree in geography or have fully developed geography departments. Those universities without geography programs are offering bachelor of Education Arts degrees and by this contributing to geographic education by training graduate teachers choosing geography as one of their teaching subject. According to Commission of University Education (CUE), Kenya, Public and Private chartered Universities offering geography degrees programs are University of Eastern Africa, Baraton, Catholic University of Eastern Africa, University of Nairobi, Moi university, and Kenyatta University.

Spatial information education is multi-disciplinary and covers a wide range of activities and disciplines. Kenya has only a few institutions offering education and training on surveying, mapping and associated disciplines and includes: The University of Nairobi, the Technical University of Kenya, the Kenya institute of surveying and mapping, regional centre for mapping of resources for development and Jomo Kenyatta University of agriculture and technology (Gachari, 2001). In this paper Spatial Information education encompasses GIS and Geography since they are easy to mount in most of the universities because of the already developed support infrastructures. The rapidly evolving geospatial landscape in Kenya today has led to the increasing swell of geographic awareness with many of the upcoming universities mounting degree programs in Geospatial Science, GIS and Remote Sensing, Geomatic Engineering and Geo-Informatics among others. This is indicative of the increased learning and knowledge pool the country is experiencing as the demand for Geospatial Skills is on rise in the areas of education, government and Non governmental Organizations, Business and community.

Prospects of rolling out GIS into Secondary schools

GIS has not been introduced to secondary school geography education in Kenya. Incorporating GIS into secondary education will help teach students relevant skills in spatial analysis, reasoning, and data processing (Alibrandi, 2003). Many schools are introducing computer classes and labs which form a good entry point for GIS education. Additionally, the high school geography curriculum textbooks contain topics which can be taught with GIS such as photography and fieldwork, Environment, Weather and Climate. Fieldwork is one of the interesting aspects of geography because it enables students to conduct research and do a comparative study of other areas (Milson.A. et al, 2012). As a prerequisite for Secondary geography syllabus, students should go for at least one fieldtrip during their four years of schooling. This presents an opportunity to integrate geospatial tools such as GPS, Google Earth and GIS into fieldwork. In fact the area of fieldwork forms the best background to introduce GIS into geography education as it forms a link between theory and reality helping students learn more about their own community, identify problems and propose suitable solutions. The prospects for GIS to flourish are ripe given the many GIS user conferences organized annually by ESRI Eastern Africa in the region. These forums have opened avenues to create awareness and the need for GIS among the students and how it is going to help them in their day-to-day life.
Most universities offering education programs are training geography teachers who are becoming interested in GIS for Education. This is because GIS is taught as a course unit to students training to be geography educators. This makes it easy to introduce GIS in the pre-collegiate levels leveraging on the initial awareness created to the in-service teachers during their university education. The trend is promising due to the increasing number of universities running degree programs in bachelor of education arts. Currently the number of in-service teachers enrolling for masters’ degree in Geography is increasing partly due to the rising demand for people with geographic knowledge. For example, Chuka University which is one of the newly chartered public universities in Kenya has admitted more than over 37 students into its master’s of Arts Geography program since the year 2011 to date. The diversity of courses having a GIS and remote sensing component being offered to both undergraduate and postgraduate students in this university (Geo 702: Geographic Information Systems, Geo 425: Remote sensing and Geo 0222: Aerial Photography and Remote Sensing) attest to the potential for spatial information education to thrive in Kenya. The better part is that some students while on teaching practice are experimenting with the concepts, skills and knowledge about geospatial techniques they have gotten during their training.

**Case Study: Geography Awareness Week and GIS day at Chuka University**

In 1987 the then U.S. President Ronald Reagan signed legislation that established the third week in November as Geography Awareness Week (www.geographyawarenessweek.org). The Week seeks to promote geographic education in schools and among the public through knowledge sharing. As an outgrowth, GIS Day is held on the Wednesday of Geography Awareness Week and seeks to encourage Geographic Information Systems (GIS) users and vendors to showcase to schools, businesses and to the general public real-world applications of this valuable technology. In Kenya the events are gaining popularity in universities due to the well established support infrastructures and industry partnerships. The case of Chuka University is unique because it was the first time Geography Awareness Week was hosted in a university without geography or geospatial science degree programs. For the past two years since 2012, Chuka University in partnership with ESRI Eastern Africa has successfully hosted GIS day event to create general awareness for Geography and GIS in Education and Administration.

This event is now proclaimed annually in line with the GIS day international calendar as an important academic activity within the department of Arts and Humanities at Chuka University. The seminar has helped introduce geospatial technology to the students and teachers providing a way to address the issues of geography standards, job market skills matching and how to teach with GIS in classrooms. GIS is no longer a new concept anymore as students can relate the term to the number of activities carried out during the event such as GIS software demonstrations, presentations, mapping projects, field excursions and school visitations. The number of the students attending the GIS day celebrations has increased gradually since 2012 when the event was first hosted in the institution. During our first event held on 14th November 2012, a total of 57 students taking geography as a teaching subject from bachelor of education Arts degree program turned up later increasing to over 200 students in the year 2013 drawn from different disciplines such as; environmental sciences, wildlife management, security studies and journalism. The case study showed that there is a growing interest for GIS among university students and lecturers because of its spatial analytical capabilities and excellence data presentation methods. However, most students who attended the workshop lacked spatial perspective and problem-solving constructivist learning style which hinder the use of GIS in real life situations. To address this challenge, the Geography Students Association whose motto reads “rediscovering geography education for a spatially literate society” was formed with an objective of increasing awareness for the need of geospatial skills among teachers, students, schools calling for increased support for GIS in schools and universities.

Chuka University has set up a multi departmental GIS Lab and has just procured a multi seat Arc GIS 10.1 Desktop teaching lab kit from Esri Eastern Africa as a move to infused spatial thinking among its graduates. All these efforts are a move to create multi-disciplinary career pathways that are increasingly in demand in the 21st century. It has been argued in many academic circles that GIS will help students think critically, use authentic data, and connects them to their own community (Bednarz, 2004; Kerski, 2008). At a regional scale, GIS is gaining recognition as a vital tool for teaching and learning. This is exemplified by the recent inauguration of the annual Education GIS user Conference by Esri Eastern Africa as it seeks to promote and strengthen sharing of experiences from educators, students and institutional administrators on how Arc GIS software products are impacting universities teaching, research and training in East Africa (www.esri ea.co.ke). For GIS to take hold in Kenya there is need for more awareness creation to ensure diffusion of these cutting edge geospatial techniques. The participants should also be drawn from informal education (museums, libraries, afterschool clubs, outdoor programs, and elsewhere) formal education (primary, secondary, and university-level), and in career and technology-training centers because of the varying cultures and education context (Esri, 2010).
Challenges and opportunities of promoting GIS Education

With the increasing recognition of the importance of spatial thinking skills, geography is slowly finding its place in education. More employers are coaching for graduates with geographic knowledge as the concept of “space” is becoming an important consideration in decision making. As a subject, geography has a great impact in influencing the choice of careers and degree courses in universities, putting geographers in a lime light where they are surely being appreciated. A niche for geographers is slowly emerging in academic and professional fields where the call for geographic action is their contribution in helping the return of geography in schools through proclamation of GIS days, mentorships to GIS and Geography School clubs and development of GIS teaching resources. The decentralization of education to counties opens yet another avenue to advocate for the inclusion GIS education in secondary schools by building on the fact that there exists a base to foster curriculum change and also for introducing GIS as part of the drive toward the use of ICT in schools. It is true that integrating GIS technology into secondary schools education can aid students’ abilities in problem solving, critical thinking, and communications (Baker and White, 2003). The foreseeable challenges of integrating Geospatial technologies into learning are:

- How to sell GIS as a part of the high school geography curriculum given the standard national secondary education leaves no room for changes to be made on topics which can be taught with GIS.
- Lack of computer labs with GIS soft wares is a major impediment to the set up and implementation of GIS in schools. This technical constraint manifests itself in form of software and data availability.
- GIS education is lacking in the training of secondary education teachers because it is not part of the secondary curriculum. This means there currently few teachers with hands-on- experience GIS Education
- The level of understanding of GIS education by Secondary school teachers and ministry of Education officials is lacking making it difficult to introduce GIS in schools.

GIS education suffers from similar issues as geography education (Lambert, 2010). Despite these challenges, GIS will play a more important role in education and development of counties and the nation at large. The implementation of GIS education in Kenya can be realized if the training for geography teachers is strengthened and that the importance of GIS should be well understood by teachers before use in the classrooms (Bednarz, 2004; Demirci, 2009). Similarly, Secondary schools and universities should establish a spatial data library and design GIS exercises as a part of the geography curriculum (Keiper, 1999). Important of all, free Web-based applications such as Google Earth could be the starting points for introducing GIS into secondary schools (Wiegand, 2001).

As the world become one seamless globe, sharing and interactions are inevitable in this technology savvy generation where Information and Communication Technologies seem the only way to bridge the digital divide. There is a substantial growing need for institutional collaboration and partnerships with GIS industry players if the dream of implementing GIS in Kenya’s education sector is to be realized. True to this statement is the fact that GIS as a subset of Geospatial Technologies is rapidly evolving with better and more power full GIS software releases find their way into the market annually. Without working together with both the universities and GIS industry the taught Geo-spatial skills in these institutions will likely not match the market needs especially in this changing world of GIS applications occasioned by better geospatial tools and knowledge

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CULTURAL DIPLOMACY AS SOFT POWER: A COMPARATIVE STUDY OF CHINA AND SOUTH AFRICA 1990-2010

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ABSTRACT

Cultural diplomacy carries a set of prescriptions which are material to its effectual practice such as unequivocal recognition and understanding of foreign cultural dynamics and observance of the tenets that govern basic dialogue. Individual nations commonly use cultural diplomacy to improve international relations and secure agreements that cover issues like trade, investment, immigration and security. The continued evolution of cultural diplomacy depends on behavioural economics of its adherents, as people develop better understandings of each other and new mediums of dialogue. Emergence of globalization carries with it cultural erosion which directly affects relevance of cultural diplomacy, a prevalent culture would remove the need for cultural recognition and understanding, if all people identified with a common culture. This study was based on the search for better ways of relations between states other than the previous domination of hard power use. With the growing trend of countries ‘looking-east’ it is definite that China’s growth has caught the attention of the world. This paper identified why it could be attributed to their intense effort in soft power and cultural diplomacy. The study examined cultural diplomacy as a form of soft power, and how it affects foreign policy and inter-state relations. The framework used was theory of idealism, which helps explain why soft power is more effective than hard power. It uses two case studies: China and South Africa. This study concluded that cultural diplomacy as a form of soft power not only boosts relations but also economies.

INTRODUCTION

Cultural diplomacy specifies a form of diplomacy that carries a set of prescriptions which are material to its effectual practice; these prescriptions include the unequivocal recognition and understanding of foreign cultural dynamics and observance of the tenets that govern basic dialogue. Milton C. Cummings Jr draws out the meaning of these cultural

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dynamics in his description of cultural diplomacy as,” the exchange of ideas, information, art, lifestyles, values systems, traditions, beliefs and other aspects of cultures.”

Cultural diplomacy can be practiced by any number or combination of adherents. Owing to this nature, the roots of cultural diplomacy can be traced back to the very beginnings of human exchanges in dialogue. However, cultural diplomacy conducted by governments and rulers of nations often have the greatest effects on the lives of ordinary citizens and provide the most comprehensive records of its use.

Individual nations commonly use cultural diplomacy to improve international relations and secure agreements that cover issues like trade, investment, immigration and security. The continued evolution of cultural diplomacy is dependent on the behavioral economics of its adherents, as people develop better understandings of each other and new mediums of dialogue.

The development of new technologies has arguably had the most profound effect on the conduct of cultural diplomacy. The advent of multimedia technologies including telecommunication, electronic mail, VoIP and audio video conferencing has made it possible for adherents to conduct cultural diplomacy. The emergence of globalization carries with it the emergence of what can be described as a prevalent global-culture which has the potential of eroding the cultures it comes into contact with. Cultural erosion directly affects the relevance of cultural diplomacy, as the establishment of a prevalent culture would remove the need for cultural recognition and understanding, if all people identified with a common culture. This study aimed at understanding the tenets of cultural diplomacy, how it has been successfully used by states to promote their foreign policy and why it has not been so successful for other states.

**Soft power Versus Hard Power**

The use of hard power and soft power has had effects on people’s lives as well as states. Hard power use has resulted to destruction of lives and property, while soft power has influenced states to seek more amicable and friendly ways of relating with each other.

Over the years, states have interacted with each other in the quest for satisfaction of national interests. In this struggle states have formed alliances and organizations to seek support and strength. Realism as the predominant paradigm in international relations is most visible in the states interactions with each other. This is due to some states seeking to have influence and power over each other to achieve national interests. States are constantly investing in their economic strength, military strength and political strength. The strong states are often ready to go to war or use threats to make other states comply with their interests. The emergence of hegemonies or superpowers has led to unipolar and bipolar kinds of international systems. Such could be seen during the world wars and the cold war period, where hard power was predominantly used.

This not only led to colonialism but also to loss of lives and deteriorating economies. States that were colonized have taken long to get back on their feet to restructure their economies. Use of hard power led to loss of lives, properties, freedom, and even esteem. Most of these states are still regarded as third world countries. These states rely on donors from strong states and are constantly in debts with major powers. This makes them be reliant on other states and thereby still be under their rule indirectly. When there is too much hegemony there effects felt in almost all areas of life.

This paper examines the contemporary China and South Africa and how they have preserved their cultures in rebellion to western influence after years of war and apartheid and how they have resulted to using soft power to promote their foreign relations.

**China’s Soft Power**

From the onset, in the foreign policy of china, there is advocacy of soft power use this is by peaceful co-existence. While China has moved increasingly towards a market-based system, the principle of noninterference in the internal affairs of others remains constant, with the consequence that China’s aid to Africa is unconditional.² China believes that upholding noninterference and offering unconditional aid are important to its principles to develop lasting relations with Africa. The Five Principles of Peaceful Co-existence are mutual respect for sovereignty and territorial integrity; mutual non-aggression; noninterference in each other’s internal affairs; equality and mutual benefit; and peaceful coexistence.³

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3  Ibid p. 40
It is worth noting that China has really bought her way through Africa the hard way. There is no other country that is investing in developing the third world states currently like China is. China is building roads, constructing railways, developing mining, and giving scholarships among other things. China has really worked hard to be acceptable to the developing states considering that it has been enclosed from the world for many years, now it has to actually teach people Chinese because few know the language in the first place. As a state she could not be able to penetrate African market if the language is a barrier.

Directly, China has used cultural diplomacy through the many events and functions she has hosted like the Shanghai Expo, the 2008 Olympics, the Miss World Competations and the FOCAC among many other means like the Confucius Institute. This is helping bring China to good world light as states are able to know more about China and interact with her people. During the FOCAC meeting in Beijing the African leaders who went were met by slogans on bill boards praising Africa outside the venue. That alone is using soft power to impress other states. China has taken advantage of where the western powers had failed and is utilizing every chance to penetrate the world market.

**South Africa’s Soft Power**

Having suffered racism, South Africa has been in the fore front to advocate for human rights. The Ubuntu philosophy is meant to promote good relations and respect for other humans. It has been discussed earlier that South Africa used cooperation strategies to promote anti-racism. South Africa has been in the fore front of regional integration. This has been through the formation of intergovernmental organizations like SADC and international organizations like the AU. South Africa is said to have used cooperation strategies to bring people together during apartheid, this was also through soccer. Soccer is at the heart of the South Africans. Hosting the FIFA 2010 was a major privilege, and they did not hesitate to take pride in it. The Vuvuzela (South African horn) became known world wide as well as South African music heard. The country has taken the spirit of soccer to promote relations with other states especially her neighbours. She has funded soccer projects in states like Mali.

**The relationship between China and South Africa**

**Common Backgrounds**

He Wenping says that both China and Africa have a common sense about human rights and sovereignty, meaning that the Chinese government sees an abiding cultural and political context based on historical experience felt by both the Chinese and the Africans. Examination of China’s diplomatic focus on Africa and historical context in which China’s African policy emerged reveals a deep relationship based on common experiences, values and principles.

More to the past wars and economic strains the two states have both suffered under the hegemony of the west countries, the previous superpowers when the world was having bipolar and unipolar systems. This has led to the two states and other pro-South-South states to have ties to basically counter the existing superpowers. As Wen Jiaobao, Chinese premier said at the China-Africa cooperation in Addis Ababa 2003 that hegemony of the west is raising its ugly head and that Chinese ties with Africa would be to counter that hegemony.

**Trade, economic and investment asymmetry**

Due to the advancement in technology and development there is more trade on China’s side. According to Broadman, China along with India invests more in Africa than Africa invests in China. It is imperative that both sides of this promising South-South economic relations address asymmetries and obstacles to its continuous expansion through reforms.

Economically, the growth in two-way trade and investment since the start of diplomatic relations in 1998 has allowed SA to diversify its commercial relations away from their traditional northern axis, but it has not been without its challenges. Trade between the two replicates traditional North-South patterns, where South Africa largely exports raw materials and imports manufactured goods. One way to diversify South Africa exports to China is through the removal of non-tariff barriers that are holding back the export potential of other.

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5 Ibid
According to Ana Cristina Alves, China Research Fellow and Elizabeth Sidiropoulos national director at the South African Institute of International Affairs in Johannesburg, the economic relationship of the two states is assymetrical. China’s global competitiveness makes it difficult for South Africa, with its high-cost structure in some sectors, to compete. South Africa’s reluctance to proceed with a free trade agreement with China reflects concerns about the threat it may present to the survival of the local labour-intensive industry (namely textiles and clothing), although a recent study by the Trade Law Centre indicated that expected losses (fall in employment, wages and manufactures production) would be largely offset by gains in other sectors with a stronger competitive potential (chemicals, plastics, non-ferrous metals, machinery). SA’s decision to implement its own industrial strategy to address the erosion of its industrial base and job losses is also an important factor.

Chinese investment in South Africa is smaller than South Africa’s into China. Despite the strong Chinese appetite for South Africa mining resources and the attractiveness of its open market, South Africa’s significantly more complex socio-economic structure (with strong labour unions and a large industrial base) compared with other African countries, has largely constrained the expansion of Chinese interests in Africa’s largest economy. In 2008 discussions between the two states focused on negotiating a Partnership for Growth and Development, which would include market access for value-added and beneficiation products from South Africa. As of 2010, China was South Africa’s largest trading partner. In March 2009 business deals worth more than R2.3 billion were signed. These included SA supplying more goods to China, including mohair, fish, wine, wool, copper, manganese, granite blocks and ferrochrome. The Comprehensive Strategic Partnership signed in Beijing on August 2009, the first of its kind ever put forward by China with another country, recognises the need to address these issues going forward.

In the recent years, there has been successful investment of Chinese enterprises in South Africa, the case is also dazzling. In the past few years, ZTE and Huawei, and some other Chinese companies have had outstanding success in South Africa, Chinese enterprises invest and build factories, and select companies in South Africa as the headquarters of the African continent. China Steel Group is South Africa’s largest Chinese companies, which in 2008 committed to Limpopo Province, South Africa, 400 million U.S. dollars of new investments. With this growing trend there seems to be likeliness that many Chinese companies will enter the African market South Africa as a base, and the use of local enterprise network quickly into the African continent.

In 2008, China Industrial and Commercial Bank of China, South Africa, Standard Bank acquired a 20% stake, worth 5.5 billion. In July 2009, China Construction Bank’s second-largest banking group in South Africa - South Africa’s First Rand Bank signed a strategic cooperation memorandum of understanding aimed at expanding the two sides in consulting, finance, investment and other areas of practical cooperation. The collaboration is aimed at focusing on the joint for the relevant provision of advisory and financing services to customers. In addition, the China-Africa Development Fund has opened an office in South Africa, the fund created by the Chinese government to encourage Chinese enterprises to invest in Africa, and it is currently in South Africa for power and alternative energy-related projects to provide assessment of the financing. No doubt that China determined to penetrate the African market.

South Africa’s investments in China are also growing. For example, South Africa, Standard Bank and Industrial and Commercial Bank of China set up a joint venture, by the end of 2009, Sasol (Sasol Synfuels International, Inc.) and the Shenhua Group and other large Chinese companies co-operation coal-oil investment, South Africa’s rainbow mining company, Anglo-American is also active in China and other South African companies.

In December 2010, South Africa was invited to join China in BRIC group of emerging economies. With the invitation,  

9 http://www.algorithm.seks-anonse.pisz.pl/p-People%27s_Republic_of_China_%E2%80%93_South_Africa_relations.html
12 Ibid
13 Ibid
it was expected that South Africa would expand its trade relations with other BRIC countries, including China.\(^{14}\) The two states’ relationship is based more on the principles of sustainability and mutual benefit rather than charity, aid projects are both stable and inherently equal, whereby China’s aid to Africa is not one of a “superior” providing for an “inferior” but rather of one developing nation assisting another.\(^{15}\)

China’s bilateral trade with South Africa grew to over R40-billion in 2005, with SA’s exports to China growing from R7.85-million in 1996 to well over R8.5-billion in 2005, and imports surging from R2.4-million to R31.5-billion over the same period.\(^{16}\)

China is looking to further cooperation with Africa both horizontally and vertically – to increase interaction between China and Africa at a multitude of political, social and cultural levels while also expanding economic cooperation beyond traditional sectors to all areas of commerce, industry and technology.\(^{17}\) Both states have been in the front line of promoting South-South cooperation.

**High Level Exchanges and Visits**

This paper explores also the visits made by officials of both governments to enhance relations as a form of cultural diplomacy and soft power. The visits though friendly brought about economic benefits, which in most cases yielded cooperation for mutual benefits.

By 2005, cooperation in culture, science and technology, education, tourism and other field made rapid progress. A grand cultural event entitled “Bravo China --- Chinese Cultural Tour to Africa” staged in South Africa successfully in 2004. A series of culture activities named “Experiencing China” will take place in South Africa later this year. The Confucious College (Chinese Language Center) was established at Stellenbosch University. There are currently 3000 Chinese students studying in South Africa. Since South Africa was granted Approved Destination Status for out-bound Chinese tourist groups in 2001, more and more Chinese sightseers have traveled to South Africa.\(^{18}\)

Talks between Foreign Minister Nkosazana Dlamini-Zuma and her Chinese counterpart, Foreign Minister Yang Jiechi, in Pretoria in January 2008, South Africa and China, who were celebrating 10 years of diplomatic relations, are to strengthen these further through the establishment of a strategic dialogue mechanism. The strategic dialogue mechanism will focus on boosting cooperation and support between South Africa and China in the economic, trade and political spheres.

Dlamini-Zuma said that it was the Beijing Olympics this year in China, and in 2010 it would be the Fifa World Cup in South Africa. “The year 2010 will be a big year for both of us, as it is also the 2010 World Expo in China, which South Africa hopes to participate in.” Yang said the last decade had seen “rapid progress in our relations … and this is indeed a partnership of strategic importance.” His visit to SA forms part of a four-nation which includes the DRC, Ethiopia and Burundi. “The China-Africa Cooperation Forum is witnessing good progress,” Yang said, with China committed to an eight-point programme that includes increased debt relief, certain tariff exemptions and increased aid for the continent. For the first time in China’s diplomacy, released *China’s African Policy*. In April and June, President Hu Jintao and Premier Wen Jiabao visited 10 African countries respectively. At the end of 2006, the Forum on China-Africa Cooperation (FOCAC) and the first Chinese and African leaders’ summit was successfully held in Beijing. Early in 2007, in order to implement the achievements of the summit and promote concrete cooperation between China and Africa, President Hu Jintao set foot on the African continent for the second time in nine months, visiting nine countries in Africa.\(^{1}\) In 2007, President Hu Jintao completed his 8-country tour of Africa.\(^{2}\) Countries visited were: Cameroon, Liberia, Sudan, Zambia, Namibia, South Africa, Mozambique and the Seychelles.\(^{3}\) The year 2010 marked the height of China-South Africa cooperation characterized by many high-level visits and agreements. The following are excerpts form a report by the Ministry of Foreign Affairs of the People’s Republic of China.\(^{4}\)

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\(^{15}\) He Wenping. The Balancing Act of China's Africa Policy. Op cit. p 33


\(^{17}\) He Wenping. The Balancing Act of China's Africa Policy. Op cit. p 36

\(^{18}\) Chinese Embassy in South Africa (2006/06/12) Ever Deepening China-South Africa Strategic Partnership.
From 28 March to 1 April 2010, CPPCC Chairman Jia Qinglin paid a visit to South Africa and met with South African President Jacob Zuma and held talks with Chairman of the National Council of Provinces of South Africa Mninwa Mahlangu. Chairman Jia Qinglin attended the China-South Africa Economic and Trade Cooperation Forum in Pretoria, the administrative capital of South Africa, and delivered a speech entitled “Deepening Economic and Trade Cooperation to Achieve Mutual Benefit and Win-Win Results”. Chairman Jia also attended the China-South Africa commodity purchase contract signing ceremony. The total contract value was more than US$300 million.

Vice President Xi Jinping paid a visit to South Africa from 16 to 19 November 2010. He met with President Zuma and Speaker Sisulu in Cape Town, the legislative capital of South Africa, held talks with Vice President Kgalema Motlanthe and co-chaired the fourth plenary of the China-South Africa Bi-National Commission (CSABC). Vice President Xi and Vice President Motlanthe attended the signing ceremony of four documents regarding cooperation between the two sides in energy, trade statistics, banking regulation and supervision and other areas. In Pretoria, Vice President Xi attended the opening ceremony of the seminar commemorating the 10th anniversary of the establishment of the FOCAC and delivered a speech entitled “Work Together to Create a Promising Future for China-Africa New Type of Strategic Partnership”.

Before the fourth plenary of the CSABC, Chinese officials accompanying Vice President Xi held subcommittee meetings with their South African counterparts under the CSABC. Vice Minister of Foreign Affairs Zhai Jun and Deputy Minister of International Relations and Cooperation Ebrahim Ebrahim held the third meeting of the CSABC Diplomatic Sectoral Committee and the third China-South Africa Strategic Dialogue. On 23 December, following the consensus with Russia, India and Brazil on South Africa’s participation in the “BRIC” cooperation mechanism, President Hu Jintao, in his capacity as the BRIC rotating chair, sent a letter to South African President Jacob Zuma to invite him to attend the third BRICS Leaders’ Meeting in China in 2011. Earlier in the year on 15 April 2010, President Hu Jintao met with President Zuma on the sidelines of the second BRIC Summit. NPC Chairman Wu Bangguo had a bilateral meeting with Speaker Sisulu on the sidelines of the Third World Conference of Speakers of Parliament in Geneva on 20 July.

President Zuma paid a state visit to China from 23 to 26 August 2010. President Hu Jintao held talks with President Zuma. NPC Chairman Wu Bangguo, Premier Wen Jiabao and Vice President Xi Jinping met with President Zuma separately. The two heads of state signed the Beijing Declaration on the Establishment of a Comprehensive Strategic Partnership Between the People’s Republic of China and the Republic of South Africa, taking the relations between the two countries to a new level, and making overall plans for the practical cooperation between China and South Africa in nearly 30 fields. Competent government departments of the two countries signed seven documents on setting up a mineral subcommittee and an energy subcommittee under the CSABC and engaging in cooperation in environment, transportation and other fields.

The speaker of the National Assembly of South Africa Max Sisulu visited China from 21 to 29 October 2010. President Hu Jintao met with him. Chairman Wu Bangguo held talks with him, and the two sides had in-depth exchange of views on China-Africa relations and international and regional issues of shared interest. Foreign Minister Yang Jiechi maintained frequent communication and exchanges with Minister of International Relations and Cooperation of South Africa Maite Nkoana-Mashabane. Mashabane visited China in February. Vice President Xi Jinping met with him and Foreign Minister Yang Jiechi held talks with him. In September, Foreign Minister Yang met with Mashabane on the sidelines of the 65th UN General Assembly. Foreign Minister Yang Jiechi talked with Minister Mashabane on 23 December and informed him of the unanimous decision of China, Russia, India and Brazil to have South Africa as an official member of the BRIC cooperation mechanism. Exchanges between the ruling parties of the two countries have been active. In September, alternate member of the CPC Central Committee and Deputy Secretary of CPC Chongqing Municipal Committee Zhang Xuan attended, upon invitation, the National Congress of the African National Congress (ANC) as the representative of CPC.

Bilateral trade recovered from the impact of the international financial crisis and grew by a large margin. During Vice President Xi Jinping’s visit to South Africa in November 2010, Vice Chairman of NDRC and Director of the National Energy Administration Zhang Guobao and Deputy Director of the National Energy Administration Qian Zhimin had in-depth exchange of views with Minister of Energy Dipuo Peters and Director General of the Energy Department of South Africa N. Magubane on nuclear energy and renewable energy respectively.
New progress was made in exchanges and cooperation between the two countries in art, culture, news media, tourism and other people-to-people and cultural fields. In May 2010, the preliminary of the third Chinese Bridge-Chinese Proficiency Competition for Foreign Secondary School Students in South Africa was held in Pretoria. The South African Department of Tourism set up an office in Beijing in the same month. In July 2010, Deputy Director of the General Administration of Press and Publication Li Dongdong visited South Africa at the invitation of the Department of Arts and Culture of South Africa. The China Publishing Group and China International Book Import and Export Company organized and sent a delegation composed of representatives from over 60 Chinese publishing units to the Cape Town International Book Fair. In August, the “Exhibition of Art Photography Farmer Painting of Henan Province, China” was held in the Capital Arts Festival in Pretoria.

The two countries cooperated closely on matters relating to the Shanghai World Expo. In April 2010, commissioned by the Chinese Embassy in South Africa, *Business Day* of South Africa published a special issue on the Shanghai World Expo. Minister Mashabane attended the opening ceremony of the South Africa Pavilion in May. President Zuma visited the Shanghai World Expo Site in August. The South Africa Pavilion, which covered 2,000 square meters, was the largest rented pavilion in the Expo Site. About 4.1 million visitors from across the world visited the Pavilion. Military-to-military exchanges between the two countries were deepened. Exchanges between local authorities of the two countries maintained good momentum.

**Confucius Institute**

These institutes are a prominent feature of China’s cultural diplomacy or soft power. More than 20 such institutes out of 300 worldwide have been opened or will soon be opened throughout Africa which teach Chinese language and culture. This focus helps Africa-China relations to move away from the skewed economic focus. I agree with Bodomo that there is a danger of creating an asymmetry if Africa does nothing in return, and that South Africa as the most stable economy in Africa has a role to play to balance the symmetry of China-Africa relations.

China is setting up Confucius Institutes around the world to spread its language and culture and to increase collaboration with foreign academic institutions. The institutes could increase China’s “soft power” and help it project an image of itself as a benign country. Concerns exist about a “Trojan horse” effect. There is anxiety around the world especially with the super powers on China’s rise, which has led the government to strive for a more favourable image to reassure the world that its intentions are benign, its approaches includes espousing theories of China’s peaceful rise and development.

**The role of South Africa**

With the development of South Africa’s political, economic and cultural stability she is more and more portraying better skills to advance her relations with many states including China. South Africa is already playing a leading role in advancing Africa-China relations only after 10 years of diplomatic relations with Beijing, since January 1998. Bodomo says that South African firms have been more successful in penetrating the Chinese markets than Chinese firms in establishing themselves on the South African market. The following report by the China Business Frontier (April 2008) newsletter testifies to this:

“What followed (since the start of diplomatic relations in January 1998) was an initial rush of Chinese investment into the country…However, a general lack of local market knowledge, inexperienced management and a vastly different business culture all contributed to failure of these companies.”

“In contrast, South African corporations have been extremely successful in penetrating the often challenging China market. A handful of firms have been “industry shapers” in the Chinese economy – after entering the market in 1994, SAB Miller became the largest brewer by volume in China last year, Naspers is a leading media player…. and Sasol could soon become the single largest investor in China if it goes ahead with two coal-to-liquid gas projects in China.”

22 Ibid
South Africa is trying to strengthen her cultural ties with other states like India. On 24th August 2011 marked the start of the ‘Festival of India’ a two months long extravaganza exploring Indian culture. The festival is part of South Africa-India Programme of cultural cooperation aimed to strengthen the cultural ties between the two countries. Present at the kick off was Virendra Gupta, the High Commissioner of India to South Africa and S’bu Xaba, Director General of department of arts and Culture. Gupta said that this is the first time the festival is taking place on such a high magnitude. Xaba informed that culture is important to South Africa as it promotes people-to-people contact and social cohesion, passing on skills to young people, and contributes to the wealth of a nation. He added that South Africa will hold a cultural diplomacy conference this November to discuss the power of culture as a tool of South Africa’s international relations, inviting India and other states to share about their cultural diplomacy experiences. Being the most stable economy in Africa, South Africa can use such forums that brings African countries together on a different, less political level, where the states share a experiences to find for better avenues of bringing solidarity and selling the African name internationally.

Though South Africa has come a long way in developing its cultural diplomacy using soccer. Since apartheid, when Soccer was for the elite to now where it is for business by all classes. Soccer, is being challenged by the global political economy of the game which is challenging African and Third world soccer today. The country needs to venture more avenues using cultural diplomacy to promote its foreign policy. For example, opening cultural institutes. In 2010, during a parliamentary briefing on 25th May 2011 of the Monitoring South African Parliamentary Committees since 1996. When asked about the cultural agreements and who they benefit, Ms Louise Graham, Chief Director, International Relations, Department of Arts and Culture, responded that it was difficult to find a balance between South African arts and culture taken out of the country with skills and benefits brought in.

Xaba, addressed how agreements were linked to job creation, and listed a number of ways in which the creative industry could drive growth. Films made in South Africa, which were then showcased internationally, marketed South Africa, its expertise and facilities for film-making, which then would grow the industry and create jobs. Additionally, major cultural events could create a large number of sustainable jobs. The Department was currently developing business plans and creating enterprises to popularise arts and culture in various areas, and would brief the Committee further. Xaba, added that the Department of Arts Culture was working to develop nationally supported arts and culture festivals in every province. It was also looking at the possibility of hosting “carnivals” in cities other than Cape Town and Johannesburg.

**Mandela Institutes**

Ms, Graham, notes that other countries had cultural institutions based in South Africa, such as France’s Alliance Francais. However, South Africa did not have similar cultural institutions based in other countries, to teach South African languages and culture. This would be one of the issues discussed during the cultural diplomacy conference at the end of 2011. It would, however, have huge financial implications.

Bodomo suggests that African countries should aim at setting up African Cultural Institutions in China. For South Africa, he proposes that the most apt designation should be the **Mandela Institute:**

- Teaching South African languages and cultures and spreading Mandela’s policy of rapprochement between races and all peoples of the world.
- African governments can collaborate with Chinese government and Chinese Universities to promote African Studies by setting up MoUs.
- The new University of Hong Kong African Studies Programme (www.hku.hk/AfricanStudies) and similar programmes in mainland China have an important role to play given the right intergovernmental support.

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2006 marked the “Year of Africa” in China’s diplomacy. According to He Wenping, a research fellow for the Institute of West-Asian and African Studies, Chinese Academy of Social Sciences and secretary general for the Chinese Asian and African Research Society, the highly intensive diplomatic activities that took place were unprecedented both for China’s diplomatic history and the China-Africa relationship. On 2006, November 3 China hosted a Forum on China-Africa Cooperation Summit in Beijing with the leaders of 48 African countries designed to cement its economic and political influence in the continent. Over 2000 business were being negotiated at the time. At the opening of the summit, President Hu Jintao stated China would offer $3 billion in preferential loans and $2 billion in export credits over the next three years. China announced that it would double its foreign aid though it did not offer details.

China’s Success in Overtaking Superpowers

The fact that China has come up very fast using cultural diplomacy, doesn’t mean that though insignificantly, that America was making efforts too. During the cold war, two superpowers emerged and the world was torn into two. After this, America made efforts to enhance its image to the world through promoting its culture of music, slang and more. Few scholars have studied this option, Prevots explores how dance touring programme from 1954, and how the modern government of post cold war was the government’s desire to present America’s culture positively to the world. Dr. Harvey Feigenbaum suggests to Americans that since, both cultural exchanges and public diplomacy need the resources and administrative muscle to carry out their particular mandates, they should both be funded and structured separately. He adds that since the terrorist attacks of September 11, 2001, the Americans national conversation has assumed a new tenor. Americans now better understand how culture affects the way we are viewed by some people in other parts of the world.

However, whether or not China is a superpower now or is going to be is still not certain. But China’s efforts have paid off well so far, she has become popular especially with the developing states. This is because china’s strategy is not only different but also friendlier. Chinese aid is different. The context of Chinese aid is simpler influenced by their own form of development, they emphasize production, infrastructure and scholarships at a time when traditional donors downplayed all these. China has had the most tremendous growth as a developing state in the last decade that it has sparked concern from Europe and America.

In the 1990s, increasing numbers of Chinese companies developed connections with African countries with the aim of increasing trade between China and the African continent. This development of Sino-African relations has not gone unnoticed, but the discussion in the West has not been well informed. The relationship is on African exports of natural resources, the export market for Chinese products in Africa, and Chinese investments in Africa.

It has been found that more interpersonal strategies have been employed by Chinese and Indian business managers when initiating a business relationship. In contrast, the New Zealand and South African managers tend to use more impersonal communication strategies to promote public relations. Similar interpersonal communication strategies are employed in all the target cultures for maintaining relationships. However, a stronger orientation for long-term relationships in the Chinese and Indian cultures has been identified. Furthermore, the communication strategies are dynamic in all the countries investigated since they are becoming more and more multicultural and increasingly globalized in international business and management.

The global governance of the 1990’s was geared towards a multilateral world order and creating new patterns of co operations between governmental and private actors. Corporations and non-governmental organizations became more prominent in global governance.

31 “China to double its aid to Africa”, BBC News, November 4, 2006
36 International Journal of Cross Cultural Management. SAGE Publications. December 2006 vol. 6 no. 3 pp.319-341
There is a rising China’s foreign policies towards three targeted regions in the global south—Africa, East Asia, and Latin America. On the one hand, due to Beijing’s carefully-designed and soft power-based foreign policies, the global south has become an increasingly harmonious environment for Beijing to cultivate a favorable national image, exert its political influence on regional affairs, benefit its own domestic economic developments, etc. On the other hand, some problems such as the so-called “China’s New Colonialism” and the increased vigilance from the other powers have already began to challenge Beijing’s harmony in those regions.

During the last decade Chinese media and scholars have paid more attention to the development and wielding of Chinese of soft power-based foreign policies in the recent years.38

To the South African case, the crucial significance of institutional foreign policy instruments for the power over policy outcomes at the regional and global level is demonstrated. But although Pretoria is ready to pay the costs of co-operative hegemony (capacity building for regional institutions and peacekeeping for instance), the regional acceptance of South African leadership is constrained by its historical legacy.39 Additionally Pretoria’s foreign policy is based on ideational resources such as its reputation as an advocate of democracy and human rights and its paradigmatic behaviour as a ‘good global citizen’ with the according legitimacy. The Mbeki presidency was more successful in converting these resources into discursive instruments of interest-assertion in global, than in regional bargains. In effect the regional power’s reformist south-oriented multilateralism is challenging some of the guiding principles of the current international system.

Challenges facing China and South Africa in Promoting Cultural Diplomacy

China and South Africa still have a long way to go in impressing the world especially with their system of governance. But both have rich cultures and a big potential at that to attract other states. China needs to work on improving the image especially because of the low quality of products and the pollution. The three top most polluted cities in the world are in China. There is still the pending debate on whether China should be classified as a developing or developed state there by following the annex 1 states rules on environmental conservation. There is also the problem of overproduction which has led to an influx of low quality products. Some people argue that China is penetrating raw market in such of places to sell their surplus.

China also has the problem of promoting its governance image. Most states especially the west do not support communism kind of governance. It seems like the kind of governance that is government controlled and can be use to benefit a few elite. The west view it with scepticism as though it’s a dictatorship kind of leadership. Furthermore, China is known for supporting dictatorships like the Zimbabwe’s Mugabe regime and Sudan’s Bashir regime.

China’s stand of being non-aligned is also questioned most times. Their non-interference policy can be interpreted as a selfish strategy to make sure that no side appears as an enemy. They all then take China as a neutral partner.

South Africa on the other hand is working on development and needs to look into her immense potential to promote herself culturally around the world. Ms Graham40, said that not all of the arts, heritage and culture sectors in the various provinces were well organized, which gave rise to some problems. She stated that South Africa had about half a dozen cultural attachés, who were appointed by Dirco some years ago, but after their terms of office the practice was discontinued, for financial reasons. This discussed during the national cultural diplomacy conference. She agreed that diplomats generally did not have the necessary skills and expertise to speak with authority on South African arts, culture and heritage. Mr Xaba41 adds that Public schools did not have a strong tradition of teaching arts and culture, partially because of problems employing teachers. However, teaching of arts and culture at schools encouraged students to choose arts and culture as a viable career path. However, part of the problem at higher education institutions was that the arts were taught too generically, and did not equip students with specific skills.

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41 Ibid
### Comparative analysis

<table>
<thead>
<tr>
<th>Soft Power Activity</th>
<th>China</th>
<th>South Africa</th>
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<tbody>
<tr>
<td>Cultural exchanges</td>
<td>China has cultural exchanges and agreements with many countries like US, Norway, India, Cuba, Ghana, Egypt and Greece.</td>
<td>South Africa has had cultural exchanges and agreements with countries like India and Jamaica.</td>
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<tr>
<td>High-Level visits</td>
<td>Many high level visits have been exchanged between China and others states she relates with. For example the Vice President Xi Jinping paid a visit to South Africa from 16 to 19 November 2010.</td>
<td>An example of high level visits by South Africa is when President Zuma paid a state visit to China from 23 to 26 August 2010.</td>
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<tr>
<td>Scholarship offers</td>
<td>China is well advanced this. The China University College Admission Scholarship(CUAS) is a platform where international students get scholarships.</td>
<td>This is not as common with international students as with China.</td>
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<tr>
<td>Aid and donations</td>
<td>China has offered a lot of technological and monetary help to developing countries. For example the construction of roads in Kenya between the year 2007 and 2011.</td>
<td>South Africa’s sporting diplomacy on the continent include assistance to Mali for its hosting of the Africa Cup of Nations in 2002.</td>
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<tr>
<td>Sports, fairs and festivals</td>
<td>China became the 22nd nation to host the Olympic Games and the 18th to hold a Summer Olympic Games. The Expo 2010 Shanghai China was held in the city of Shanghai, China, from May 1 to October 31, 2010.</td>
<td>In order to win the rights to host the 2010 FIFA World Cup leaders of the post-1994 government and soccer administrators used sport and cultural diplomacy as enabling instruments to assert South Africa’s credentials.</td>
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<tr>
<td>Language and cultural studies</td>
<td>The Confucius institutes aims at spreading Chinese culture around the world.</td>
<td>South Africa does not have similar cultural institutions based in other countries, to teach South African languages and culture.</td>
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<tr>
<td>Film and Media</td>
<td>China is now the third largest film producer in the world, after India and the United States. Famous movies are like “Shanghai express” which revolves an electric train, marketing China’s technology.</td>
<td>South African films like the ‘Sarafina’ which was advocating for freedom from apartheid.</td>
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<tr>
<td>Music and arts</td>
<td>The year 2010 was the fifth time that China has held the Miss World Final. China is also famous for martial arts like ‘Kung Fu’.</td>
<td>Four of South Africa’s eight Unesco World Heritage sites are cultural sites. South African music like the “makoma” sang in their native language are known widely.</td>
</tr>
<tr>
<td>Hosting meetings and forums</td>
<td>China hosted the World Economic Forum China Business Summit in Beijing among other forums.</td>
<td>South Africa has hosted many forums and meetings like the famous Coca Cola Popstars forum, Miss Malaika, and Kora Awards.</td>
</tr>
<tr>
<td>Tourism</td>
<td>China is the world’s third most visited country in the world. China’s tourism revenue reached $185 billion in 2009.</td>
<td>In 2007 a total of 9.07-million foreigners visited South Africa - an 8.3% increase over 2006 - as the country broke its annual tourist arrivals record for the third year running.</td>
</tr>
<tr>
<td>Bilateral and multilateral agreements</td>
<td>China has entered into many cultural agreements, both bilateral and multilateral, like the agreement with the Government of the Republic of India in 2002.</td>
<td>South Africa has many agreements like the cultural agreement between the Republic South Africa and Jamaica was signed on 14th December 2009.</td>
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</table>

### CONCLUSION

According to Nye, soft power refers to “the ability to get what you want through attraction rather than coercion or payment”. Cultural Diplomacy as a form of Soft Power is very much visible in the Foreign policies of the two states. It can be concluded that indeed it has contributed to the growth of their economies and good relations with other states. China and South Africa have both engaged in using Cultural Diplomacy for different reasons, but majorly is to boost their image; however they have met certain hurdles in pursuit of Soft power.

Cultural diplomacy use in both South Africa and China is not only by government controlled firms but also private firms and individuals. It can be concluded that Cultural Diplomacy has indeed been used by the two countries to boost their image, this has been through cultural exchanges, high-level visits, scholarship offers, aid and donations, sports, fairs and festivals, language and cultural studies, film and media, music and arts, tourism, hosting meetings and forums and bilateral and multilateral agreements.

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All these channels of cultural diplomacy are forms of soft power. Means that maintain friendly relations without coercion, use of force or threats. Soft power can be generally interpreted as all forms of conducting diplomacy that do not involve force or threats to use of force. They are friendly ways of relating with other states, aimed at impressing others.

It can also be concluded that these two states used the soft power option because they are against hard power use. The two states both suffered due to wars with the examples of apartheid and Opium War. They hence prefer to use friendly means to conduct diplomacy, since they only know too well the effects of hard power use, as they were victims of it.

The past history also explains why they are in the non-aligned movement. They have both suffered due to other people interfering with their internal affairs, hence its quite understandable that they choose to stay out of the internal affairs of other states. This has been translated otherwise to mean that they are greedy since they choose to have all parties as friends and not take sides.

One of the things that has made the two states have a good ground for cultural diplomacy is that the two have deep cultural background. Their cultures, art, music, films and languages are diverse and rich. It takes a country with a rich culture to use cultural diplomacy successfully since it has lot to offer in the international market.

**Contribution to policy making**

In policy making many factors come into play, they could be internal or external. The external factors include aid and donations, while the internal factors are the history, the people, geographic position, climate and such.

Guided by cultural diplomacy as discussed in previous chapters, the history of a country can be used to determine the foreign policy to be adopted by a state. The people of the state can contribute to the foreign policy making. For example the people of South Africa are of diverse cultures, which give them a rich background. The people and most specifically individuals can shape the foreign policy. In the case of South Africa, the presidents, Nelson Mandela, and Thabo Mbeki have been of pivotal role in marketing the country abroad.

Following South Africa’s example, it is apparent that a country can use its culture to promote its foreign policy. This is through national heritage, museums, wildlife, tourism, music and art. This is similarly reflected in the Chinese cultural diplomacy of organizing exhibitions, tours and teaching its culture and language to other states voluntarily. A country can henceforth use what it readily has to promote its image. Kenya, for example has a rich and diverse cultural background, looking at tribes that have preserved their culture up to date like the Maasai, which is has a great potential. So far, this tribe has been famous in promoting tourism, but in areas like films and music are yet to be exploited. The country can even have an airline by the name “Maasai Airlines” aimed at taking guests from the airport to any destination in the country.

Concerning language, Kenya can promote the national language which is Kiswahili by having Kiswahili institutes and teaching the world voluntarily in campuses worldwide; probably even offer short courses scholarships to Kenya to study the language.

Sports and athletics are a great tool that Kenya has, the talented athletes of Kenya have flown the Kenyan flag high wherever they have competed worldwide. The government can assist in putting up well furnished training camps and stadiums in the country to promote the sports industry. More so, use sports to unite the Kenyan people as South Africa did. This would help counter tribalism which puts Kenya on the map negatively especially during the ethnic violence that erupted after 2007 Presidential elections. Since history can tell Kenyans love athletics and this can be used to harmonize the people.

It is already a fact that regionalism helps strengthen unity. Starting with the sub-region organizations like the East African Community (EAC). Kenya being in the EAC is in the fore front of solidifying the region, however much more should be done like having a common force, language, passport, and a common stand like when voting in the UN. Further, the African Union having followed suit to strengthen the African block will henceforth give Africa a voice. The African Union can then make impact by having a united stand like in UN. Promoting relations in the African countries and boosting trade.
Countries can also increase the number of cultural exchanges they have either at the bilateral level or the multilateral level. This helps a country to know and learn more from the other country. My advise is to have cultural exchanges more with the states that have advanced in cultural diplomacy like China and South Africa. Also, have exchanges with culture-rich countries like Brazil and Korea. That way they will learn how to maintain their heritage.

Then apart from tourism, Kenyans as one culture, image should be promoted. The famous saying of “Najivunia kuwa mkenya” meaning, I am proud to be Kenyan, is a good start to unite Kenyans and be proud of their land, but there could be a slogan after that to indicate why. May be by stating “Najivunia kuwa mkenya, boma la Simba” meaning, I am proud to be Kenyan, home of the Lions. There should be a Kenyan dress to accompany that, the idea does not have to do with the flag like it is assumed one color of the flag, and the Maasai idea could be incorporated with an African design. The Chinese have their dragon, Kenyans could have their lion, and everybody who visits Kenya would like to see the lion.

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A CRITICAL DISCOURSE ANALYSIS OF KEY NEWSPAPER HEADLINE STORIES ON IDEOLOGICAL CONFLICTS IN KENYAN POLITICS

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ABSTRACT
This study examined the discourse in Kenyan newspapers headline stories within the paradigm of Critical Discourse Analysis (CDA) to determine the linguistic strategies employed by the print media in shaping the ideological positions of certain groups during the Coalition Government in 2008-2013. It was guided by the following objectives: To explain how language was used to represent political actors in Kenya during the period of the Grand Coalition Government, explain the coercive strategies used by political actors, and to show how language used in the newspapers (de) legitimized the actions of various political actors. The study was necessitated by the fact that the period of the Grand Coalition Government was characterized by political conflict and provided a rich ground for analysis to unravel the ideological underpinnings that informed the political climate then. Newspapers headline stories of Daily Nation and The Standard covering the period of the Coalition Government formed the corpus of data for the study. Purposive sampling was done to select 50 headline texts from two newspapers that were considered ‘political’. The selected stories were qualitatively analyzed, focusing on syntactic structure, lexicon, semantics, and pragmatic features of the texts to explain the underlying ideological motivations in the use of certain structures. The study reveals the ideological-driven language styles of the print media in representation of political situations and personalities. It thus adds to the existing studies based on CDA theory that aim at showing that language is a powerful ideological instrument and plays a central role in volatile political situations to exercise as well as resist power. A study on political discourse in the electronic media in the same political period would serve as a comparison to this study and reveal further language manipulations used by media and what the manipulations reveal about power relations in social and political contexts.

Key words: Linguistic strategies, Ideology, Representation, Coercion, (de)legitimization

INTRODUCTION
The media is regarded as a social and discursive institution which regulates and organizes social life as well as produces social knowledge, values and beliefs through linguistic means (Van Dijk, 1993; Fairclough 1995b). Variations of language use in the media often constitute particular ways of representing the world, social identities and relations projecting certain versions of reality depending on the media’s institutional purposes, positions and interests. In other words, the news in the media ‘is not a neutral reflection of social reality and empirical facts but a constructed reality’ because language is never neutral; ‘it is a highly constructive mediator’ (Fowler, 1991:1). Fowler suggests that analysis of media discourse can reveal propositions which may not be necessarily stated and are usually unquestioned and dominate the structure of presentations.

The media impacts on us since they tell us how the world is, like give us ideas and hence influence our attitudes (Harris, 2004). Empirically however, it is not easy to give evidence of media’s influence on peoples’ lives. Van Dijk (2008) observes that media influence is symbolic in the sense that it does not directly affect the actions of users. Yet, as Graham (2004) argues, evidence in psychology, anthropology and other social sciences supports the assumption that people will pursue what they consider to be of most value and further says that media forms disrupt and change evaluative-meaning systems both within and between social systems. The evaluative dimension of meaning by media can motivate human action.

The underlying assumption in trying to understand media influence on people is the notion of the institutional or social power in media. Van Dijk (2008: 10) defines this power as ‘a social relation between groups or institutions involving the control by a more powerful group or institution of the actions and the minds of a less powerful group. In such a situation of unequal power relations, there is a presumed influence of the actions, beliefs and opinions of the less
powerful group by the more powerful one. But it should also be born in mind that the assumed media control is limited in the sense that unlike other institutions (like the judiciary) that have sanctions against non-compliance, the media as an institutions lacks such powers and can only use the power of persuasion to influence their audience. Indeed, part of the audience will always ‘resist’ the purported media influence depending on other factors in the context of the issue at hand (Van Dijk, 2008). It then makes sense to see that language becomes a very important ‘weapon’ to the media in their endeavour to persuade their audience to ‘see’ things from a certain angle. The ‘angle’ has to do with the particular media house’s ideology and in politics, the ideology is influenced by the institution’s view of the political establishment. The relationship between language and ideology will be discussed in greater detail but at this point, it suffices to indicate that this aspect of ideological influence of media on people’s belief system is the central element in this study because it validates the Critical Discourse Analysis approach that I adopted and which views language as an instrument of social construction and reality (Moufahim, 2007).

In this study, I argue that the content and the style (in the broad sense of grammatical structures, schematic forms, lexical choices, rhetoric and others) employed in headlines and their accompanying stories are meant to influence interpretation. In making a case for analysis of media discourses, Van Dijk (1988) says that such discourses should be accounted for in their own right as particular types of language use or texts and as specific kinds of socio-cultural practice. But he also intimates that analysis of media discourse should go beyond the structural description of news stories to the description of the social context and relate the structures to the context. In essence, an analysis of media discourse should look into possible role played by the media in the cultural, political and economical power structures in the society. Such an approach allows an analyst to consider the factors that constrain production of news such as economic and social factors and also the institutional routines of news making.

The two newspapers on which the study is based command a wide readership with *The Daily Nation* taking the bigger share of the market at 70% while *The Standard* stands at 30%. The Standard is the oldest paper in Kenya having been established in 1902 as a weekly newspaper by Alibhai Jeevanjee. It has changed hands since, and in 1995, it was sold to Kenyan investors. *The Daily Nation* is the most influential paper in East Africa. It was established in 1958 as a Kiswahili weekly *Taifa* by Charles Hayes and was sold to Prince Aga Khan IV, the spiritual leader of Ismail Community in 1959. In October 1960, the first English version was published by East African Newspapers which later became the Nation Media Group. In establishing the newspaper, Aga Khan wanted to create an African nationalist public opinion and end colonialism. The majority shares of the newspaper plus two TV stations, radio stations, the business daily *East African, Taifa Leo* and the Uganda daily *The Monitor* are still owned by Aga Khan (Ali, 2009).

The Kenya Grand Coalition Government was formed in April 2008 through mediation by the former UN Secretary General Kofi Annan, between the two leading political parties; Orange Democratic Movement (ODM) and Party of National Unity (PNU) led by Raila Odinga and Mwai Kibaki respectively. The deal was brokered to stem further crisis after the country was rocked in violence following the elections that were believed to be flawed. Kibaki was the president of the cabinet while Raila was the Prime Minister in a cabinet of 42 ministers and 52 assistant ministers from both sides of the government. The fact that the coalition government was formed in a crisis means that it was a ‘forced’ coalition and consequently it was characterized by conflicts since its formation. In countries such as Switzerland, Germany and Belgium, coalition governments have existed because political parties lack majority in parliament. Hence they would not compare with the Kenyan situation. The Kenyan situation compares with Zimbabwe which formed a coalition government in similar circumstances after the elections in March 2008. The International Commission of Jurists (ICJ) criticized the formation of coalition governments that followed flawed or disputed elections. In a meeting at Geneva in 2008, the body deplored the emerging concept of coalition governments as anathema to democracy and citizens’ rights to choose their own governments. The Kenyan Prime Minister, Raila Odinga who was in the meeting called coalition governments ‘unity’ governments that should not be replicated. The period of Kenyan coalition government provided a rich ground for a systematic discourse analysis of newspaper headlines with a view to uncover ideological undertones that arise in situations of conflict.

Van Dijk (1995:22-25) suggests that situations of conflicts are especially suitable for analysis of the relationship between discourse and ideology. He further observes that ‘any property of discourse that expresses, establishes, confirms or emphasizes a self-interested group’s opinion, perspective or position especially in a broader socio-political context of social struggle is a candidate for special attention in an ideological analysis’. Based on the context of a conflict caused by disputed elections and formation of a coalition government in Kenya, this study examined how ideologies are constructed through language in both *The Daily Nation* and *The Standard* newspapers headlines stories.
It is important to explain at this juncture that there is no intention, in the scope of this study, to delve into the complex nature of ideologies and would like them to be understood as any collective beliefs and ideas that have some aspects of social reality and have a bearing on how we think and act. In this respect, no attempt is made to identify and classify the ideologies that emanate from this study as this will not serve the purpose of the study. The study instead focuses on the language features in newspaper language that communicate underlying ideological persuasions. The study, which is part of a bigger project analyzing other political issues of coercion and presentation of political actors by media was guided by this objective: To analyze texts in the headline stories of two leading Kenyan newspapers (Daily Nation and The Standard) to bring out the (de)legitimization strategies used by the newspapers in the context of political conflict in Kenya.

**Discourse and Ideology**

The relationship between discourse and ideology has long been of interest among critical discourse analysts and social researchers. Both groups seem to agree that there is an ideological motivation in the structuring of text and talk (Dijk, 1995; Bourdieu and Wacquant, 1992). Ideologies are self-serving (Van Dijk, 1995) and usually represent a group’s interests as being in conflict with others’. The group will therefore engage in acts of ‘othering’ the rival group and these acts will be evident in the structure of texts. At the individual level, people have personal mental representations of a group’s ideology. These representations, called ‘models’ by Laird (1983) control the way people act, speak or write and how they understand others. In other words, through the minds of the members, the social reproduction of a group is enacted in discourse. The remaining part of this section will look at specific levels of text manipulation that reflect underlying ideologies which are usually not questioned and passed off as common sense.

Power relations between groups can be revealed by the choice of syntactic structure. In syntax we look at the choice of structural order and ask why one order is preferred to another. Halliday’s (1994) Systemic Functional Grammar (SFG) theory is particularly important in this regard because it looks at language as a choice of options from which users make a choice. The choices are in form of functional labels which are divided into three interrelated systems of meta-functions namely: textual, interpersonal and ideational. Textual refers to the order, organization and presentation of information. Interpersonal function has to do with interactional meanings such as attitudes, feelings and judgments. This function helps in enacting humans’ diverse and complex relations. The ideational function aids in construing human experience and is the means by which we make sense of reality. Halliday (1994) looks at grammar as systems, not rules. The systems, such as mood, transitivity, voice and agency interact with the three meta-functions to explain the complex relationship between language and human beings. SFG is therefore a resource that allows us to draw meaning from structure and will be a useful methodological tool in this study.

Ideological control of meaning may be apparent in the management of meaning in a text. So we can have self-serving and biased explanations of situations (Van Dijk, 1993a). Also, information that is unfavourable to an in-group is presented implicitly while unfavourable information of an out-group is made explicit. If there is no other source of information, this ideologically shaped discourse results in biased construction of models and interpretation of issues (Van Dijk, 1995). Writers may also use connotations to convey certain meaning. Newspapers headlines particularly exploit connotative language by drawing on readers’ common experience to lead them to draw certain conclusions. McGregor (2006) points to both connotation and insinuation as ways in which writers create the meaning they intend.

The elements of syntax, semantics, lexis, and grammar fall under the microstructure level of analysis. However, Van Dijk (1988) proposes the higher of analysis comprising the macrostructures where whole topics should also be analyzed. In reference to these higher levels or macropropositions, Van Dijk (1988) says that the topics people choose to highlight or downplay depend on their subjective judgments about situations. Interpretations of social and political events that are undesirable to an in-group will not be topicalized while the desirable interpretations will be topicalised. Negative information about rival groups will be topicalized in order to make it prominent. In the same way, an in-group will detopicalize information that does not reflect positively on the group (Van Dijk, 1995).

The structuring of news or the schemata is based on what the paper may consider ‘relevant’. That means the sequence of a story comprising a summary, (headline and lead paragraph), the story, (episode and background) and consequences (final comments and conclusions) according Van Dijk (1988) are determined by ideological interests. For instance, it is possible to have one story where events are represented as ‘circumstances’ while the same events form the crucial part in another story (Van Dijk, 1995).
Rhetorical structures of discourse such as rhyme, alliteration, euphemisms, litotes, hyperbole, metaphors and others could serve ideological interests. They could be used to demean, marginalize or dehumanize others (Ehlich, 1989; Dijk, 1991a). Blunders emanating from an in-group are discussed in euphemistic and more ABSTRACT terms and attributed to circumstances beyond the group’s control while ‘their’ blunders are described in great detail. These figures of speech could also be used positively depending on the interests of certain groups (Chilton and Ilyin, 1993; Schaffner, 1993). Rhetoric is pervasive in politics and this study looked into these features as they appeared in the newspaper texts.

Pragmatically, discourse can be used to serve certain purposes. In spoken as well as in written language, social actors engage in discourse that contains speech acts such commands, advice, and threats. In commands and threats, we presuppose there is power and dominance while prejudice is assumed when unsolicited advice is offered in the assumption that the receiver is ignorant (Van Dijk, 1995). Of more interest to a discourse analyst is when the speech acts are subtle and implied rather than direct. Fowler et al (1979) observe that power can be enacted in language through indirect speech acts. This view is shared by Kress and Hodge (1979) and originates from Austin’s (1962) Speech Act Theory. Presupposition is also an important aspect of discourse and is basically about what is assumed to be common knowledge between interactants. In writing news, writers may sometimes presuppose that knowledge is shared with the readers even when it is not. For instance, in a statement like ‘the increasing crime is worrying’, there is presupposition that the audience is aware of the situation which may not be the case (Van Dijk, 1995). This is meant to align the audience with a certain view.

**Theoretical Framework**

This study will take the Critical Discourse Analysis approach. Van Dijk, a proponent of CDA defines it as a type of discourse analytical research that studies the way social power abuse, dominance and inequality are enacted, reproduced and resisted by text and talk in social and political context (Van Dijk, 2000). Wodak and Meyer (2009) observed that CDA views language as a social practice which allows multifarious approach in theoretical backgrounds and methodology. Dijk (2000) says that CDA does not have a unitary theoretical framework or methodology but involves a range of approaches. But all CDA analysts agree that text, spoken or written, is not arbitrary; it is purposeful whether or not we make the choices of words we use consciously or unconsciously.

In attempting to understand CDA, we look into the foundation of semiotics as laid by Ferdinand de Saussure, an early 20th century Swiss linguist. The principle in De Saussure’s theory was that in the world which human beings experience, there is a system of signs and these signs acquire meaning by being structured into codes, the principal of which is language. The codes endow the world with meaning by organizing it into categories and relationships which are not ‘there naturally’. These categories and relationships represent the interests, values and behaviours of human communities (Fowler, 1991). This notion of significance of language in creation of realities in human existence forms the core of CDA. As a theory however, CDA can be traced to the influence of Marxist and Neo-Marxist theory which formed the basis for establishment of the Frankfurt school of Critical theory in Europe in 1930s. Critical theory stresses the examination and critique of society and culture drawing from knowledge across the social sciences and humanities. The basic concern in critical theory is use of rational thinking to question prevailing ideas in society. Horkheimer (1982) points to the central aspect in Critical theory as its endeavor to liberate human beings from circumstances that enslave them, a critical issue in CDA. But CDA as it is now draws from by Halliday’s (1994) theory of Systemic Functional Grammar which looks at language as being functional. This theory sees and analyses language as shaped by the social functions it serves.

CDA has been used to analyze many situations where language is seen to be used to make unbalanced power situations appear as ‘normal’ or ‘common sense’ while in essence there is injustice and prejudice (McGregor, 2006). Discourse is a powerful tool in regulation and normalization of knowledge and for development of new knowledge and power relations. As such, CDA is necessary for describing, interpreting, analyzing and critiquing social life to reveal the discursive sources of power, dominance and inequality as enacted within specific social, political, economic and historic contexts (Van Dijk 1988) Wodak and Meyer (2009) give the following as the principles that characterize CDA paradigm: First, all approaches of CDA are problem–oriented and hence interdisciplinary and eclectic. Secondly, it is characterized by common interests in demystifying ideologies and power through systematic investigation of semiotic data (written, spoken or visual). Thirdly, CDA researchers also attempt to make their own position and interests explicit while retaining their respective scientific methodologies. In what seems a departure from traditional theory that aims at understanding and explaining society, CDA analysts aim at critiquing and indeed emancipating society. To CDA analysts, textual practices are social practices taking place within social, historical and political contexts and should be analyzed within these contexts.
This study uses CDA as framework to analyze the newspaper discourse to establish how they reflect ideology through various strategies of legitimization. To do this, the study links the texts (micro level) of the newspaper headline stories with the underlying power structures (macro level) through the discursive structures from which the texts were drawn (meso level). CDA scholars who have attempted to interpret media discourse have faced criticisms because they base their conclusion about the impact of media discourse on people on their own interpretations (Fairclough, 1996). While CDA practitioners acknowledge that different readers can read similar texts differently (Fairclough, 1995b), they argue that readers are not trained to be critical readers of texts (Fowler 1991; Van Dijk, 1991) and hence it makes sense for CDA scholars to describe and analyze media discourse so as to make assumptions about the impact of media on people. Fairclough (1995b), while acknowledging that asking audiences about actual interpretations of texts could help in getting the impact of texts on people states that the texts analysis is the core element in media analysis. This study adopted a similar stance in its approach in that analysis of the headline texts serves in sufficiently interpreting the discourse without seeking the opinion of audiences.

METHODOLOGY

Purposive sampling of stories was done to come up with 50 (only a few stories appear in this study which is a part of a bigger project) which were considered ‘political’ using criteria suggested by Chilton and Schaffner (2006). They were selected from different points in the 2008-2013 period of the Grand Coalition government. The criteria suggested is based on three strategic discourses that enable a political discourse analyst to focus on details that comprise what people normally regard as ‘political.’ The first function is coercion and resistance in discourse. Coercion is manifested through speech acts such as commands, laws and edits. It is also observed in selection of topics in conversations, positioning of self and others, making assumptions about realities and generally controlling others through language. In resistance, there is counter-deployment of the coercive strategies by the opposing powers.

The second function of political discourse is legitimization and delegitimization which involves using language to justify certain actions and portray ‘others’ as being wrong. The third function is representation and misrepresentation. This involves controlling information through secrecy or censorship, verbal evasion, inclusion or omission of actors among others. These criteria, by default, also ensured that the stories chosen also had an aspect of political conflict and therefore served the purpose of this study.

DISCUSSION

In the following section, I analyze some linguistic features found in the text of headline stories of Daily Nation (including Sunday Nation) and The Standard which point to the media’s attempt at influencing interpretation of political situations in certain ways. In particular, I focus on discourse structures that legitimize political action by some actors while delegitimizing others through authorization and evaluations of political actors and events.

De (legitimization) Discourse in Newspaper Headline Stories

Legitimization is the use of language to justify certain actions and portray others as being wrong. Studies of legitimization in discourse (Van Dijk, 2005; Van Leeuwen 1996, 2007; Van Leeuwen and Wodak, 1999; Reyes, 2011) aim at showing how social actors use certain strategies to justify their actions. Reyes (2011) argues that legitimization in political discourse deserves special attention in discourse since it is from such speech events that political leaders justify their political agenda to maintain or alter the direction of a whole nation. In language, there is symbolic power (Fairclough, 2002). This study engages the language of newspaper stories to establish how various groups enact this power to legitimate their actions while delegitimizing others.

Politicians are able to legitimate their actions because they possess ‘soft power’, that is, power of persuasion derived from their privileged positions as leaders and their access to mass media and hence enormous audiences (Oddo, 2011). Focusing on four speeches made by two American presidents (Franklin Roosevelt and George Bush) at different times in history, Oddo shows how the two presidents used similar strategies to justify American war against real and imagined enemies. By using the ‘Us’ versus ‘Them’ technique combined with rhetoric and deliberately chosen lexicon, the two presidents persuaded America and the world that America had moral justification in attacking Japan, Italy and Germany in 1941 and Afghanistan and Iraq in 2001. Statistics showed that after president Bush’s speech on 20th September 2001 on which he declared war, not just on those responsible for the 11th September 2001 attack on America but on all people deemed to be supporters of terrorists, 90% of Americans approved military action in Afghanistan. 80% approved military action against other countries suspected of harbouring terrorists. The two presidents use positive and presumably neutral lexical items to conceal or euphemize the resultant killing of people. Words such as ‘defend’, ‘fight’, ‘protect’, ‘confront’ are used to refer to the intended American offensive. In contrast, the verbs used to describe
the ‘enemy’s action change to ‘invade’ ‘attack’ ‘kill’ ‘dominate’, ‘murder’ among others. By showing the intertextuality in the speeches of two presidents, Oddo (2011) brings out the persuasive power of language in shaping important political decisions of nations. Generally, selection of the lexicon is done to suit certain purposes and to show the ‘other’ group as negative while ‘us’ as having the right opinion.

The current study explores how media discourse in newspaper texts legitimizes the actions of some political actors while delegitimizing others. Unlike Oddo’s study where direct utterances are used, the nature of the discourse in the current study is mediated. This means that we are looking at political actors through the eyes of the media and have to consider the role that the media itself plays in manipulating language to legitimize and delegitimize actions by some political actors and thereby persuade their audiences to adopt a certain viewpoint. Quoting authorities to legitimize certain actions is common in media. In quoting authorities, the papers purport to take a neutral role but the fact that they chose a particular person to quote is a pointer that they are not neutral and indeed they share in the views of the quoted authority. Analysis of quotation patterns can therefore point to the particular paper’s ideological stance especially its view of the political establishment.

**Legitimization through Authorization**

In the second year (i.e. in 2009), major reforms in the country were expected to begin. Among them, a new constitution, as well reforms in the judiciary and the police force. However, wrangling between the coalition partners was seen as a threat to achieving the reforms. In April 2009, the President appointed his deputy Kalonzo Musioka as the leader of government business, a move that was rejected by Raila Odinga and the speaker of the national assembly due to what he termed as lack of consultations between the two principals. The speaker of the national assembly subsequently allocated himself the role of leader of government business until the two principals would agree consensually on somebody. It is against this background that The Standard on April 30, 2009, quoted multiple authorities to show that President Mwai Kibaki was not in tandem with the rest of the people who wanted reforms in the country. Martha Karua, who had in the same month resigned as minister for justice was quoted as saying: ‘We cannot have reforms without consultations among the principals. We cannot have reforms when a section feels it owns the government.’ (The Standard, April 30, 2009) The quote itself has a rhetoric aspect with syntactic parallelism in the two clauses. Rhetoric is important in creating an emotionally-loaded appeal. Raila Odinga, Kibaki’s partner in the Coalition was also quoted as saying that leaders must embrace consultations. The story also directly quotes Western envoys like US ambassador then, Michael Ranneberger, a British envoy, Macaire, and German ambassador then, Lindner. By quoting various political actors directly, the news writer would want to appear objective but choosing who to quote is in itself subjective and has ideological implications. As Juan Li (2009) observes, representation of social actors through quotations can serve to empower and justify one group says and does while ignoring or condemning what another group does. In so doing, the particular paper or writer constructs an ideological framework within which the reader is expected to interpret the issues at hand.

The headline was: ‘The next BIG battle’ (The Standard, April 30, 2009). This was in apparent reference to the ‘battle’ that was already won by the ODM through the speaker of the national assembly’s refusal to accept the deputy president as leader of the government business as proposed by the president. By use ‘next’ the paper brings in a sense of continuity, or endlessness. Kibaki’s action is seen as a precursor of future actions, which will necessitate more ‘battles’ in future. This concept of interrelating issues can be related to Bernstein’s (1999) notion of re-contextualization as observed in Van Leeuwen (2008:7), which stipulates that knowledge produced in one context and reproduced in another undergoes semantic shifts that take place through re-contextualizing principles, which selectively appropriate, relocate and relate to separate discourses as a means of constituting its own order and ordering. So in the combination of the headline and subsequent story, we see a complex interplay of legitimatizing through authorization and re-contextualization. The process of synthesizing texts to obtain a preferred meaning points to the ideological stance of the paper.

Appointment of public officers to the newly created offices by the constitution which was promulgated in August 2010 turned out to be one of the major issues of disagreement between the coalition partners. One of the officers was that of director of NSIS (National Security Intelligence Service), Michael Gichangi who was reappointed unilaterally by President Mwai Kibaki in January 2011. ODM saw it as part president Kibaki’s plan to influence his successor at the end of his term in office. Part of that story in The Standard read:

Though President Kibaki is not eligible to run under the constitution promulgated last year, ODM diehards appear convinced that the stealth with which he reappointed Gichangi forms part of how he wants his succession to go. They see him as keen on extending his influence, through proxies, into the Government to be formed by Kenya’s fourth president (The Standard, Jan 25, 2011).
The ‘ODM diehards’ are later identified as James Orengo and Gitobu Imanyara and more quotations associated with them given. Indeed the whole story is filled with quotations from personalities who were opposed to the president’s choice. Some of the quotes were accented by rationalization, another common tactic in legitimization. For instance in the following excerpt, the writer introduces a subordinate clause to explain the importance of a view originating from James Orengo to the readers. After Gichangi’s appointment last week, lands minister James Orengo whose word is believed never to contradict Raila’s lamented that ODM was not happy with Kibaki’s move (The Standard, Jan 25, 2011: 4)

The rationalization that Orengo’s ‘word is believed never to contradict Raila’s’ is meant to draw the reader’s attention to the weight of the view given. Hence, through ‘expert’ opinion, the paper legitimized Orengo’s observation, and by extension, Raila’s, and in so doing, delegitimized the president’s action of appointing the state officer. Van Dijk (1989) says that in the process of selecting quotations, news texts redefine the power structures and create meanings about the world that the news actors inhabit. Quoting sources hence necessarily involves empowering certain actors while silencing others. This is because the media decides where to get information, who gets quoted and who does not. This in effect sheds light on newspapers perspective on the relations between social actors and the also world. Teo (2000) observes that quotations are not transparent or simple citations but rather they involve (re)interpretations of events and power relations between news participants.

The indictment of six Kenyans among them Uhuru Kenyatta and William Ruto for crimes against humanity in The Hague in 2012 was an emotive issue that played out significantly in the politics of the Grand Coalition Government. President Mwai Kibaki was perceived to be sympathetic to the indictees while Raila Odinga was not. The handling of the issue by the papers pointed to their stance in that matter. In the Daily Nation of March 11 2012, the headline read ‘Uhuru and Ruto ought to be jail, says Raila’. The paper quotes the source of the proposition in order to appear objective and detached. However, the newspaper actually shared in Raila’s view and it was not just reporting what he said. The use of the modal ‘ought’ (which suggests a strong need to effect a desired state of affairs) is an authorial addition which probably was not in the PM’s utterances and which served to reinforce his view. The fact the paper topicalized the issue by making it a headline shows the importance with which it treated the proposition. In effect the paper was justifying or legitimizing the suggestion that the two indictees should be in jail while simultaneously delegitimizing any suggestion to the contrary.

The Grand Coalition Government partners in the beginning of 2010 conflicted over the sacking of two ministers (William Ruto in Agriculture ministry and Sam Ongeri in Education) by the Prime Minister Raila Odinga over allegations of graft in their ministries. President Kibaki reacted quickly by reinstating them arguing that Raila did not have constitutional powers to make the move. In the story that developed Prof' Anyang Nyong'o the ODM secretary general while supporting the PM is quoted as saying that the disagreement between the president and the PM was not about power but was a fight against corruption (Daily Nation, Feb 17, 2010). That part of the story was set apart and the font increased to give it prominence. By quoting the secretary - general and closing out alternative voices, the newspaper legitimizes the PM’s action while delegitimizing the President’s. Quotation patterns are important in revealing how newspapers 'construct specific understandings of national images and positions’ and provide insights into the ideological position of the paper (Juan Li, 2009).

**Legitimization through Evaluations**

In reporting an event, journalists usually follow a conventional narrative style in the first paragraph which is patterned to the wh- interrogative markers namely, ‘what’, ‘when’, ‘where’, ‘who’, and ‘how’. In so doing the writer is seen as merely reporting objectively on events with subsequent paragraphs meant to fill in the details of the particular event. However, a common practice among journalists is to fill the details of a story in an evaluative way. This is done through embedding evaluative expressions in purported factual stories in order to guide interpretation. Juan Li (2009) observed this practice in a report by ‘The New York Times’ on collision of a US plane and a Chinese jet mentioned elsewhere in this study. The reporter of ‘The New York Times’ interjects the story with evaluative statements meant to make it appear that the Chinese plane was at fault (the collision happened in Chinese coastline when a US Navy spy plane collided with a Chinese jet while on surveillance). In so doing, the writer identifies herself with one particular version of the story which points to bias and betrays the ideological leaning of the paper.

In the controversy surrounding Kibaki’s appointments to various constitutional offices and which Raila was opposed to, a story appeared in The Sunday Nation of Feb 6, 2011 reporting on the way the speaker of the national assembly
had handled the appointments. In reference to the to the behaviour exhibited by the PNU side of the Coalition in anticipation of their input on the appointment issue in parliament, the writer observes that ‘the seemingly excited PNU spin doctors had trooped to town, making frantic calls to journalists.’ By referring to the PNU political actors as ‘seemingly excited’ and making ‘frantic’ calls, the writer is not just reporting events but using evaluative adjectives to influence the way the reader will regard the PNU politicians. The picture created of them is that of immature people, who like children, ‘troop’ to town with the sole aim of confronting their ODM counterparts in parliament. This in effect is meant to make the reader aware of the political context in the country and influence them in making judgment of the situation.

Evaluations may sometimes assume a moral character where writers ‘commit themselves to certain values by explicitly or implicitly expressing what is right or wrong, good or bad’ (Fairclough, 2003 in Juan Li, 105). In The Standard of April 12, 2009, there is an explicit evaluation of the political situation in the country in the headline story titled ‘Country on the Cross’ meant to bring parallelism between Easter season of pain and suffering and the political situation in the country. In the last part of the story, the writer quotes the president’s Easter message of hope to the country but immediately juxtaposes it with an evaluative statement of hopelessness:

But for long suffering Kenyans dogged by many worries about tomorrow, the Easter weekend represents crucifixion in the actual sense of the word (The Standard, April 12, 2009: 7)

In this quote, the writer while reporting the events of the Easter holiday evaluates the situation in the country and gives a verdict with finality. He paints a grim picture of the situation through the evaluative compound adjective ‘long suffering’ and the use of ‘crucifixion’. In so doing, the writer is not just a reporter but one who is authoritatively evaluating and interpreting the political situation in the country for the reader. This is a common phenomenon in media discourse where the media portrays itself as the untainted moral authority that has the right to explain and interpret situations for the audience. Notable in the above quote also is the attempt to lump people together as ‘long suffering Kenyans’ to appear as if all Kenyans have a common stance to the prevailing political situation. Fairclough (1995a) refers to such a notion as ‘democratization’ which he defines as reduction of overt markers of power asymmetry between people of unequal institutional power. By ‘democratizing’ the writer wishes to persuade the reader that the proposition made is shared by the general populace and hence it is valid. ‘Democratization’, Fairclough (1995) observes, is a pervasive feature in contemporary discourse.

Against the background of Uhuru and Ruto cases at The Hague and their declared interest in vying for the country’s top leadership, the writer of the headline story of Sunday Nation, March 11, 2012: 4 wrote:

Since their indictment, the two suspects have been holding political rallies at which they have presented themselves as victims of persecution by powerful foreign forces through the ICC proceedings with the intention of killing their political dreams. In so doing, the two have resorted to hyperbole and hysteria and many in their communities have followed them

In this text there is no attempt at subtlety and the evaluation of the two people is quite explicit. The writer, beyond reporting the story where the Prime Minister was proposing that the two characters should be in jail, indicates disdain at the apparent victimhood of Uhuru and Ruto. It is notable that the writer does not refer to them by name but categorizes them as ‘the two suspects’. In so doing, he fails to give them identity and in effect ‘reduces’ their importance. Further, the use of the alliterative expression ‘hyperbole and hysteria’ is a persuasive rhetoric meant to demean and devalue the pair. As the story progresses, the writer engages in more evaluative structures:

Despite increasing odds against their possible candidatures, the two men maintained they would be in the ballot paper regardless of the proceedings (Sunday Nation, March 11, 2012)

The foregrounding of the evaluative subordinate clause to the initial sentence position is meant to emphasize the unsuitability of Uhuru and Ruto for country’s leadership and to influence the reader in sharing the view. This is further accentuated by the reference ‘two men’ meant to show the pair as ordinary people and persuade the reader to think of them as such. Leween (1996) identifies grammatical styles of referring to social actors in order to bring out certain meanings. The grammatical styles of referring are: inclusion/exclusion of social actors, activated/passivated (whether a social actor is represented as an agent or a patient), named/classified (whether a social actor is referred to by name or as a category). Making a choice on the kind of reference to use on political actors is a subjective evaluation of the characters and serves to reveal the underlying attitude towards the characters involved. In this case by using ‘two men’ the writer demeans them and in the bigger political scene, the intention is to downgrade any apparent political value that the political actors may be said to possess.

CONCLUSION
It is clear from the analysis of the newspaper texts that media seeks to guide interpretation of political situations for its audience through choice of language styles. In particular, the study has brought to fore some of the language structures
that serve to (de)legitimize political action through subjective and selective quoting of authorities to validate the media’s ideological stance. Evaluative statements and expressions are also pervasive in newspaper discourse and which makes news not just reports but ‘stories’ with oft-times biased dimension. The evaluations are meant to legitimize the actions of political actors while delegitimizing others. While we cannot tell empirically how far the media influences people towards certain directions, there is reason to believe that the media does play a significant role in shaping attitudes and opinion. The political scene in Kenya during the Grand Coalition Government was volatile and this made it a suitable period for analysis of political discourse especially from the media’s point of view.

REFERENCES

ABSTRACT
Gender mainstreaming was prioritized as a mechanism to achieve gender equality by the Beijing Platform for Action in 1995. Although since this Beijing meeting many institutions, the world over have attempted to put into practice the ideas of gender mainstreaming, the issue has not clearly been understood. While there has been some research regarding the opportunities and challenges of its implementation, very little has focused on understanding the concept, background, details and concerns of the entire topic. Through an exploratory research design and by use of documented evidence, this study seeks to provide insights towards understanding the meaning and background of gender mainstreaming in Kenya. The study will further explore the extent of research in the area in order to identify the gaps in the field. Literature on international, regional and national policies as well as declarations, coupled with the government and other stakeholders reports and academic research on the subject will be key in the study. It is therefore hoped that this study will provide a basis for establishing future research priorities in the area.

Key words: Gender Mainstreaming and Equality, Policies, Inclusiveness

INTRODUCTION
Background of the Study
Gender mainstreaming is an organizational strategy to bring gender perspective or consideration in all aspects of an institution’s policy and activities, through building gender capacity and accountability. Gender mainstreaming became necessary, especially because of the inequalities that were visible in work places and societies in general. It therefore emanates from institutionalized patterns of distributing resources, social value and power in public and private spheres worldwide (Mbilinyi 2000). The Beijing Platform for Action (BPA) of 1995 prioritized gender mainstreaming as the mechanism to achieve gender equality. Since then, member states (Kenya included) have been involved in the intergovernmental discussions on the topic and have, in consensus, adopted mainstreaming as an integral global strategy for promoting gender equality. However, nearly two decades later, there is vigorous debate as to whether this has achieved its objectives.

Although most countries have put in place gender mainstreaming polices, the implementation of these policies poses significant challenges (Valks, 2000). This is attributed to the fact that the concept has remained vague and difficult to translate into action. For many, gender is synonymous with women, thus a one-sided and biased concept. Gender mainstreaming has also been adopted as a matter of compliance, without a complete transformation of the institutions. This leaves organizations addressing gender, but in the real sense not thinking gender (Wendoh, 2005). A change of attitude is thus necessary to achieve the intended purpose of gender mainstreaming. For this change to happen there must be factual information to create understanding. This study therefore aims to explore the concept of gender mainstreaming in order to provide more insights into appreciating and grasping the concept, establish the strategies that have been developed to this end and suggest possible avenues for future research on gender mainstreaming.

Objective of the Study
- Understand the genesis and evolution of gender mainstreaming,
- Explore the laws, policies, guidelines and practices of gender mainstreaming in Kenya,
- Identify the gaps and suggest possible avenues for future research on gender mainstreaming.
opportunities and relationships socially construed and learned through socialization process (Engender Health 2005).
The National Commission on Gender and Development (2009) defines gender as the state of being woman or man in a particular society or culture; the social characteristics ascribed to men, women, boys and girls. Society teaches expected attitudes, behaviours, roles, responsibilities, constraints, opportunities and privileges of women, men, girls and boys in any context, which is often called learned behaviour, or gender identity. Gender is thus a social, rather than a biological construct, and varies with the roles, norms and values of a given society or era. Being able to bear a child is, fundamentally, a function of biology, while expectations about the nature of parenting, or status associated with being a mother or father are more closely linked to gender roles and expectations.

Gender is learned through the process of socialization. It is not static or innate, but evolves to respond to changes in the economic, social, technological, political and cultural environment. People are born female or male (sex), learn how to be girls or boys and then become women or men (gender). Gender roles unlike sex are created by society and thus are socially determined and vary among cultures. The set up in many societies, especially in Africa where patriarchal suction were strong ensured that men accrued more advantages from the societal activities. Women were more often than not relegated to the level of second class citizens. Many societies in Africa have been patriarchal since time immemorial, whereby the male acts as the leading authority figure in a social organization. In a patriarchal society, fathers hold authority over women, children, and property. Patriarchy therefore implies male rule and privilege, and entails female subordination. Schipper (1987) argues that in any given cultural context in Africa “male and female behaviour patterns are fixed by norms and anyone who tries to break the rules can meet with serious problems in a community in which the ruling group produces images and conceptions of the others to legitimize the status quo” (35). Patriarchy ensures that it is the male who is in control and therefore in such societies women are expected to venture only in territories that men endorse. Men have therefore tended to take leadership positions, for example, by belonging to councils of elders where women cannot belong. Since gender role expectations has culturally relegated women to the house-hold level, they have limited access to communal resources, are under-represented in public decision making bodies, have limited bargaining power in labour markets and often lack opportunities to improve their social economic position (Bryan and Varat, 2008). Deliberate efforts to bring them to the limelight are therefore essential, which is the main agenda in gender mainstreaming.

**Gender Disparities**

Gender disparities in terms of opportunities, security, and participation have become important issues for developing economies, and in particular for Africa (World Bank, 2010). This is why gender equality is now among the aims of most poverty reduction strategies and also one of the United Nations Millennium Development Goals (MDGs 3). In the context of gender inequality, gender disparities in labour markets are especially important. Literature shows that in a number of African countries women are less likely to be in paid jobs, are disproportionately concentrated in informal and precarious employment and are usually paid less (ILO 2002; Nordman 2009).

Various factors have been identified to explain the causes of gender gaps at the labor market. For example, according to the World Bank (2010) differences among individuals, especially in human capital in terms of education and training play a major role. This is mainly contributed by the fact that women have less available time to work in the job market because of their domestic chores. Besides, women lack access to credit, which is probably strongly influenced by their relative inability to control collateral since men own or otherwise control a larger share of capital than women. This contributes to the lesser incomes of women which lead to inequalities not only at the labor market but also within the household in terms of decision making power.

In Kenya, women experienced social, economic and political inequalities in relation to men throughout the colonial period where education and paid labour used by settlers was given to men (Mueller and Mulinge, 2001). According to Luise White (1988), those men who migrated and got jobs in the colonial city of Nairobi in Kenya were provided with very small rooms for accommodation by their employers. Provision of such small rooms was an attempt to restrict numbers in a household or precaution so that women or the wives of those men could not move to the city and live with them. This arrangement ensured that women and children stayed in the rural area and it resulted to underrepresentation of women in paid labour. Even after independence, the role of women did not seem to get into the public life. For example, women representation in parliament remained negligible between 1963 to 2007 as shown in Table 1. The Table shows that women were for a long time sidelined in matters of politics. While it is women’s own initiative to campaign and be elected that gets them into parliament, the most likely thing is many electorates, including women, are not keen to elect women MPs because of the ingrained patriarchal tendencies.
Table 1. Gender representation and participation in Kenya’s Parliament: 1st to 10th Parliaments

<table>
<thead>
<tr>
<th>Parliament</th>
<th>Time/ Duration</th>
<th>Total No. of Constituencies</th>
<th>Total No. of Women MPs</th>
<th>No. of Elected Women MPs</th>
<th>No. of Men Nominated to Parliament</th>
<th>No. of Women vs. Number of Men Nominated to Parliament</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Parliament</td>
<td>1963-1969</td>
<td>158</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>Women 2</td>
</tr>
<tr>
<td>2nd Parliament</td>
<td>1969-1974</td>
<td>158</td>
<td>2</td>
<td>1</td>
<td>10</td>
<td>Men 10</td>
</tr>
<tr>
<td>3rd Parliament</td>
<td>1974-1979</td>
<td>158</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>Women 2</td>
</tr>
<tr>
<td>4th Parliament</td>
<td>1979-1983</td>
<td>158</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>Men 10</td>
</tr>
<tr>
<td>5th Parliament</td>
<td>1983-1988</td>
<td>158</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>Women 1</td>
</tr>
<tr>
<td>6th Parliament</td>
<td>1988-1992</td>
<td>188</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>Men 10</td>
</tr>
<tr>
<td>7th Parliament</td>
<td>1992-1997</td>
<td>188</td>
<td>7</td>
<td>6</td>
<td>1</td>
<td>Women 1</td>
</tr>
<tr>
<td>8th Parliament</td>
<td>1997-2002</td>
<td>210</td>
<td>9</td>
<td>4</td>
<td>5</td>
<td>Men 5</td>
</tr>
<tr>
<td>9th Parliament</td>
<td>2002-2007</td>
<td>210</td>
<td>18</td>
<td>10</td>
<td>8</td>
<td>Men 8</td>
</tr>
<tr>
<td>10th Parliament</td>
<td>2008-2012</td>
<td>210</td>
<td>22</td>
<td>16</td>
<td>6</td>
<td>Men 6</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>50</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


The nomination statistics also show this bias because as late as 6th parliament (1988-1992), there is evidence of zero nomination of women to parliament as compared to ten men who were nominated during that period. Although the number of women in parliament increased in 7th to the 10th parliament, disparity is still visible which called for the rule inclusiveness, where two thirds of MPs were supposed to belong to either gender. Were it not for such statistics then the situation would not have changed even in the 1st parliament. What remains at stake is whether such opportunities are given to women willingly or it is just a matter of compliance to the rule.

In the private sector, evidence of non-inclusiveness in gender terms is vividly evident. For instance, by the close of 2012, 34% of the 57 listed companies did not have a woman in the board. There was only one female chair in a listed company by the end of 2012, a figure that rose to only 5 by the end of 2013. Moreover, women take about 15% of wage employment in manufacturing, building and construction, electricity and water sectors. (NGEC 2013). This shows there is still need to work on the revision of the situation by enacting the policy of inclusiveness in such companies.

Meaning and Strategies for Gender Mainstreaming

As showed at the beginning of this article gender mainstreaming is a strategy that has strong roots in the Beijing Platform for Action (1995) that requires governments and other actors to promote an active and visible policy of mainstreaming a gender perspective in all policies and programmes. With gender mainstreaming strategy, gender concerns are seen as important to all aspects of development, for all sectors and areas of activity and a fundamental part of the planning process. According to Hazel and Sally (2000), political as well as technical skills and goodwill are essential to a mainstreaming strategy, with organizations using mainstreaming tools like gender training and introduction of incentive structures which reward efforts on gender dimensions.

A study by the Public Service Commission (PSC) of South Africa (2006), revealed three key components of gender mainstreaming, that it is about:-

(i) Bringing about institutional changes to ensure the empowerment of both women and men through equal participation in decision-making on issues which affect their lives;
(ii) Analyzing all government policies and practices to examine different impact they have on men and women;
(iii) Providing training and capacity building to enhance gender management skills and raise the general level of gender awareness and thus enhance change of attitudes and behaviors of individuals and organizations.
The concept of gender mainstreaming differs from previous efforts to integrate women’s concerns into government activities in that it does not add a component of women to the existing policies, plans and programs but brings in a gender perspective to all these stages and in every aspect of the decision making process.

Unlike some perspectives like women empowerment that purely relate to women, significantly, gender mainstreaming takes an unbiased approach as it does not hold an assumption about women’s disadvantage but rather a thorough and rigorous analysis of the development situation. Such an analysis almost invariably reveals gender-differentiated needs and priorities, as well as gender inequalities in terms of opportunities and outcomes, which gender mainstreaming then seeks to redress. Analysis will determine the level of priority and the degree of intervention that should be accorded to solving these problems. Given the above, it is clear that a gender mainstreaming approach does not necessarily make the need for specific policies, programmes or projects on gender equality obsolete. According to the DGD (1999) report, the level of and GM intervention should entirely dependent on the specific needs and priorities revealed by a gender-sensitive situation assessment.

Although the government of Kenya recognizes the importance of providing equal opportunities for all its citizens, Kenya is ranked among the ten most unequal countries in the world and the most unequal in the Eastern Africa region (Kihara, 2005). For instance, in education, disparities are not only reflected in students’ admission but also in the recruitment and promotion of academic staff and managers in the university with women forming a small percentage in all cases (Onsongo, 2011).

The Need for Gender Mainstreaming
Gender mainstreaming is an essential part of good governance and is critical if a country wants to ensure that institutions, their policies and programmes respond to the needs and interests of all employees, and distribute benefits equitably between men and women (UN, 2001). Gender mainstreaming considers both sexes and not just women. At the same time while gender mainstreaming is a move away from women-specific initiatives, it is important to recognize that women have different needs and priorities from men and are therefore affected differently by policies and development interventions.

Mainstreaming of policies does not occur in a vacuum but are devised in institutions which are already gendered in ways that undermine women and their interests. In addition, gender mainstreaming is taken up by individuals in authority, who by the very nature of gender imbalance in leadership, happen to be men who might have their own interests in keeping the existing gender order intact. When this happens, the strategies can end up entrenching existing power imbalances (Wendoh and Wallace 2005). Often the resistance to gender equality hides behind an acceptance that gender equality means nothing more than employing more women, leaving the culture, rules and procedures of institutions unchanged. For true gender mainstreaming to happen, the forces that reinforce the status quo must be challenged.

Link between Gender Equality and Gender Mainstreaming
Gender mainstreaming is a strategy for promoting gender inclusiveness. The strategy seeks to ensure that any policy formulation is informed by consideration of gender differences and inequalities and efforts made to narrow gender gaps and support greater equality between men and women. Paragraph 79 of the Beijing Platform for Action makes the distinction by advising governments to address the inequality between men and women in the sharing of power and decision-making at all levels, through active and visible policy of mainstreaming a gender perspective. Mainstreaming is not about adding a gender equality component to an existing activity, but involves putting gender equality issues at the centre of policy decision, government budgets and institutional structures and processes.

LEGAL FRAMEWORKS FOR GENDER MAINSTREAMING
Kenya applies international, regional and national legal framework to address gender mainstreaming in her jurisdiction. This session reviews laws and declarations at international, regional as well as national levels that address gender mainstreaming.

REGIONAL LEGAL FRAMEWORKS
These are instruments promulgated by the African states and Heads of governments that govern the member states.

Protocol to African Charter on Human and People’s Rights on the Rights of Women in Africa
The protocol was adopted in Maputo in 2003 and ratified in 2005 by member countries of the African Union, including
Kenya. It recognizes that culture, traditions and customs are major obstacles to achievement and full enjoyment of human rights of women. The protocol requires that states parties shall take specific positive action such as enacting laws that clearly stipulate and encourage the participation of women in the political life of their countries on equal footing with men. These affirmative actions, national legislation and other measures should ensure that women participate without any discrimination and are equal partners with men at all levels of development and in the implementation of development policies and programmes. States Parties should ensure increased and effective representation and participation of women at all levels of decision-making.

The protocol calls for States Parties to enact laws to guarantee equal opportunities for women and men in work and career advancement and access to other economic opportunities. This can be achieved through equal access to employment, equal pay for jobs of equal value and encouraging women working in informal sector to have social security. In addition, member countries are required to take the necessary measures to recognize the value of the work of women in the home and recognize that both parents bear the primary responsibility for the upbringing and development of children. This is meant to protect women against the oppression created by patriarchy which delineate women into domestic work which cannot usually be quantified in economic terms.

Solemn Declaration on Gender Equality in Africa
This Declaration was passed by the Heads of States of the African Union in 2004 at Addis Ababa, Ethiopia to reaffirm their commitment to gender equality. In Article 5 of the declaration, the governments committed to expand and promote the gender parity principle at the national as well as the local levels in their respective countries. As an accountability measure, Article 12 commits the members to report annually on the progress made in terms of gender mainstreaming. The declaration was meant to keep watch on the members and synergize each other and hold one another accountable as regards to implementation of gender mainstreaming actions.

INTERNATIONAL LEGAL FRAMEWORKS
International Frameworks are benchmarks for state parties in assessing their obligation and responsibility in matters of human rights for the enjoyment of the citizenry. State parties commit themselves to uphold and guard the rights of their citizens through the application and enforcement of these instruments within their borders. As a state party, Kenya is bound by the rules of the international instruments or treaties ratified by her.

Convention on the Elimination of all Forms of Discrimination against Women (CEDAW)
CEDAW (1979) is the United Nations instrument for human rights of women. It has been applauded as the first instrument in the United Nations history that is dedicated specifically to the human rights of women globally (National Commission on Gender and Development, 2010). The Convention defines discrimination against women as any distinction, exclusion or restriction made on the basis of sex which has the effect or purpose of impairing or nullifying the recognition, enjoyment or exercise by women, irrespective of their marital status, on a basis of equality of men and women, of human rights and fundamental freedoms in the political, economic, social, cultural, civil or any other field. The constitution of Kenya 2010 guarantees equality and freedom from discrimination for both men and women. Article 27 (3), for example, states that “Women and men have the right to equal treatment, including the right to equal opportunities in political, economic, cultural and social spheres”, while article 45 (3) guarantees married couples equal rights at the time of the marriage, during the marriage and at the dissolution of the marriage. In addition, article 81(b) states that not more than two-thirds of the members of elective public bodies shall be of the same gender, showing that women are expected to be given a space in the electoral process. Article 29 (1, 8) provides women and men with three months and two weeks maternity and paternity leave respectively, which show a recognition of the role that women play in domestic work. While these provisions are geared towards according women space to rejuvenate and giving them opportunity to develop, the provision on longer maternity leave and an acknowledgment that they should not forfeit annual leave on account of having been on maternity leave (29, 7) still shows that women should be given special attention. This then means that mainstreaming is not equality because however much women would be willing to be equal to men they would still find themselves disadvantaged because nature demands that they perform certain duties like suckling infants and taking special care especially during the toddler days.

The Beijing Platform for Action (BPFA)
In 1995, women representatives from 180 United Nations Member countries, Kenya included, gathered in Beijing, China, for the Fourth World Conference on Women and signed the Beijing Declaration and Platform for Action, a document containing issues and concerns of the world’s women. In the Declaration was an item that there should
be nondiscriminatory treatment of women and men in economic and other matters. The document recognized the lack of gender perspectives from governmental decision making particularly in educational systems as a challenge to women. It asked organizations, including trade unions to push governments to commit themselves to numerous actions including researching gender issues and taking appropriate actions to address them. Although the Beijing platform is not binding and has no mechanism for redress, implementing its recommendation would be an effort for Kenya to enhance national development in line with Vision 2030 and other national instruments. What remains for researchers therefore is to find out the extent to which the declarations at this conference have been implemented and the practical implications of their suggestions.

**International Labour Standards**

The International Labour Organization (ILO) is a United Nations agency founded in 1919 to regulate international labour standards in the world. ILO pursues its vision based on the premise that universal lasting peace can be established only if it is based on social justice. It aims to promote rights at work and encourage decent employment opportunities. In its gender policy, ILO supports a two-pronged approach to gender mainstreaming, that is, systematically analyzing and addressing in all initiatives the specific needs of both women and men, and targeted interventions to enable women and men to participate in and benefit equally from development efforts.

**Vienna Declaration and Programme of Action 1993**

The Vienna Declaration recognizes the fact that gender based violence is incompatible with the dignity and worth of the human beings and calls on state parties to work towards the elimination of violence against women and girls in all spheres of life including public and private life. Paragraph 18 stresses that full and equal participation of women in political, civil, economic, social and cultural life, at the national, regional and international levels, and the eradication of all forms of discrimination on grounds of sex are priority objectives of the international community. It recommends establishment of legal measures through national action and international cooperation in such fields as economic and social development, education, safe maternity and health care, and social support.

**Universal declaration of Human rights**

This Declaration was adopted by the UN General Assembly in 1948 as a result of the experiences of the Second World War. With the end of the war, and the creation the United Nations as a body in 1945, the international community vowed never again to allow bloodshed like that of the conflict to happen again. The Universal Declaration of Human Rights contains 30 items which must be respected regardless of gender or other characteristics of human beings to promote an equal and just society.

**NATIONAL LEGAL FRAMEWORKS AND GUIDELINES**

Kenya has a volume of laws policies and guidelines that address Gender mainstreaming. Major among the laws are the Constitution 2010, Employment Act 2007, the Penal Code and The Sexual Offences Act. Besides, the national policy for gender mainstreaming includes the national gender and development policy, gender equality and development Sessional paper No.2 of 2006, National Framework Towards Response and prevention of Gender Based Violence in Kenya and the National Vision 2030. The National Gender and Equality Commission (NGEC) is the country’s arm for promoting gender equality in Kenya. All these policies are meant to ensure that there is minimal gender discrimination in all matters.

The constitution of Kenya (2010) expressively recognizes the need to get women in employment and public participation. This principle is clearly stated in Article 27 (8) that the State shall take legislative and other measures to implement the principle that not more than two-thirds of the members of elective or appointive bodies shall be of the same gender. Article 81 further reiterates that not more than two-thirds of the members of elective public bodies shall be of the same gender. However, statistics show that by 2013, the two-thirds gender principle is yet to be achieved in key areas of government institutions as represented in figure two.

Table 2 shows that gender mainstreaming is a project that is more actualized on paper than in practical because majority of positions in parliament and parastatals are headed by men. More research is therefore needed to reveal the real cause of such disparity so that they can be addressed. In addition to the employment act discussed earlier, which exempts women from working during certain hours and in certain places like the mines, there are other laws in Kenya that either give priority to women or clarify the course of action for both men and women. For example, one of the broad objectives of the ministry of gender in Kenya is to promote gender mainstreaming in national development processes,
and engender the national budget. The Ministry is also mandated to review and implement gender responsive policies and programmes in order to promote women’s rights and economic empowerment. The ministry further promotes interventions for the reduction of sexual and gender based violence.

Table 2. Gender Representation for Elective and Nomination Position at National Level in the 11th Parliament

<table>
<thead>
<tr>
<th>Position</th>
<th>Total Number</th>
<th>No. of Men</th>
<th>No. of Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governor</td>
<td>47</td>
<td>47 (100%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Deputy Governor</td>
<td>47</td>
<td>38 (81%)</td>
<td>9 (19%)</td>
</tr>
<tr>
<td>Elected member of National Assembly</td>
<td>290</td>
<td>274 (95%)</td>
<td>16 (6%)</td>
</tr>
<tr>
<td>Nominated member of National Assembly</td>
<td>12</td>
<td>8 (67%)</td>
<td>4 (33%)</td>
</tr>
<tr>
<td>Elected Senate Member</td>
<td>47</td>
<td>47 (100%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Nominated Senate Member</td>
<td>20</td>
<td>2(10%)</td>
<td>18 (90%)</td>
</tr>
<tr>
<td>Cabinet secretary</td>
<td>18</td>
<td>12 (67%)</td>
<td>6(33%)</td>
</tr>
<tr>
<td>Principle Secretary</td>
<td>26</td>
<td>19 (73%)</td>
<td>7 (27%)</td>
</tr>
<tr>
<td>Head of parastatals</td>
<td>36</td>
<td>34 (94%)</td>
<td>2 (6%)</td>
</tr>
</tbody>
</table>

Source: National Gender and Equality Commission (2013)

Article 19 of the Revised Edition (2009) of the Kenyan penal code stipulates that a married woman takes responsibility of a criminal offence she commits whether in presence of her husband or not, unless where there is prove that the offence was committed in the presence of, and under the coercion of, the husband. In addition, article 21 of The Sexual Offences Act, No 3 of 2006, shows that females will be punished in the same measure as the males (article (20) in case they are involved in incest. This means that the female person is regarded in her own capacity when it comes to criminal affairs and not under the protection of man as patriarchy is wont to imply.

RESEARCH ON GENDER MAINSTREAMING IN KENYA

Many scholars have attempted to uncover the problematic of gender inequality in Kenya and the extent to which this gap has been bridged, as compared to the international regional and national policies outlined above, in order to ensure inclusiveness of women in all areas of operation. Such studies are for example visible in forestry (Kaudia and Obonyo, 2007). In addition, Björg Ryan (2007) examines how Action Aid Kenya (AAK) administers the programme, advocates, implements and develops gender mainstreaming and empowerment at various levels in the Kenyan society. From this research, he concludes that there is coherence in how AAK and Sida interpret the concepts of gender mainstreaming and empowerment. AAK focuses more on capacity-building and on women and girls, and their ability to be recognized as equal members in Kenyan society. These two organizations regard women’s issues as playing an important role in fighting poverty.

Ryan however notes that the biggest problem is the lack of political will when it comes to the question of promoting gender equality. He reiterates that many relevant frameworks and tools have been developed the new governmental national machinery for promoting gender equality in Kenya, but they are not used. He adds that the presence of rampant poverty and the lack of education mean that the focus of many people is to survive the next day. They are not aware of, or have no access to, information and are unable to understand the opportunities that are available. Ryan sees hope in the new decentralized authority (CDF) that the government has decided on has given people access to, and more influence in, the local decision-making process, which is an important governmental framework change, that is hoped to make the achievement of gender mainstreaming and empowerment more likely in communities all over the country. This could form a foundation for future research questions.

Ponge’s (2013) research on gender mainstreaming and women empowerment in political party process in Kenya reveals that increase of women presence in the key decision-making organs has not resulted into key influence within the party hierarchy and has not been seen to impact on party affairs and activities as this is still under the tight grip of men. More gender equality in terms of participation in education has not resulted in more gender equality in the areas of political economy. It is therefore clear that the number of women has increased in decision-making positions, but women still face a number of challenges in these critical areas of development.
On gender mainstreaming in Kenyan schools, Sang, Masila and Sang (2012) show that much more need to be done to achieve gender equity in administration of secondary schools in Kenya and they suggest an introduction of a quota system that allocates slots for female administrators. They also propose that training programmes could be necessary to equip administrators with leadership skills and also encourage female principals.

All these researches reveal that Kenya is far from achieving the requirements of gender mainstreaming policies. This means that more work and research is needed to aid in not only discovering the extent to which implementation has taken place but also what causes the failure to implement these policies.

CONCLUSIONS AND RECOMMENDATION
This study aimed at understanding gender mainstreaming, the international, regional and national policies that advocate for gender mainstreaming and finding the gaps that are visible in the process of understanding the policies of gender mainstreaming and implementation so that more studies can be done to fill up such gaps. From the overview done in this study, it is clear that the concept of gender mainstreaming differs from previous efforts to integrate women’s concerns into government activities in that it does not add a component of women to the existing policies, plans and programs but brings in a gender perspective to all these stages and in every aspect of the decision making process. Mainstreaming therefore is not about adding a gender equality component to an existing activity, but involves putting gender issues at the centre of policy decision, government budgets and institutional structures and processes. Gender mainstreaming therefore, does not imply equality. It is however clear that however much women would be willing to participate in all activities, they would not make it to similar levels with men, as women still find themselves disadvantaged by natural demands like giving birth, suckling infants and taking care of them at night. The capacity within the woman’s body may also not allow her to work in certain areas like men, which calls for exemption from such jobs, - meaning that the policy of inclusiveness may not after all work naturally.

The laxity or failure for gender mainstreaming to take place effectively could also be attributed to the fact that opportunities are most likely given to women, not willingly, but just as a matter of compliance to the rule. It is also evident that gender mainstreaming is taken up by individuals in authority, who by the very nature of gender imbalance in leadership, happen to be men who might have their own interests in keeping the existing gender order intact. The biggest problem in Kenya for example, is the lack of political will in promoting gender equality, despite the many frameworks and tools developed to promote it. In addition, poverty and the lack of education makes many people desperate in looking for food and means of survival which are more relevant to them that thinking about gender issues. This means that because of lack of proper education, strategies of gender mainstreaming cannot be completely effective in Kenya as many people have no access to information and are sometimes not aware about this information so they are unable to understand the opportunities that are available.

Our study suggests that implementing the declarations and recommendations on gender mainstreaming put forward at international, regional and national levels would be an effort for Kenya to enhance national development. For true gender mainstreaming to happen, the forces that reinforce the status quo must be challenged because the resistance to gender equality hides behind an acceptance that gender equality means nothing more than employing more women, leaving the culture, rules and procedures of institutions unchanged, and this does not help.

Since, as mentioned above, gender mainstreaming often fails because of failure by the female figure to access education levels comparable to those of men, which is attributed to the said natural demands on women, more research is needed in higher institutions of learning in Kenya to gauge the level of gender inclusiveness. In addition, the extent to which the national, regional and international declarations on gender mainstreaming have been implemented and the practical implications of such declarations should be examined. More so, the effect that the decentralized authority (the devolved government) in Kenya has on matters of gender mainstreaming and empowerment should be looked into to gauge whether the situation has changed.

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A COMPARATIVE STUDY OF AFRICAN INDEPENDENT CHURCHES AND NEW RELIGIOUS MOVEMENTS IN KENYA

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ABSTRACT

Kenya is the home of a larger number of African Independent Churches (AICs) than many other African countries are. One can also find a great number of them in for example Nigeria and the countries of Southern Africa, while there are not very many in Tanzania or Uganda, both immediate neighbours of Kenya. One question that revolved in my mind was: if those independent churches are able to attract people, does that not mean that they have achieved to strike a cord in their “followers” that the New Religious Movement has tried to strike. And secondly: May they be more successful in their effort to give an African face to Christianity? It would clearly go beyond the scope of this paper to explore the effort of New Religious Movements in achieving to illustrate the Christian faith into the African context. There is strong reason to question how much of the respective concepts being worked out as New Religious Movements are
actually finding their way to the “ordinary” church members. This paper will compare the AICs with New Religious Movements in Kenya to assess the strengths, weakness, opportunities and threats of the movements based on their different contexts. It will also trace the influence of Pentecostalism and future prospects of AICs. Other features that will play an important role here are issues such as the ways of worshipping, the specific teaching and doctrines, the gender issue and the ways of evangelizing.

Key Words: Africa, Christianity, Churches and Independent churches

INTRODUCTION

The first group of Africans to embrace Christianity would appear to be those who were regarded by Africans as social outcasts and the down trodden such as lepers and others who suffered various forms of social disabilities in traditional African societies. There were those Africans who rejected the message of Christianity and stuck to their religious and cultural traditions of their forefather, seeing in them more meaning and significance than what the missionaries preached. Finally there were those who chose to adapt the new religion by founding what have come to be known as separatist or Independent Churches. These churches were of two main types, those which broke away from already existing Independent Churches and those which sprang up independently of any existing religious groups. In most instances these churches sought to incorporate larger measures of African beliefs and practices into Christian life than was permitted in churches under missionaries.

The AICs in this paper refers to the religious movement, founded in African by Africans and have therefore not been started on African soil as offsets of European or North American churches by missionaries sent for that purpose. The Organization of African Instituted Churches (OAIC) in Nairobi which is an important umbrella organization having many AICs as members. This paper has borrowed Kagema and Maina definition of NRM “as religious founded by pastors/ preachers/ individuals with charisma in response to social, political, economic and religious changes in the contemporary Kenya Society” (Kagema and Maina, 2014: 35). Other features that played an important role in this paper were issues such as the ways of worshipping, the specific teaching and doctrines, the gender issue and the ways of evangelizing. Moreover, this study has assessed the strengths, weakness, opportunities and threats of the movements based on their different contexts.

Background of the History of AIC churches in Kenya

The first big influx of missionaries in Kenya, came only in the second half of the 19th century. Driven by the idea that the faith and culture they brought from Europe was to fit, to be of benefit for all mankind. Most of those first missionaries had little time for the ideas that today we would summarise under the term inculturation. They set up the local congregations and structures of the church parallel to what they were familiar with at their home countries. For the purpose of being able to spread the “good news” more effectively many of them were ready to go through the hardship of learning the indigenous languages with no grammar books and dictionaries available and there must have been a lot of genuine concern for the understanding of the local culture and heritage.

Despite that one has to decry the widespread racism that often influenced the daily work as well as the general attitude of the white clergy sent to spread Christianity in a world perceived as savage and utterly uncivilized. It was the age of new imperialism and many African Christians were able to see through the mixture of concern for the gospel and the concern for the colonization of their people, which in some cases made them to leave the church and in some of those cases again to start an own Christian movement using the familiar structures and offices on a much smaller scale. Often it was such critical minds, coupled with charismatic talent of leadership that brought into being the AICs. Many early missionaries displayed fundamental human weakness behaving cruelty and harshly towards Africans. Others stood firm yet on the side of their people and were ready to speak out loud against their fellow Europeans in the colonial government or from the white settler community. Among the issues bringing about a lot of controversies was the question as to whether members of polygamous families could become Christians (baptized). It was not only the polygamous men that were excluded from baptism in many cases but also the second, third, fourth wives etc. and even their children. The attitude of the missionaries towards the indigenous culture and religion was generally disastrous.

In their well known work “A place to feel at home”, F.B. Welbourn and B.A. Ogot have tried to show, that the emersion of independent churches in Nyanza lead to a “localization” or “indigenization” of Christianity in the region. By being a local response to the problem of how to translate the Christian dogma to the African world of thinking and worshipping and especially by being churches on a smaller scale, ready to adopt to local problems, the two authors hold that these churches become a “place to feel at home” for the local Christians. According to their findings, the independent
churches could “because they were small, and local, and led by Africans, [...] preach a message which was at all points felt to be relevant to the social and material problems of its members. They could provide homes in which mythological and empirical factors were felt, as in traditional society, to be inextricably linked” (Welbourn and Ogot. 1966). Following Ogot and Welbourn, one can therefore conclude that there was and is a conscious effort of AIC to look for answers to the challenge of cultural change in Africa. A challenge that has left so many people “homeless” in spiritual and emotional term, but also in concrete social term.

Examples of the Independent Churches in Kenya also referred to as “spiritual Churches” African Independent Pentecostal Church, Church of Maria Legio, Church of Christ in Africa, Musanda Holy Ghost Church, Nomiya Church, Holy Trinity Church in Africa, African Israel Church Nineveh, African Divine Church, Power of Jesus Around the World, Church of Peace in the Africa, Sayun Church of God in East Africa, Musanda Holy Ghost Church of East Africa, Miracles and Wonders Church, Nomiya Fueny Maker Church, Ruwe Holy Ghost Church in East Africa, Mercy and Holy Ghost Church, Power of Jesus Around the World, Musanda Christian Church of Kenya, Coptic Orthodox Church, Sayun Church of God East Africa, Voice of Salvation and Healing, Roho Revelation Church etc. (Verweyen, 2001).

Beliefs, teaching and doctrine of AIC

Any doctrine of the church has to come from the bible. In most of the AICs the text of the bible is regarded to be literally binding. This bible-fundamentalism is found in almost all Evangelical and Pentecostal churches and is a very strong religious driving force that gives the members a sense of being on very secure ground. Together with the conviction that “to have the Spirit is enough” it has been a reason why in the past, members of independent churches have laid very little accent on theological education. There is a set of rules that seems to be a continuation of Traditional Religion. This includes the purification rules of women after menstruation and after having given birth as well as other rules referring to ritual purity. The rule of 33 days of staying out of the church after the birth of a boy and 66 after the birth of a girl must be seen in this line also. The strong connection between being “saved” and the abstinence from alcohol is a very important concern of NRM and Independent Churches in Kenya. It is regarded almost as important as the teaching about salvation itself. Most probably this is a continuation of the Puritan tradition brought along by Pentecostal and Evangelical missionaries. Smoking of tobacco can or can not be included in this package of moral laws. It is remarkable that for many “born again” Christians to go to a disco hall is considered to be equal to acts of adultery or other improper behaviour by AICs (Verweyen, 2001).

Dancing plays a very central role in African traditional culture. It is however well known that traditional dances often include movements of the bodies suggesting sexual connotations. It is possible that the strong rejection and even condemnation of traditional dancing by the early missionaries still resounds in the refutation of discos by many Independent Churches. The teaching about polygamy generally differs between mission churches and AICs. What is important for a particular church often becomes transparent in the feasts and events that are celebrated during the year. The fact that Christmas is generally considered to be more important. Considering the history of the founded earlier than the beginning of the 20th century, many of AICs would celebrate the day of foundation, which is usually the day when the new church broke away from the mission church or the day when it was officially registered. The importance of the Holy Spirit and of the gifts of the Spirit are valued so much in many AICs that it would seem strange not to commemorate this important biblical event with a special feast day. They speak in tongues and are possessed by the Spirit every Sunday.

Evangelization

The answers to the question “how does your church evangelize, how does it get new members” do not provide a very clear picture. NRM have a definite strategy that consists mainly of so-called “crusades”. “Crusades” in this context are open-air gatherings featuring an enthusiastic preacher (usually accompanied by an equally enthusiastic interpreter) and a musical band playing gospel music and other religious songs. They usually aim at converting the listening people to “allow Jesus to take control of their lives”, to become “born again Christians”, but not so much to convince them to join a particular church. “Door-to-door” or “house-to-house” evangelism is a method of spreading the gospel that is practised in a number of AICs and that also has its origins in the practice of NRM. African Divine Church (ADC) is very active in organizing open air gatherings accompanied by singing and dancing. According to these statements this presence in many public places (mainly open-air markets) is the reason why this church is spreading very fast and is well known to many people (Barrett, D.B. (ed.) 1973).
One could compare the pattern found in the AICs toward the issue of gender with the traditional division of the roles and tasks of men and women in the African society: Men take the overall leadership and are extremely defensive about this. Women however have certain areas of responsibility within which the “rule” in every aspect and men would not even think of “intruding”. The fact that women can perform some responsibility in the church as pastors shows that some independent churches have moved much further, gender equality in AICs as a whole is far from being a reality or a manifested objective for the near future.

New Religious Movements

Over the past few years, the number of smaller crusades has risen steadily and at the same time there is an upsurge of “miracle centres” in Nairobi and other big Kenyan towns that offer a much more regular service. The most striking element these new “centres” and “chapels” have in common is the “Gospel of Prosperity”. The founding of churches is a career open to talent, for which no formal qualifications are needed.” The remarkable economic success of the above mentioned “Universal Church of the Kingdom of God” or of a number of American TV-preachers serve as an example for local people to try to carry out the same model in Africa. The principle means of receiving income for such churches or “centres” is what they term “tithing”, the giving of 10% of the wealth of the faithful to God. What people are made to believe is, that God will reward them one hundredfold more if they give part of their wealth to the particular movement and its leader. References to the bible are made by citing Genesis 14:18-20, or Malachi 3:8-10. To enhance the spirit of giving, “testimonies” of people are usually presented, who visit the prayer meetings and tell their “story of success”. Whilst this practice of “tithing” is a sure way for many of the leaders of such movements to acquire immense wealth, it is also a part of a philosophy, that associates poverty and sickness with lack of faith or even the devil. Wealth and Health are consequently sure signs of faith and trust in God. At the same time however the Prosperity Gospel also provides a welcome justification for the (relatively newly) acquired riches of an urban higher class (Hastings, 1994).

Those very few “lucky ones” who have been able to climb into the range of higher income earners see themselves engulfed by poverty, by countless members of the urban poor who pose a constant threat and challenge to them. They want to find a way on how to combine their faith with their wealth and naturally react very irritated when hearing of church policies like the “new option for the poor”, or the “solidarity with the underprivileged” As we have seen, NRM services are famous for their liveliness and the enthusiastic congregation celebrating them. NRM go far beyond that: Their Sunday meetings are nothing short of big shows, well orchestrated, with a clear plan as to when the climax has to occur and a clear arrangement of seats for the audience and the stage for the leader, whose personal performance is the centre of the show. Very often the places of worship are cinema halls, where large crowds can gather and where the show has its most effective ambience. The best known example in Nairobi is Pastor Pius Muiru’s “Maximum Miracle Centre” at the Odeon Cinema, the “Winner’s Chapel”, a movement that originated in Nigeria, “ Deliverance Church” “Achievers’ Chapel”, “ Nairobi Chapel”, “Overcomers’ Chapel”, “Destiny Ministries”, “Abundant Life Ministries” etc. are very popular and there is hardly anybody in Nairobi who has not heard of them. For apparent reasons, the success of NRM is bound to the towns and to an audience able to speak English, or at least Swahili. At the same time it is important to note, that along with an ever increasing mobility (for reasons of trade, education, employment etc.) and rate of urbanization in Kenya, the number people exposed to town life is also constantly on the rise. This is one reason why it has to be expected that more and more people are going to hear of such “miracle services” and possibly take part in them, especially since such “centres” are no longer found in Nairobi and Mombasa only, but also in many smaller towns (Burgman, 1990).

Future prospects of AICs

Although it is questionable, whether the NRM will eventually prompt the fast decline of the AICs which belong to an “older image of Kenya if not an older generation of Kenyans”, Shorter’ assessment of the situation certainly has its merits. The rural areas, which are still the strongholds of AICs, will continue to loose significance in favour of the towns, where people are more and more confronted with a fast changing world. One has to consider the fact that growing urbanization first and foremost means the influx of young people to the towns and away from the rural areas. This in turn means that the rural strongholds of the AICs will more and more depend on the older generation. The rural areas around the major towns in Western Kenya still have a strong influence on the urban life and the AICs with specific ethnic membership will continue to play an important role among those ethnic communities in Kisumu and Kakamega town for instance. When attempting an outlook at the future of AICs, in Kenya, the following aspects are likely to play an important role:
i) Financial situation
Since they are specific African churches, there is not much motivation of Christians in the wealthy countries of the North to donate money to them. Donations from wealthy people among the own members are also very rare, since this part of the society is almost completely absent among AIC-members – with some few exceptions proving the rule. One conclusion from this is that many pastors of AICs will also in the future depend on their own subsistence farming activities for their income.

ii) Theological education
Owing to the financial situation of many pastors of AICs, also the theological education of these leaders is difficult to organize. Many leaders have not gone to secondary school, some not even to primary school, so that theological teaching would probably be very difficult for them to follow. The economic situation of many pastors and of the churches brings about the question: If Pastor X leaves the home in order to study, who will cater for the income of the family? OAIC has designed a programme called “Theological Education by Extension (TEE)”, which tries to take this situation into consideration. It offers a long-term course that requires the participants’ presence over several periods of about one week each, between which they can perform their normal duties and activities at home. By doing this, OAIC shows that it has identified the need for a better theological basis for the AIC pastors and leaders. At the same time one has to consider the possibility of inherent difficulties in such an undertaking.

As it has been mentioned above, the “gifts of the Spirit”, which are so important for many AICs, are in many ways a concept in diametrical opposition to intellectual (theological) reflection. If the pastors of the “Spirit-centred” AICs for instance would all become theological scholars, it would probably be increasingly difficult for them to accept and understand the belief in the spirit world that is so important for the church members. They might then become a bit like the “missionaries who applauded spirit possession as ‘client-centred therapy’”, but “took it for granted that these spirits hand no ontological reality”. If it is true, that the inculturation within AICs is based on sub-conscious processes, one could ask, if conscious reflection on this would not endanger its success. It will therefore be a difficult task for those who are organizing theological courses for AIC Christians, to find a balance between the participants’ being part of a belief system that basically goes against scientific teaching and a theological education that provides tools for sufficient reflection on Christianity and Church.

Organization, structure and co-operation
It is a phenomenon that has to puzzle the outside observer that despite the strong sense of unity intrinsic in the traditional African culture, Independent churches that owe so much to traditional cultural values, would continue splitting among themselves in seemingly unending divisions and by doing so creating ever smaller and smaller sub-groups that register as separate churches. If it is a fact, that AICs have to take up the challenge of the NRM in the coming years, it would be very important to create a much stronger sense of unity and co-operation. This could help the reflection on the specific role of the Independent churches vis-à-vis the traditional (and large) mission churches and the mushrooming NRM.

There is a need of the AICs also to stress what is their strength and where they are vulnerable. Although Kenya is still far from being a “multi-optional” society like the ones of Europe and North America, there is still a growing sense of people being able to make choices according to their liking. This includes more and more also the choice of churches or “worship centres”. A very valuable attempt to unify the voices of AICs is the OAIC, which has its international co-ordinating offices in Nairobi. It tries to work out common strategies (like the TEE programme and different development activities) and voice the interest of its member churches towards other churches, the governments in Africa and society in general.

Profile
Large AICs in a number of countries have been developing strongly towards becoming “mainstream churches”. The Kimbanguists in the DR Kongo are one example of this. In Western Kenya, the Church of Christ in Africa could in the future be a church that looses the sense of being a “breakaway” and instead become similar to the established mission churches in organization and manner (Hastings, 1994). To take the profile of the “mainstream churches” is therefore one possibility for the future of certain AICs. What could further give the AICs a clearer contour to distinguish them from the NRMs would be a definite decision for the concern of the underprivileged of society. Since “the poor” are so strongly represented as members, it could be a future challenge for the AICs to offer religious alternatives to the Prosperity Gospel and yet attempt to answer the biting questions concerning poverty and desolation that many of their members ask themselves daily. Another possibility to sharpen the own profile against the backdrop of the NRMs and
the mainstream churches would be to overcome the condemnation of everything associated to traditional culture. The NRM s are even more vocal in this matter and it could become a merit of the AICs to defend traditional values and cultural identity.

CONCLUSION
The AICs have come a long way in planting the Christian faith deeper in the soil of the African continent. They have enabled many Christians in Kenya especially Western Kenya, who were estranged from their cultural background, to reconcile their faith and their daily lives. To further discover the concern for the social (and therefore political) situation of their members and to become advocates of the indigenous culture and ways of thinking would enable them to remain –and indeed become more and more- “a place to feel at home”.

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TAMING PATRIARCHY: THE TOWER OF BABEL IN FEMINIST DISCOURSE

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ABSTRACT
The quest for the runaway gender equality the world over has been fronted by several parties with various consequences. Nonetheless, success in the attainment of gender equality has been more a paperwork and rhetoric exercise rather than practical one with tangible deliverables. One such attempt has been feminism, through whose disjointed discourse, little has been achieved except for the wrangling voices that have largely resorted to fighting one another over the way forward to attaining gender equality. From Marxist through socialist and radical to black feminism, the striking attribute of feminist discourse has largely remained confrontational not only with one another, but also against patriarchy. Like the Babylonians building the Tower of Babel, this feminist conflict is not only against wrestling power from patriarchy, but also weakening their collective resolve. Given this feminist approach, there is likelihood that the movement is doomed. There is hence need for middle ground feminism, accommodative feminism, which should be a give and take situation between feminists and patriarchy. Thus the absence of accommodative feminism, like the Babylonians who failed in their attempt to build the Tower of Babel, feminists are unlikely to achieve their objectives.

Key words: Equality, gender, feminist discourse, middle ground, patriarchy

Understanding Feminism and Patriarchy
There are several misconceptions about the concept feminism especially by the ignorant. There are those who believe that the concept is synonymous with women and at the same time others think that it has implications of women fighting men and overturning the status quo. There are those who think that feminism is a movement led by women, without realizing that there are fierce men feminists and that some women participate actively in systems that oppress other women. Yet there are still others who believe that feminism is a collective stand and hence fail to understand that it is largely a disjoined movement that purports to take the society to the same destination but using different routes.

The foregoing notwithstanding, feminism is seen as the movements and ideologies aimed at defining, establishing and defending equal political, economic and social rights for women and men (Hooks, 1984; 2000). It includes seeking to establish equal opportunities for women and men in society especially in the areas of education and employment.
Therefore, feminists advocate for the rights and equality of men with women and the feminist theories aim to understand the nature of gender inequality by examining women’s social roles. Through this examination, it is expected that a strategy will be found to ensure equity of opportunity between men and women and therefore affording women the opportunities in decision-making that they have historically been denied by the patriarchy and its support structures in the economy, polity and culture.

According to Sultana (2010), patriarchy refers to the male domination both in public and private spheres. Hence the term patriarchy is used to describe the power relationship between men and women. Thus, patriarchy is more than just a term; feminists use it like a concept, and like all other concepts it is a tool to help us understand women’s realities. Sociologically speaking though, a concept cannot be understood unless it is defined after which the reality that it presents comes to the fore. Hence, patriarchy may be seen as the male domination over females in terms of property ownership, reproduction, production and decision-making in all spheres of life. Indeed, male domination and authority is largely seen as the best governance archetype in social institutions including the family, religion, school, workplace and the polity-male figures are more or less seen as ideal type leaders in all spheres of human endeavour.

Hence, the fact that a man may have his name on a family land title deed and not his wife, the fact that it is the name of the man on a family car logbook and not the wife, the fact that children trace their lineage through a male relative particularly the father and not the mother, the idea of the women moving to stay permanently with the man’s relatives after marriage, all constitute the power of patriarchy. Hence, the foregoing definition is an apparent pointer to the fact that patriarchy is an encompassing, almost omnipresent phenomenon in socio-cultural, political and economic relationships, an enigma so to speak. It is one big thick blanket under which women have historically worked under, willing or otherwise.

**Varieties of Feminism**

The feminist movement gave rise to a large body of theory that attempts to explain gender inequalities and suggests how the inequalities can be done away with. From feminist literature, it is evidently clear that there is no single feminist theory, rather, there are varieties of feminist theories and hence, several feminisms. Although there are various strands of feminism, their central thesis is that women have been confined to motherhood, domesticity and an economic dependence on men through gendered socialization in which biological make up is exploited as though it was social (Fulcher and Scott, 2011). Consequently, many feminists particularly those of Marxist and radical leanings see mainstream feminist theory as malestream theory anchored on patriarchy that imply male power over females and whose language remains largely masculine.

While most strands of feminism seem to have a bone to pick with patriarchy, the difference between them is their individual approaches that no doubt target patriarchy and its support structures and interestingly and fiercely so fight one another. Hence, in addition to attacking patriarchy and capitalism, they also seem to fiercely look down upon one another regarding their ability to augment women liberation. A striking feature of all the varieties of feminism is that they seem to present a negative critic, sometimes justified of all the others-each take a moral high ground. It is this moral high ground position taken by each strand of feminism that makes them unable to reach consensus and tame patriarchy, their aim. Like Babylonians building the tower of Babel therefore, the possibility of achieving their aim is not just remote but highly impossible without a change of tact and organization. To get a clear understanding of the foregoing, it is important to appraise the arguments in each strand of feminism and finally make a conclusion.

To begin with, Marxist feminists believe that the subordination of women by men and therefore apparent invisibility in matters of property and development are rooted in the capitalist system of economic production and the privatization of property and means of production (Fulcher and Scott, 2011; Haralambos, Holborn and Heald, 2008). As such Marxist feminists accentuate the intercourse between patriarchy and capitalism and hence contend that the subordination of women in the household benefits the capitalist employer by providing free domestic labor. The wife’s domestic labor is seen by Marxist feminist as a windfall to capitalism in two ways. On the one hand, it meets the home needs of the male worker, enabling him to work long hours in the capitalist economy, while the nurturing and nursing work of the wife helps to bring up the next generation of workers.

Based on the foregoing, Marxist feminists see the disadvantaged position of women as a consequence of privatization of property and its skewed ownership which bestows power on men while denying women of the same (Haralambos, Holborn and Heald, 2008). Indeed, many studies attribute gender stratification to economic roles and see certain
roles as more sex-linked than others (Fulcher and Scott, 2011; Ganihar and Begum, 2007; Kottak, 1991). Due to their arguments, Marxist feminists have been criticized by socialist feminists on the ground that they are gender-blind in their analysis—causes of gender inequalities are invisible in structural Marxist analysis of class inequality (Connelly, MacDonald, Li and Parpart, 1996). In general, Marxist feminists prefer a revolution to overthrow the capitalist society so that inequalities are done away with when a communist society, which is classless, is finally installed (Turner, 1991; Abraham, 1982).

Radical feminism contends that patriarchy is not however especially associated with capitalism but found in all known societies. As such, radical feminists rejected the liberal ideas of legislative reforms for direct political opposition aimed at challenging the basis of the social and political order (Haralambos, Holborn and Heald, 2008; Fulcher and Scott, 2011). The central concern of radical feminism is women rights as opposed to gender equality and as such blame the exploitation and discrimination of women on men. Even as they are united in their fight for women rights, there are however, just like other feminisms, variance among radical feminists about “both the origin of women’s oppression and the possible solution to it” (Haralambos, Holborn and Heald, 2008: 101). True to their name, radical feminists call for radical changes and believe that a revolution is the only solution to liberate women from oppression. In addition, the radical feminists regard men as the real oppressors of women and hence reject any assistance from men since they see men as the problem rather than the solution. One strand of radical feminism, the separatists believe in organizing their liberation separate from men while the female supremacist sees women as not equal to men, but actually superior. They advocate for the abolition of patriarchy and replacement with matriarchy.

Socialist feminism borrows from both Marxist and radical feminist frameworks and the general argument of this school is that women subordination to men has been due to the capitalism-patriarchy nexus, which oppresses and exploits women. According to Ritzer (2004) in the patriarchal capitalist society, women are defined as the property of men. In analyzing the two, this framework combines them, hence capitalist patriarchy and sets out to describe and explain all forms of social oppression and domination using knowledge of class and gender as a base (Mwenzwa, 2011). It is from this base that oppression and domination of women by men, starting at the family unit and running through to the global hierarchization of nations is explained. Jordan and Weedon (1995) have captured the foregoing thus:

Capitalism has an interest in maintaining gender identity relations which guarantee a low paid expendable female workforce in manufacturing and service industry, a largely feminized and low-paid public sector and an underpaid workforce to care for the children, elderly and disabled in their own homes (Ibid, 1995:185)

As a departure from the traditions of other strands, socialist feminism is concerned not only with women oppression by men, but also how women participate in the systems that oppress other women. This way, the theory helps to confront the prejudices and oppression practices within the community of women itself while remaining committed to the analysis of what Ritzer (2004) calls material and social arrangements in society, capitalist patriarchy. In this commitment, the socialist feminists use the strategy of the process of rediscovery in which they attempt to involve the oppressed groups so as to act together in pursuit of collective emancipation.

Peet and Hartwick (1999) say that, this theory has significantly involved the re-theorizing of the importance of women’s work, by regarding the needs for childbearing and raising as being as important as material needs. In this approach, the theory questions the under valuation of domestic work, most of which requires female physical labor (Haralambos, Holborn and Heald, 2008; Mwenzwa, 2011; Fulcher and Scott, 2011). By emphasizing on the importance of both domestic and off-farm work, the theory demystifies and tries to de-stereotype the society with regard to gender roles, seeing each individual as important in development.

On its part, liberal feminism takes a moderate view and hence posses less challenge to the existing values including the system of patriarchy. It therefore proposes gradual change in the political, economic and social systems of western society. It is rooted in the liberal philosophical tradition of the 16th and 17th centuries whose focus was equality and liberty (Connelly, MacDonald, Li and Parpart, 1996). Liberal feminists see women subordination as resulting from social norms and not biological make up. For this reason, inequality that is skewed against women cannot be justified rationally, but with appeal to gender-based biases. While acknowledging that women are at a lower social, economic and political pedestal as compared to men, they unlike radical and Marxist feminists root for legal reforms.

The concern for liberal feminism is equality of opportunity for men and women and equal treatment before the law.
This requires a minimum threshold of non-discriminatory laws and policies (Fulcher and Scott, 2011). The liberal conception of equality is that all people are capable of rational thinking and that equality has to be justified on rational terms (Connelley, MacDonald, Li and Parpart, 1996; Haralambos, Holborn and Heald, 2008). Given their soft stance regarding women liberation, they have ruthlessly been criticized by radical feminists and accused on encouraging women to accept unequal society and its competitive character (Giddens, Duneier and Appelbaum, 2006; Eisenstein, 1978). On this ground, liberal feminism is seen by other feminisms as being incapable of upsetting the status quo and consequently incapable of liberating women from the yoke of patriarchy and capitalism.

Black feminism was born out of the dissatisfaction with other strands of feminism in that they were seen as treating women as a homogeneous group with identical needs and experiences. Black feminists argue that the other feminism are basically based on the experiences and discourse of white middle class women and therefore failing to tackle the problems that face black women adequately (Eisenstein, 1978). They contend that while middle class white women are discriminated on the basis of gender and class, black women face triple discrimination by virtue of their gender, race and social class. The foregoing is captured by Haralambos, Holborn and Heald (2008) thus:

Black women suffer from disadvantage because they are black, because they are women and because they are a working class, but their problems are more than the sum [total] of these parts Haralambos, Holborn and Heald (2008, 104)

It is the intercourse of race, gender and social status as far as black feminism is concerned that reinforces and multiplies the other inequalities to the great disadvantage of black women. Given, black feminism is therefore a discourse to understand the tri-nexus between race, gender and class and how this intersection shape lives and restrict the self-actualization of black women. It may however need to be pointed that, whereas black feminism criticized other strands on the ground of theoretical racism, the emergence of black feminism itself is based on racist ideology-the kettle calling the pot black. This is due to the fact that, although black feminists pride themselves in fighting sexism and racism, their organization and discourse seems racist in nature. Indeed, as captured by Eisenstein (1978) racism was a major reason why black feminists were unwilling to work with white feminists.

Other strands of feminism are no different from the previously discussed as they are all hell-bent on criticizing one another, although primarily concerned with women liberation, albeit racist and other sectarian standpoints. For example, African feminism takes a racist stand by advocating for the rights of African women, while accusing other feminisms of being racists and hence ignoring the plight of African women. It tries to justify its stand by claiming that its aim is to bring out the differences between women who were colonized and those who colonized. Akin-Aina (2011) has characterized African feminism as a movement which is an ongoing process of self-definition and re-definition; a broad-based membership; a resistance to the distortions and misrepresentations by Western global feminism; a ‘feminism of negotiation’; as well as efforts to reconcile power dynamics on the continent, nationally and within the movement (Akin-Aina, 2011: 66)

African feminism is therefore against the western universalizing and homogenizing of women, which is characteristic of western feminist discourse. African feminist aver that African women had experiences that are significantly varied from those of western women and therefore a single feminist discourse cannot adequately capture the experiences in the continent.

Based on the foregoing expose, it is clear that feminism remains disjointed and as such working together is not one of theforeseen aspects of its present strands. While feminists are not united against oppressive behavior of the capitalist society and patriarchy, they seem to be in fierce battle with one another. Unity as such is elusive as captured by Hooks (2000) thus:

But women could not band together to further feminism without confronting our sexist thinking. Sisterhood could not be powerful as long as women were competitively at war with one another (Hooks, 2000, 3).

In conclusion, there are socio-cultural imperatives that must be put in place so that gender insensitive practices that have been institutionalized through cultural umbrella of reality can acquire a paradigm shift from their negative effects towards rational thinking about men and women in society. To bring change in the social, political economic and educational fields among others, like Ganihar and Begurn (2007) attest, there is need for substantive change of attitude comprised of contracts, relations and values about men and women in society. Without such substantive transformation, women are likely to remain, like Hooks (1984) points out, at the margins of society and fail, like the Babylonians to
erect their Babel. This is more so given that most feminist discourse is anti-male and hence patriarchy-disengaging in nature. Pointedly, by viewing men as bad and women good, many strands of feminism seem to ignore the fact that there are many women who take active part in systems that oppress women and at the same time there are respected men feminists.

**Patriarchy-Feminism Discourse**

Simply defined patriarchy is the incapacitating dominance of men over women, children, and weaker men in any set up. The institution of patriarchy has been in the society since time immemorial. Fortier (1975) contends that almost every society has been patriarchal and this structure defines the relationships that enable men ‘own’ and rule women and children. Further, throughout history, patriarchy has had consistent support of religion, political system, and culture (ibid, 1975: 278). Johnson (1995) equates patriarchy to terrorism against women and underlines that the menace is a product of patriarchal practices which give men rights to control women. Precisely, the terrorism involves control of wives by husbands through a well planned violence, economic subordination, threats, isolation, and other limiting tactics (ibid 1995: 284).

Further, Marler (2005) reiterates that patriarchy is exclusive of women and other marginalized groups because it is “the social arrangement in which men possess structural power by monopolizing high-status positions in important social, economic, legal, and religious institutions” (Marler, 2005: 53). Taking this line of argument on a historical timeline, Lerner (1993: 2) highlights that “once established as a functioning system of complex hierarchical relationships, patriarchy transformed sexual, social, economic relations and dominated all system of ideas”. In summary, Rutere (2010: 28) maintains that “it is appropriate to presume that patriarchy entails the amassing of power by men, and the consequent domination of the powerless in the society”.

Despite the intrusive nature of patriarchy, there have been consistent arguments, especially from advocates of various strands of feminism, among them scholars, on the need to deconstruct this institution in order to establish gender respect, equity, equality, and parity for gender partnership in social, political, and economic domains in society. Before the vogue of feminisms in the dawn of 20th century to date, right-minded scholars have expressed dissatisfaction with patriarchy. For instance, from literary world Zora Neale Hurston, a prominent African-American writer exposed the institution of patriarchy, while exploring the dynamism and resilience of African-American family unit at the periphery of competitive American society. Hurston (1995) argues that marital love and harmony undermined by frustrated and oppressive men are necessary ingredients for stabilizing the dysfunctional African-American family to withstand the dehumanizing American society.

Rutere contends that Unmistakably, Hurston ultimately contends that the institution of marriage can only work well if men respect, accept women as equals, and give them unconditional love (Rutere, 2010:42). Indeed, in appreciating Hurston’s ground breaking campaign for gender harmony at family level, Rutere (ibid) underlines that “Hurston therefore takes credit for addressing women’s issues even before the term “feminism” gained currency and was used to define women’s struggle for their rights in mid 20th century”(ibid,41 ). This effort in itself would become an inspiration to later women struggles against patriarchy.

At the dawn of 20th century, the rise of feminism in Western world shaped the discourse of deconstructing patriarchy. Beechy (1979) argues that the women’s struggles against male hegemony and its attendant crippling social structures have been given impetus by radical and revolutionary feminisms. Even in the Orient, Barlow (ND) adds that feminist thinking in modern Chinese history is part and parcel of the discussions pertaining to nation and development. In Africa, African feminist scholars are embracing western feminisms to reconstruct their appropriate feminisms to tame patriarchy. Indeed, Mikkel (1997) maintains that “women are also significantly moving away from gender limitations emanating from patriarchy to asserting female autonomy through political and community involvement (ibid, 341-342).

Nonetheless, to accomplish the battle against patriarchy, women fraternity need to empower themselves through gender awareness, bonding, collaboration with gender sensitized men without losing the focus of campaigning consistently for legal and policy reforms which support women’s advancement in the society (Nzomo, 1989; 1997). In the same vein, the core argument of this paper underlines that divergent discourses emanating from various strands of feminisms notwithstanding, patriarchy is exclusive and oppressive; hence should be tamed by all means for harmony and progress in the society. Nonetheless, it is the argument that a struggle that disengages the culprit may not bear fruits. Feminism
has no choice but to engage and negotiate with patriarchy without having the former having to see the latter as the devil incarnate like most strands of feminist seem to argue.

**Tower of Babel Analogy: A Spotlight on the Kenyan Scenario**

Based on the foregoing expose, it is clear that feminism remains disjointed and as such working together is not one of the foreseen aspects of its present strands. While feminists are not united against oppressive behavior of the capitalist society and patriarchy, they seem to be in fierce battle with one another. Unity as such is elusive as captured by Hooks (2000) thus,

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**Towards Accommodative Feminism: A Radical Alternative**

Given the divergent feminist discourse in deconstruction of patriarchy, this paper advocates for gender harmony through accommodative feminism that will ensure gender respect, equality and partnership for the survival of the family and the society. Gender respect and human progress, observes Friedan (1977), will only be guaranteed when men and women come together, be free with each other, learn the strengths and limitations of each other, and ultimately be able to complement each other well and moreover in a reciprocal manner (ibid, xxxiv). Arguably, radical feminism and related feminisms are not suitable strategies of taming patriarchy and its attendant gender conflicts because these feminisms are likely to create a vicious circle of gender battles in the society. Once again, the give and take approach between a man and woman is humane and accommodating for the family survival and progress in the society. It is this approach that has a human face that we advocate for in this work.

**REFERENCES**


