11th Egerton University International Conference and Innovation Week

THEME:
Knowledge and Innovation for Social and Economic Development

29TH - 31ST MARCH, 2017
FEDCOS Complex, Njoro Campus
11th International Conference and Innovation Week

Theme:

KNOWLEDGE AND INNOVATION FOR SOCIAL AND ECONOMIC DEVELOPMENT

PROCEEDINGS

29th – 31st MARCH, 2017
FACULTY OF EDUCATION COMPLEX
Egerton University, Njoro, Kenya
Welcoming Message from the Vice-Chancellor

Prof. Rose A. Mwonya
Vice Chancellor

On behalf of the Egerton University Community, I am happy to heartily welcome you all to our 11th International Conference and Innovation Week. It is the 11th event of welcoming international pool of scientists, eminent personalities and young professionals to share knowledge, innovations and debate knowledge that can inform the future for our societies. I thank you very much for purposing to participate in this Research Conference graced by such an accomplished audience.

I find the theme of the conference “KNOWLEDGE AND INNOVATION FOR SOCIAL AND ECONOMIC DEVELOPMENT” relevant to development debate in Kenya and Africa today. With the eminent personalities in the audience, from Kenya, other African countries, the United Kingdom, the Netherlands, and from India, among other many countries represented, I get the confidence that the conference will substantially add ideas and inform the ongoing development debate.

Egerton University prides being a premier Agricultural University in this region of the world with a history dating 78 years back when it was founded as a Farm School in 1939 with a few students. The growth since then has been a tremendous expansion in student enrollment, physical infrastructure, academic faculties, scientific research and innovation. This has culminated into Egerton University recently attaining best university positions, in the web biometric ranking, the 2nd in Kenya, 22nd in Africa and 1727th among the world Universities.

My interpretation of this web ranking is that our efforts in transforming lives through quality education is receiving recognition and that we if redouble investments in research, knowledge and innovation, we shall be the world best in offering exemplary education to society and generating knowledge for national and global development. The University has committed to this goal by pursuing five strategic objectives, to:
1. improve the quality higher education and training
2. increase research, consultancy and community outreach
3. enhance physical infrastructure and ICT capacity
4. increase linkages and collaborations
5. enhance governance and resource mobilization

I thank the Technical Committee organizing this event, with the support of the Division of Research and Extension, for linking the conference theme with the University vision, mission and strategic objectives. It is a reminder to all that Knowledge and Innovation is key driver for Social and Economic Development. I will be happy if this conference provides convergence to all of us that investing more in science and innovation capabilities is the pathway to accelerate transition to knowledge-based, innovation-led economy in our mother earth.
I want to encourage all of you to network well, especially with the Egertonians, in order that together we widely use our science, technology and innovation for social and economic development of our societies.

Prof. Rose A. Mwonya

Vice Chancellor

Email: vcre@egerton.ac.ke
Welcoming Message from the
Acting Deputy Vice Chancellor of Research and Extension

On behalf of the University, the Division of Research and Extension is hosting this 11th International Conference and Innovation Week, which has dedicated the first day to Education and Development Summit. Parallel to the conference is Innovation Week, which has attracted exhibitors from private, NGOs and public sector. I want to assure that your decision to participate in this conference among an audience of prominent, lead and upcoming scientists and personalities, will be rewarding and of quality time to you. I am pleasantly excited and welcome you to engage with the other participants from different nationalities.

In total, five keynote speeches will be delivered, 150 papers and 20 posters will be presented and over 300 participants from Africa countries, United Kingdom, the Netherlands, France and India will be in the audience. In addition, people in the business sectors will exhibit their products and services.

Papers and posters will be presented within seven sub themes:

i. Food security
ii. Science and technology
iii. Health and the environment
iv. Education and capacity development
v. Governance, law and security
vi. Climate change and natural resources
vii. Culture and socio-economics

In this three-day conference, the first day is allocated to Education and Development Summit with three keynote addresses and lead papers which will be discussed by high profile professionals from diverse sectors. This time, poster presenters will have time specifically allocated for interaction with the audience and this will be made by delivering elevator pitch plenary presentations to inform the audience of the research issue, methodological approach to resolving the issue, and outputs, outcomes and the target beneficiaries of such products.

You will find in the conference bags an evaluation form with provisions for daily feedback. I urge you to fill the form daily and hand it in to registration desk staff on Friday. Your feedback will point to us services we need to prioritize to better your participation in our future annual conferences. This is important to the Division of Research and Extension for effective organization of this annual event to create very good mood for you to share and disseminate your research and innovation outputs. This is a commitment we have undertaken in order that new knowledge from research is beneficial to advancing humanity.

Professor Alfred K. Kibor, PhD
Ag. Deputy Vice Chancellor (Research and Extension)
# TABLE OF CONTENTS

## PLENARY KEYNOTE ADDRESSES AND LEAD PAPERS

### DAY ONE

**Prof. Bitange Ndemo**

Knowledge and Innovations: Opportunities and Challenges of Re-Inventing the Kenyan Education System to Transform Our Society

**Prof. Ganesh Narayan Devi**

Speaking of Culture and the Culture of Speaking - the Future of Human Languages

**Martin Pickford**

Mio-Pliocene palaeo environments of the Gregory and Albertine Rifts, the ape-human dichotomy, and the earliest phases of hominidevolution

**Hedwig Irene Jozef Bruggeman**

Knowledge and Innovation for Food Security in Africa

### DAY TWO

**Prof. Dulcie A. Mulholland**

Knowledge and Innovative Breakthroughs for Managing Emerging Health Challenges in Sub-Saharan Africa

### DAY THREE

**Musimbi D. Murunga**

Corruption and its Implication to the Kenyan Economy

**Snr. Counsel Nzamba Philip Kitonga**

Corruption Menace: Is the New Constitution an Enabler or a Hindrance to the Fight against Corruption

## PAPER PRESENTATIONS

### FOOD SECURITY

Prevalence of Subclinical Mastitis and Associated Risk Factors in Dairy Farms in Urban and Peri-Urban Areas of Thika Sub County, Kenya ................................. 1

_D K Mureithi and M N Njuguna_

Mastitis Prevalence Increased Somatic Cell Counts and Milk Postharvest Losses in Smallholder and Pastoral Herds of Kenya ......................................................... 8

_O. B. Kashongwe, J. W. Matafari, B. O. Bebe, C. Huelsebusch_

Generation Mean Analyses for Stem Rust (_Puccinia Graminis F. Sp. tritici_) Resistance in Wheat (_Triticum Aestivum L._) ................................................................. 14

_H. W. Gitonga, P. O. Ojwang and G. K. Macharia_

Utilizing the Old to Fight the New: Seeking Resistance to Wheat Stem Rust Race Ug99 from Old Kenyan Accessions ................................................................. 21

_Waweru B. N.¹; M. G. Kamau and C. Bernard_

Efficacy Assessment of Commercial Rhizobium Inoculants on Common Bean and Soybean Growth in Two Soil Types ................................................................. 26

_Korir, H. Mungai, N. W., Masso, C. and Thuita, M._

Effects of Coloured Agronet Covers on Microclimate Modification, Insect Pest Infestation Reduction and Tomato Yield Improvement .................................................. 41

_C. J. Lang’at, M. Saidi and A. Opiyo_
Children’s Rights an Assessment of the Level of Knowledge on Children’s Rights among Parents and Caregivers in Rural Kenya: The Case of Rongo Sub-County, Migori County .......................................................... 54

T. I. Shivachi

Formalized Alternative Family Care for the Best Interests of Children as an Innovation for Social Development .......................................................... 64

E. A. Onyango, N. M. O. Sanganyi and J. T. Oduor

Social Protection Targeting Approach for Cushioning Street Children in Kenya .......................................................... 68

N. M. O. Sanganyi and E. A. Onyango

The Influence of Social Cultural Factors on Crop Farming among Pastoralist Communities with a Focus on Sweet Potato Production In Samburu County, Kenya .......................................................... 72

L. C. Lepariyo, C. N. Munyua and A. Olubandwa

Drivers of Small Scale Farmers’ Participation in Agricultural Land Rental Markets: The Case of Kwale, County, Kenya .......................................................... 78

J. J. Mbudzya, O. I. Ayuya and P. M. Mshenga

Relationship between Entrepreneur Innovativeness and Performance of Agro-Based Small and Medium Manufacturing Enterprises in Kiambu County-Kenya .......................................................... 84

R. W. Waithaka

Determinants of Choice of Agricultural Information Sources and Pathways among Sorghum Farmers in Ndihi Sub-County, Western Kenya .......................................................................................... 90

S. Mbanda-Obura, I. Tabu, D. Amudavi and R. K. Obura

Effectiveness of Agricultural Extension Wildlife Mitigation Strategies on Human-Wildlife Conflict among Smallholder Agro-Pastoralists: A Case of Smallholder Maize Farmers in Laikipia County, Kenya .......................................................... 101

R. O. Nyamwamu and J. M. Ombati

Analysis of the Effect of Agricultural Extension Development Initiatives on Household’s Agricultural Food Productivity and Sufficiency among Small-Scale Farmers: A Case of Kilifi County, Kenya .......................................................... 106

A. H. Ong’ayo


J. A. Osanya A. Rahma, D. J. Otieno and R. Nyikal

Small Holder Farmers Perceptions on the Impact of Sustainable Agricultural Practices on Productivity and Wellbeing: Evidence from the Central Kenya Highlands .......................................................................................... 126

G. N. Mbure, G. N. Ngae, S. N. Njihia and S. T. Ledermann

Matumizi Ya Udhahania Katika Walenisi Na Mafuta .......................................................................................... 134

M. Kwambai, Furaha Chai, Wendo Nabea and Dave Bowen


S. Mutie, N. Kamau-Goro and A. M. Rutere

Role of Globalization in the Diminishing of African Indigenous Education Systems: An Example of Abagusii Circumcision Ceremony .......................................................................................... 149

Mwangi B. A.

Widow Inheritance among the Luo of Kenya: A Virtue or Vice? .......................................................................................... 154

G. A. Owiti

Methods for Translating ICTS’ Survey Questionnaire into French and Bambara .......................................................................................... 159

M. Kante, C. Chepken and R. Oboko

Structure, Conduct and Performance of Smallholder Cereal Farmer Groups in Tharaka Constituency, Kenya .......................................................................................... 165

D. K. Wambua, M. W. Ngigi and J. K. Langat
ENVIRONMENT AND HEALTH

Label-Free Surface Enhanced Raman Spectroscopic Detection Hiv-1 Infection in Blood and Plasma Adsorbed on a Conductive Silver Pasted Glass Substrate

B. Otange 1,*, Z. Birech 2, R. Rop 1 and J. Oyugi 2

In Vitro Antiplasmodial Activities of Carissa Edulis, Azadirachta Indica, Cassia Siamea and Harrisonia Abyssinica against Plasmodium Falciparum

Oduor L. O.

EDUCATION AND CAPACITY BUILDING

Prediction Modelling of Academic Performance with Logistic Regression - A Case of Rural Primary School Students in Kenya

M. Mgala, and A. Mbogho

Educational Technology and Higher Learning

S. A. Wuodi

Promising Environmental Education Practices at Primary Schools: Study Reflections from Geography Primary Teachers and Pupils

J. Kashaigili and K. M. Osaki

Impact of Technologically Enhanced Language Learning on Learner Achievement in Writing Skills-A Case Study of Nakuru County

R. A. Asilla and M. Okere

Educational Planning and Practices in Kenya

H. Onderi and G. Malala

Challenges of Technical Training Institutes Student Mothers, Coping Mechanisms and Support Accorded

Wambu C.

GOVERNANCE, LAW AND SECURITY

Alternative Strategies against Mal-Functioning Criminal Justice System in Ensuring Security in Kenya

Omboto J. O.O

Influence of Community Policing on Incidences of Armed Robbery in Low Income Areas of Nakuru Town, Kenya

K.O. Ogutu and M. I.O.Okere

CLIMATE CHANGE AND NATURAL RESOURCES

Morphometric Analysis of Watersheds for Flood Risk Assessment using QGIS

D. T. Gitundu

Differentiated Costs and Benefits of Conservation: Decentralized Wildlife Management in Tanzania

Kiwango, W.A., Komakech, H.C., Tarimo, T.M.C. and Martz, L.

SCIENCE AND TECHNOLOGY

Determination of L-Carnosine, L-Anserine and L-Carnitine of Meat-Type Quails and the Preliminary Study of its Antioxidant Activity on Human Adenocarcinoma Colon Cancer Caco-2 Cells

V. A. Kimindu, M. Mor-Mur, A. Bassols and A. H. Karlsson

Phytochemical Composition and In Vitro Antiproliferative Activity of Oxygonium sinuatum on Selected Cancerous Cells

Impacts of Climate Change on Agro-Ecosystems and Food Security in Africa. A Review

_Nyongesa K. W., F. O. Obiria, and B. S. Omuya_

Role of Knowledge Acquisition in Enhancing the Performance of Micro, Small and Medium Enterprises in Migori County, Kenya

_Maurice Ochieng Oyoo_,

Organising Committee
PLENARY KEYNOTE ADDRESSES

KNOWLEDGE AND INNOVATIONS: OPPORTUNITIES AND CHALLENGES OF RE-INVENTING THE KENYAN EDUCATION SYSTEM TO TRANSFORM OUR SOCIETY, UNDER THE SUB-THEME OF EDUCATION AND CAPACITY DEVELOPMENT

_Bitange Ndemo_

My presentation will focus on the nexus between knowledge and opportunity as key ingredients to creativity and innovation for economic transformation. To succeed, educational systems must transform society. In the past universities have focused on academics but knowledge from Newly Industrialized Countries (NICs) show that applied education especially in sciences will transform the economy.

Strathmore University that in the process of launching its engineering program, has indeed begun to show the much needed leadership. My presentation shows that the many problems in Africa are opportunities waiting to be exploited. There is no opportunity that presents itself as a fully formed idea. The Government working with research institutions and private sector must work such that our curiosities will find themselves into research institutions funded by the government and actualized by the private sector. This is what is referred to the triple helix.
The global challenges of today are calling out to go beyond food security and start working from a food systems approach that can nutritiously, inclusively and sustainably feed the growing population in Africa. The perspective of food systems is increasingly used as an organising framework for transformative action, by scientists and policy makers. However we need to consider the interconnectedness of different (national& global) food systems and how they impact each other in order to respond strategically. This contribution will present evidence that different global and national food systems should and can exist side by side in Africa in order to address the core aspiration of world food systems defined as: inclusive, sustainable, efficient, nutritious & healthy. This requires innovative approaches towards knowledge development, knowledge accessibility and knowledge transfer. For enhancing innovation to a next level within each food system and between food systems stronger and anticipated linkages between agribusiness, farmers, government and knowledge systems (research and education) are crucial for knowledge driven sustainable and inclusive food systems. This strong connection has been the key factor behind the success and competitiveness of Dutch agriculture and food industry. Wageningen CDI is part of Wageningen University & Research with the mandate “Knowledge in Action”. This means that knowledge is generated in a constant dynamic of development, application and adaptation. Knowledge and innovation is linked to action and partners are asked to contribute and update our joint knowledge on innovative approaches. In this contribution a number of examples of this “knowledge in action” approach from Kenya, Uganda, Ethiopia and Ghana will be highlighted.
Abstract
Corruption poses a serious challenge in Kenya since it undermines economic, political and social development. According to the Transparency International corruption has been defined as the misuse of public power for private benefit. Corruption therefore undermines democratic institutions and good governance, reduces accountability and negates representation and overall policy making. Today in Kenya, corruption has been perfected by crafty government officials and local rent-seeking software merchants by manipulating an accounting package referred to as Integrated Financial Management Information System (IFMIS), for example, the Auditor-General found in the special audit report on the National Youth Service how some civil servants had user rights that allowed them to siphon and commit funds from the Ministry of Devolution and Planning even when they were not employees of the ministry. Corruption has therefore lead to slow growth of the economy, sufferings of many Kenyans, and disparities in standard of living as it diverts effective use of public resources for private gain. The methodology used involves an empirical analysis that is conducted with a regression analysis, using data on democracy, fertility rate, life expectancy, education and the Initial GDP per capita that are also considered to affect GDP. The empirical results show that corruption does have a significant effect on economic growth after multicollinearity has been dealt with. This paper therefore recommends that appointment to government offices should be based on individual’s integrity test, the organs fighting corruption should be empowered and filled in by qualified people, and citizens should not elect leaders with histories of corruption.

Key Words: Accountability, Corruption, Economy, Integrity, Poverty and Wealth.
POLITICAL ECONOMY OF IRRIGATED MAIZE PRODUCTION IN GALANAKULALU FOOD SECURITY PROJECT, KENYA

D. Otieno¹, L. Kirimi¹, H. L. Oduor¹ and N. Odhiambo¹
¹Tegemeo Institute of Agricultural Policy and Development, Egerton University, Kenya.

The research was financed by USAID.

Abstract
The establishment of GalanaKulalu food security project continues to draw mixed reactions from the political class and economic analyses in Kenya concerning the value of the investment in Kenya. The project initiation mirrors the ideology enshrined in the post-independence sessional paper no. 4 of 1966 which favored development of high potential areas in Kenya with the trickle-down effect expected to benefit other areas. In this paper we argue that although development of irrigation aimed to improve food security and alleviate poverty, vested interests limited the projects achievement. We established although productivity of irrigated maize production was low, due to factor use inefficiency, it was viable and sustainable. Vested interest led to negative perception about irrigated maize production. Improving factor use efficiency would increase production, productivity and can reduce the payback period. This would improve farmers’ willingness to pay for irrigated maize production was positively influenced by irrigation service cost, availability of sufficient water and the output level. The study recommended further research to develop high yielding maize technology, training to develop farmer skills, participatory investment prioritization, clear definition of the roles of the national and county government and empowerment of water users association would lead to greater acceptance of the project.

Keywords: efficiency, irrigation, maize, profits, viability,
It is now generally accepted that the ape-human dichotomy occurred during the Late Miocene, some time between 12 Ma and 6 Ma. However, there are only a few fossil hominoids known from Africa during this time span (Ethiopia, Kenya, Namibia, Chad, Niger). Hominoids are well represented in Eurasia during this period, and this imbalance between the African and Eurasian fossil record of hominoids has given rise to scenarios that suggest that the human lineage originated in Eurasia and then dispersed to Africa, the so-called « Back-to-Africa » hypothesis. An alternative scenario is that, even though hominoid remains are scarce in the Late Miocene of Africa, they indicate that the continent was never devoid of the group, which means that the ape-human dichotomy might well have occurred in Africa. In order to throw more light on the earliest stages of human origins soon after the split from the apes, palaeo anthropology so rely needs more fossil evidence, not just of early hominids, but also of Late Miocene apes. The most appropriate way of locating such evidence is to survey Late Miocene sedimentary deposits from as many parts of Africa as possible.

Recent surveys in the West Nile sector of the Albertine Rift Valley reveal that the area contains fossiliferous late Miocene and Pliocene deposits, similar in age to parts of the stratigraphic succession in the Tugen Hills, Kenya, where the earliest evidence of fully bipedal hominids was found in 2000 (Lukeino Formation, 6 Ma). The West Nile sector of the African Rift System currently lies in a Guinean Woodland ecosystem, intermediate between Tropical Forest on the one hand and various kinds of wooded « Savannah », on the other. Fossil mammals from the area indicate that this was likely the palaeo environment at the time of deposition (dominance of bunodont herbivores, rare hypsodont forms). In contrast, during the Late Miocene to Pliocene (ca 7 Ma to 2 Ma) the Kenyan palaeoecosystem was somewhat more arid than that of West Nile, but considerably more humid than it is today.

Whilst there is some fossil evidence of early hominid devolution from the Late Miocene of the East African Rift, there is little known about the origins of the gorilla and chimpanzee lineages (three isolated teeth from the Tugen Hills have been interpreted as representing a proto-chimpanzee and a proto-gorilla). The rarity of ape fossils in the African fossil record is likely due to the probability that the ancestors of the African Great Apes did not live in East Africa, but were confined to the more humid zones of western and central Africa where few fossiliferous deposits are known (only a proto-chimpanzee in Niger has been described). For this reason, surveys need to be carried out in parts of Africa that preserve elements of the more humid ecosystems.

This bias in the fossil record has introduced a bias into our understanding of human origins, if only because interpreting human origins without any knowledge concerning the evolution of our nearest living relatives renders the interpretations incomplete, not only from a morpho-functional perspective, but also from geochronological and palaeo environmental ones. Because West Nile is close to the tropical forest zone, there is a possibility that during the Mio-Pliocene, proto-chimpanzees and proto-gorillas might have lived within the area or close to it. Chimpanzees occur in the area today.

It is therefore proposed to continue field surveys in the West Nile and the Kaiso Peninsula regions of the Albertine Rift in the hope of gathering data relevant to understanding better the ape-human dichotomy. At the same time it is proposed to continue surveys in the Tugen Hills, Kenya, in order to throw more light on the palaeo environment of early hominids there.
Studies will involve classic field surveying and collecting techniques, faunal analysis and geochemistry (stable isotope studies on mammalian enamel). By this means data relevant to understanding past changes in the climate and environments will be obtained. It is naturally hoped that fossil apes and early hominids will be found.

Recall that the discovery of six-million-year-old *Orrorin tugenensis* in 2000, led to a radical paradigm shift concerning interpretations of human evolution prevalent up to that time, especially regarding the timing of the ape-human dichotomy, and the palaeo environment in which early hominids lived. Prior to this discovery, the generally accepted opinion in palaeoanthropological and neoanthropological (molecular biology) circles was that the ape-human dichotomy occurred during the Pliocene (estimates varied between 5 Ma and 2.5 Ma) and that the transition from ape-like to human-like locomotion and other adaptations occurred in a « savannah » setting. The unearthing of *Orrorin* doubled the age of the dichotomy (now estimated to have occurred between 12 Ma and 8 Ma) and showed that early bipedal hominids lived in dry evergreen forest.

Further fossil evidence from the Late Miocene of Africa is sorely needed for throwing light on the ape-human dichotomy (when, where, in what palaeo environments). West Nile and the Tugen Hills are two key areas where such evidence may exist.

This research will be carried out in collaboration with local institutions, Egerton University and the Orrorin Community Organisation in Kenya, and the Uganda Museum in Uganda.
CONFERENCE PROGRAMME

11TH EGERTON UNIVERSITY INTERNATIONAL CONFERENCE AND INNOVATION WEEK

THEME: KNOWLEDGE AND INNOVATION FOR SOCIAL AND ECONOMIC DEVELOPMENT

29TH – 31ST MARCH, 2017
FACULTY OF EDUCATION COMPLEX, EGERTON UNIVERSITY, NJORO, KENYA

Programme Coordinators: Prof. Bockline O. Bebe/ Prof. Mwangi Ndirangu

CONFERENCE DAY ONE WEDNESDAY 29TH MARCH 2017

8.00am-8.30am REGISTRATION:
VENUE FACULTY OF EDUCATION THEATRE II (ET 2)

CONFERENCE OPENING SESSION

TOpic OPENING PRAYER: PROF. FR. S.N. MBUGUA
9.00am -9.30am WELCOMING REMARKS: PROF. A. C. KIBOR,
Acting Deputy Vice Chancellor (Research & Extension), Egerton University

9.30am-10.00am OPENING REMARKS: PROF. ROSE A. MWONYA,
Vice Chancellor, Egerton University

10.00am-10.45am KEYNOTE ADDRESS: Prof. Bitange Ndemo
Knowledge and Innovations: Opportunities and Challenges of Re-Inventing the Kenyan Education System to Transform Our Society

DISCUSSANTS Prof. Ezra Maritim, Egerton University
Prof. Fred Keraro, Egerton University

QA Session with Plenary Speakers

10.45am-11.15am HEALTH BREAK

11.15am-11.30am GROUP PHOTO COORDINATORS: Dr. J. Masika and Dr. J. Thuo

11.30am-12.15pm KEYNOTE ADDRESS: Prof. Ganesh Narayan Devi
Speaking of Culture and the Culture of Speaking - the Future of Human Languages

12.15pm-1.00pm Martin Pickford: Mio-Pliocene palaeo-environments of the Gregory and Albertine Rifts, the ape-human dichotomy, and the earliest phases of hominin evolution

DISCUSSANT Dr. Tom Odhiambo, University of Nairobi

1.00pm-2.00pm LUNCH BREAK

AFTERNOON BREAKOUT SESSIONS

CHAIR Prof. Joshua O. Ogendo
RAPPORTEUR Dr. Mary Ambula

2.00pm-2.30pm LEAD PAPERS: Prof. Gideon A. Obare
Intensification Pathways for attaining Food Security: Lessons from East and Central Africa
Dr. Dennis Otieno
Political economy of irrigated maize production in Galana Kulalu food security project, Kenya.

2.30pm-3.30pm KEYNOTE ADDRESS: Hedwig Irene Jozef Bruggeman
Knowledge and Innovation for Food Security in Africa

DISCUSSANT Mr. Amos Manyara, Executive Director, Highchem Agriculture Ltd.

DISCUSSANT Prof. Symon Mahungu, University Industry Liaison Officer

4.00pm-5.00pm ORAL POSTERS PRESENTATIONS
(POSTERS DISPLAY IN ROOM GO15 WEDNESDAY – FRIDAY FOR VIEWING)
<table>
<thead>
<tr>
<th>VENUE</th>
<th>THEATRE I</th>
<th>THEATRE II</th>
<th>ED 13</th>
<th>ED 14</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUBTHEME</td>
<td>CLIMATE CHANGE ADAPTATION</td>
<td>CROPPING SYSTEM</td>
<td>ECOSYSTEM AND HEALTH</td>
<td>ANIMAL RESOURCES</td>
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<tr>
<td>CHAIR</td>
<td>Dr. G. Ogendi</td>
<td>Prof. N. Mungai</td>
<td>Dr. S. Muthoka</td>
<td>Dr. T. Okeno</td>
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<td>Dr. W. Moturi</td>
<td>Dr. D. Kweya</td>
<td>Dr. J. Masika</td>
<td>Dr. J. Thuo</td>
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<td>An Overview of the Impacts of Climate Change on Mountain Biodiversity and Local Livelihoods: A Global Perspective with a Focus on Tropical Mountains</td>
<td>Interaction of Uganda Passiflora Virus and Cowpea Aphid Borne Mosaic Virus on Passion Fruit Plant</td>
<td>Evaluation of Effectiveness of Traditional Drinking Water Treatment Methods</td>
<td>Effect of Formulated Concentrate Feeding Level on Milk Yield and Quality among Lactating Friesian Cows</td>
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<td>4.20pm-4.30pm</td>
<td>P.M. Maina</td>
<td>O. H. Ochieng, A. M. Opiyo, M. Saidi</td>
<td>C. K. Moranga</td>
<td>Lotesiro J.E, King’ori A.M, Bebe B.O.</td>
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<td>Benefit Sharing Mechanisms Perspectives; Linking Biodiversity and Community Livelihoods in Mt Kenya West Community Forest Associations Nyeri County</td>
<td>Different Agronet Covers Influence Yield and Nutritive Quality of African Nightshade and Spider plant (Cleome Gynandra L.)</td>
<td>Factors Hindering the Uptake of Free Delivery Services: A Case of Londiani District Hospital – Kericho, Kenya</td>
<td>Comparative Assessment of Livelihood Roles of Indigenous Chicken in Pastoral and Agricultural Households of Kenya</td>
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<td>Assessment of Factors influencing Smallholder Farmers’ Adoption of Mushroom for Livelihood Diversification in Western Kenya</td>
<td>Evaluation of Yield And Yield Components of Advanced Kenyan Barley (Hordeumvulgarel) Genotypes</td>
<td>Impacts of Artisanal Gold Mining on Water Quality: A Case Study of Gold Mining at Farabacoura in Sikasso Region, Mali</td>
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<td>Response of Potato (Solanumtuberosum. L.) to Faecal Matter Based Fertiliser Products in Nakuru County, Kenya</td>
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<td>Impacts of Artisanal Gold Mining on Water Quality: A Case Study of Gold Mining at Farabacoura in Sikasso Region, Mali</td>
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<td>7.30pm-10.00pm</td>
<td>CONFERENCE COCKTAIL</td>
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### CONFERENCE DAY TWO: THURSDAY 30TH MARCH, 2017

**8.00am-8.45am**

**REGISTRATION:**

<table>
<thead>
<tr>
<th>VENUE</th>
<th>FACULTY OF EDUCATION THEATRE 2 (ET 2)</th>
</tr>
</thead>
</table>

**SESSION COORDINATORS:** Prof. Mwangi Ndirangu

**CHAIR**
Prof. Julius Kipkemboi

**RAPPORTEUR**
Dr. Faith Toroitich

**OPENING PRAYER:**

<table>
<thead>
<tr>
<th>9.00am- 9.45am</th>
<th>KEYNOTE ADDRESS: Prof. Dulcie A. Mulholland Knowledge and Innovative Breakthroughs for Managing Emerging Health Challenges in Sub-Saharan Africa</th>
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<tr>
<th>9.45am-10.00am</th>
<th>QA Session with Keynote Speaker</th>
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<th>10.00am-10.30am</th>
<th>HEALTH BREAK</th>
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### BREAKOUT SESSIONS

<table>
<thead>
<tr>
<th>VENUE</th>
<th>THEATRE 1</th>
<th>THEATRE 2</th>
<th>ED 13</th>
<th>ED 14</th>
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<tbody>
<tr>
<td><strong>SUBTHEME</strong></td>
<td>FOOD SECURITY (Animal foods)</td>
<td>CULTURE AND SOCIO-ECONOMICS (Culture)</td>
<td>HEALTH AND ENVIRONMENT</td>
<td>EDUCATION AND CAPACITY BUILDING</td>
</tr>
<tr>
<td><strong>CHAIR</strong></td>
<td>Prof. C. I. Muleke</td>
<td>Prof. G. Narayan Devi</td>
<td>Dr. S. Obure</td>
<td>Dr. A. Olubandwa</td>
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<tr>
<td><strong>CO-CHAIR</strong></td>
<td>Dr. J. Anyango</td>
<td>Dr. D. Kweya</td>
<td>Dr. F. Toroitich</td>
<td>Dr. W. Moturi</td>
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<tr>
<td></td>
<td>Taji I. Shivachi Children’s Rights an Assessment of the Level of Knowledge on Children’s Rights among Parents and Caregivers in Rural Kenya: The Case of Rongo Sub-County, Migori Country</td>
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<tr>
<td></td>
<td>M. A. Obonyo and E. N. Salano Human Aflatoxin Exposure in Eastern Kenya: Seasonal and Perennial Events</td>
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<td>Mvurya M, and A. Mbogho Prediction Modelling of Academic Performance with Logistic Regression - A Case of Rural Primary School Students in Kenya</td>
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<thead>
<tr>
<th>10.50am-11.00am</th>
<th>D K Mureithi, M N Njuguna Prevalence of Subclinical Mastitis and Associated Risk Factors in Dairy Farms in Urban and Peri-Urban Areas of Thika Sub County, Kenya</th>
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<tbody>
<tr>
<td></td>
<td>E. A. Onyango, N. M. Sanganyi, J. T. Odour Formalized Alternative Family Care for the Best Interests of Children as an Innovation for Social Development</td>
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<tr>
<td></td>
<td>A.K. Maranga-Ondieki Assessment of Nurses’ Knowledge on Cancer-Related Pain Management at a County Referral Hospital in Kenya</td>
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<td>J. Nemes and P. Loisulie Development of Soft Skills: A Solution to Governance Quagmire in Higher Education Institutions in Tanzania</td>
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<thead>
<tr>
<th>11.00am-11.10am</th>
<th>O.Kashongwe, J. W. Matofari, B. O. Bebe, C. Huelsebusch Mastitis Prevalence Increased Somatic Cell Counts and Milk Postharvest Losses in Smallholder and Pastoral Herds of Kenya</th>
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<tr>
<td></td>
<td>N. M. O. Sanganyi and E.A. Onyango Social Protection Targeting Approach for Cushioning Street Children in Kenya</td>
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<td>M.I. Isalambah, J. M. Okoth HIV Infection Prevention Strategies in Heterosexual Couples in Kakamega County, Kenya</td>
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<td>S. A. Wuodi Educational Technology and Higher Learning</td>
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<tr>
<th>11.10am-11.20am</th>
<th>F. Agutu, J.O. Ondiek, B. O. Bebe Associations between Intensification Interventions and Herd Productivity in Smallholder Dairy Farms in the Kenyan Highlands</th>
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<tbody>
<tr>
<td></td>
<td>R. Mugata Reinforcing Inheritance by Children as a Means of Enhancing Child Protection Rights</td>
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<td></td>
<td>J. K. Keter, S.W. Wachanga and Z.O. Anditi Effects of Computer Based Cooperative Mastery Learning (CBCML) on Secondary School Students’ Skills Acquisition in Chemistry Practicals</td>
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<thead>
<tr>
<th>11.20am-11.30am</th>
<th>D. Cherop Physicochemical Parameters Effects on Fish Production; Lake Baringo, Kenya</th>
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<tr>
<td></td>
<td>Masinde, G. A Changing Masculinities and Inter-generational Resource-Related Conflicts in Rural Kenya: Mituki D.M, Tuitoek P.J, Varpolatai A., Ngotho D., Kimani E., Cheserek M. Effectiveness of Community Health</td>
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<tr>
<td></td>
<td>V. Onjoro The Future of Education in Kenya Is in the Internet, Tablets, I PAD, Google, Videos and Tablets</td>
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<tr>
<td>11.30am-11.40am</td>
<td>Socio-Economic Implications for Households Workers in Improving Initiation and Exclusive Breastfeeding Rates in a Low Resource Setting: A Cluster Randomized Longitudinal Study</td>
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<td>Physico-chemical properties of extruded Fish feed pellets containing Black Soldier Fly Larvae and Adult Field Cricket (Ac/eta domesticus) flours</td>
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<td>Dominant Masculinities and Gendered Silences at Selected Monuments and National Heritage Sites - Perspectives from South Africa</td>
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<td>Decentralisation of Health Systems and the Fate of Community Health Fund in Tanzania: Critical Review for Poor Performance in Some Districts</td>
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<td>Promising Environmental Education Practices at Primary Schools: Study Reflections From Geography Primary Teachers and Pupils</td>
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<td>The Hyena that Seeks to Impregnate Returns with Pregnancy: Interpreting the Hyena Symbolism in the Borana Cultural Lore</td>
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<td></td>
<td>Scalability of Learners’ Success Rates in Open Distance and E-Learning: A Survey Study from the Learner’s Perspectives</td>
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<tr>
<td>11.50am-12.00noon</td>
<td>Comparative Feed Preferences and Intake Patterns of Field Cricket (Gryllus Bimaculatus) and Common House Cricket (Ac/eta Domesticus) Fed on Different Agro-by Products</td>
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<td></td>
<td>The Influence of Social Cultural Factors on Crop Farming among Pastoralist Communities with a Focus on Sweet Potato Production in Samburu County, Kenya</td>
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<tr>
<td>12.00noon-12.10pm</td>
<td>Review of Locusts as Human Food: Processing Methods, Safety, and Nutritional Aspects</td>
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<td>Spatial Distribution of Latrine Coverage in Isiolo County, Kenya</td>
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<tr>
<td>12.10pm-12.20pm</td>
<td>Descriptive Sensory Quality of Kenya’s Indigenous Chicken Meat from Different Ecotype-Clusters Reared under an Intensive System</td>
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<td></td>
<td>Alternative Healthcare Financing Models: Lessons For Kenya</td>
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<td>Educational Planning and Practices in Kenya</td>
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<tr>
<td>12.20pm-12.30pm</td>
<td>Analysis of Clients’ Satisfaction in the Fitness Center of Rift Valley Sports Club, Nakuru County</td>
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<td>Challenges of Technical Training Institutes Student Mothers, Coping Mechanisms and Support Accorded</td>
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### 12.30pm-12.40pm

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<tr>
<th>J.W. Kiragu, B. N. Mitaru, S. M. Badamana, L.W. Kabuage and K.R.G. Iru ngu</th>
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<tr>
<td>Effect of feeding forages and concentrate on growth, health and rumen development of male calves slaughtered at various ages</td>
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<th>Oduor P. L.</th>
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<tr>
<td><em>In Vitro Antiplasmodial Activities of Carissa Edulis, Azadirachta Indica, Cassia Siamea and Harrisonia Abyssinica against Plasmodium Falciparum</em></td>
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### 1.00pm-2.00pm

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<tr>
<th>VENUE</th>
<th>THEATRE 1</th>
<th>THEATRE 2</th>
<th>ED 13</th>
<th>ED 14</th>
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<tbody>
<tr>
<td>SUB-THEMES</td>
<td>FOOD SECURITY (Crop Foods)</td>
<td>CULTURE AND SOCIO-ECONOMICS (Socio-Economics)</td>
<td>SCIENCE AND TECHNOLOGY</td>
<td>GOVERNANCE, LAW AND SECURITY</td>
</tr>
<tr>
<td>CHAIR</td>
<td>Prof. R. Mulwa</td>
<td>Dr. M. Udoto</td>
<td>Prof. P. Cheplogoi</td>
<td>Dr. H. Murenga</td>
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<tr>
<td>CO-CHAIR</td>
<td>Dr. J. Anyango</td>
<td>Dr. J. Masika</td>
<td>Dr. F. Toroitich</td>
<td>Dr. H. Wario</td>
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### 2.10pm-2.20pm

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<thead>
<tr>
<th>H.W. Gitonga, P. O. Ojwang and G. K. Macharia</th>
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<tbody>
<tr>
<td>Generation Mean Analyses for Stem Rust (<em>Puccinia graminis f. sp. tritic i</em>) Resistance in Wheat (<em>Triticum aestivum L.</em>)</td>
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<tr>
<th>S. Mbanda, I. Tabu, D. Amudavi and R. K. Obura</th>
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<tbody>
<tr>
<td>Determinants of Choice of Agricultural Information Sources and Pathways among Sorghum Farmers in Ndziwa Sub-County, Western Kenya</td>
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<thead>
<tr>
<th>Mwando N, Nyasani J.O, Tamiru A, Obonyo MA, Subramanian S.</th>
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<tr>
<td>Biochemical Alterations in Maize Plants Induced by Viruses Causing Maize Lethal Necrosis and their Relevance for Insect Vectors</td>
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### 2.20pm-2.40pm

<table>
<thead>
<tr>
<th>Waweru B.N, M. G. Kamau C. Bernard</th>
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<tr>
<td>Utilizing the Old to Fight the New: Seeking Resistance to Wheat Stem Rust Race Ug99 from Old Kenyan Accessions</td>
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<tr>
<th>Nyaruri P.O., J. K. Gekonge</th>
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<tr>
<td>Role of Media and ICT in Empowering Kenyan Rural Communities with Information on Development</td>
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<tr>
<th>Ombati TS, Kihia CM B and Kirui</th>
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<tr>
<td>Performance of Eucnid Polychaetes Commonly Exploited by Artisanal Fishers under Different Culture Regimes</td>
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<tr>
<th>N. Omuria</th>
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<tr>
<td>Influence of Social Factors on Implementation of Childrens’ Rights Policy in Nakuru County, Kenya</td>
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### 2.40pm-2.50pm

<table>
<thead>
<tr>
<th>Mwende N, Danga B.O, Mugwe J, Kwen a K</th>
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<tbody>
<tr>
<td>Effect of Tied Ridges, Fertilizers and Seed Priming on Soil Moisture Content and Maize Yield in Semi-Arid Areas of Machakos County, Kenya</td>
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<tr>
<th>Okello G.</th>
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<tr>
<td>Factors Affecting Effectiveness of Media Use in Disseminating Agricultural Technologies to Farmers in Bondo Sub-County, Kenya</td>
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<thead>
<tr>
<th>Chepkemei J., Makwai J., Ngeiywa M., Anjili C., Njau V.</th>
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<tr>
<td><em>In Vitro Antipromastigote Activities and Toxicity of Mormodica Foetida against Leishmania Major Parasites</em></td>
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<tr>
<th>K. O. Ogutu, M. I.O.Okere</th>
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<tbody>
<tr>
<td>Influence of Community Policing on Incidences of Armed Robbery in Low Income Areas of Nakuru Town, Kenya</td>
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### 2.50pm-3.00pm

<table>
<thead>
<tr>
<th>Mugwe JM, Mucheru-Muna M, Mugendi DN, Mwaaura G, Ngetich FK</th>
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<tbody>
<tr>
<td>Response of maize and soybean to tied ridging and combined application of manure, tithonia and fertilizer in the central highlands of Kenya</td>
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<thead>
<tr>
<th>Obama M. O.</th>
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<tbody>
<tr>
<td>The Role of Mobile Phones in Marketing Horticultural Crops from the Kimira/Oluch Smallholder Irrigation Scheme of Homa Bay County, Kenya</td>
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<thead>
<tr>
<th>Chepkorir, J. C. Matasyoh, I. N. Wagara</th>
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<tbody>
<tr>
<td>Two Withanolides from <em>Withania somnifera</em> (Solanaceae) and Activity of Methanolic Extracts against Fungal and Bacterial Pathogens that affects Bean and Maize</td>
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<thead>
<tr>
<th>Mwangi A.M., Wandago B. O., Kivandi N. K.</th>
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<tr>
<td>The Role of the Social Media in Countering Radicalisation in Kenya</td>
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### 3.00pm-3.10pm

<table>
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<tr>
<th>Murage, F.M., Mugwe, J.N., Ngetich, K.F., Mucheru-Muna, M.M. Mugendi, D.N.</th>
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<tr>
<td>Effect of Phosphorous on Yield and Growth of Soybean Varieties in Central Highlands of Kenya</td>
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<tr>
<th>R. Wanyama, J. Ochieng, L. Kirimi, M. Mathenge</th>
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<tr>
<td>Mobile Phones and Agricultural Performance: The Case of Smallholder Maize Farmers in Kenya</td>
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<th>V. W. Nasimiyu, I. N. Wagara, M. A. Obonyo, J. C. Matasyoh</th>
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<tr>
<td>Isolation, Identification and Bioactivity of Fungal Endophytes from Selected Kenyan Medicinal Plants</td>
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<th>G. Ojwang’ Ochieng’, M. D. Murunga</th>
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<tr>
<td>Terrorism and its Implication to Security in Kenya</td>
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<td>3.10pm-3.20pm</td>
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<td>3.50pm -4.00pm</td>
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## CONFERENCE DAY THREE: FRIDAY 31ST MARCH 2017

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
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<tbody>
<tr>
<td>8.00am-8.30am</td>
<td><strong>REGISTRATION:</strong></td>
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<td><strong>SESSION COORDINATORS:</strong></td>
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<td></td>
<td><strong>VENUE</strong>             FACULTY OF EDUCATION THEATRE 2 (ET 2)</td>
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<td></td>
<td><strong>CHAIR</strong>             PROF. FR. STEPHEN MBUGUA</td>
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<td><strong>RAPPORTEUR</strong>         <strong>OPENING PRAYER:</strong></td>
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<tr>
<td>8.10 am – 8.15am</td>
<td><strong>REGISTRATION</strong></td>
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<tr>
<td>8.15am-8.30am</td>
<td><strong>LEAD PAPER:</strong> Musimbi D. Murunga</td>
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<tr>
<td>8.30am – 8.45am</td>
<td>Corruption and its Implication to the Kenyan Economy</td>
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<tr>
<td>8.45am-10.30am</td>
<td><strong>KEYNOTE ADDRESS:</strong> Snr. Counsel Nzamba Philip Kitonga</td>
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<tr>
<td></td>
<td>Corruption Menace: Is the New Constitution an Enabler or a Hindrance to the Fight against Corruption</td>
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<tr>
<td>10.30am– 11.00</td>
<td><strong>HEALTH BREAK</strong></td>
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<td><strong>BREAKOUT SESSIONS</strong></td>
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<td><strong>VENUE</strong></td>
<td><strong>THEATRE II</strong>            CULTURE AND SOCIO-ECONOMICS (Culture)</td>
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<tr>
<td><strong>THEATRE 1</strong></td>
<td>CULTURE AND SOCIO-ECONOMICS (Socio-Economics)</td>
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<td><strong>ED 13</strong></td>
<td>SCIENCE AND TECHNOLOGY</td>
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<td><strong>ED 14</strong></td>
<td><strong>CLIMATE CHANGE</strong></td>
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<tr>
<td><strong>CHAIR</strong></td>
<td>Prof. K. Ngetich</td>
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<td>Prof. P. Mshenga</td>
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<td>Dr. M. Obonyo</td>
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<td>Dr. G. Obwoyere</td>
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<tr>
<td><strong>SUBTHEME</strong></td>
<td><strong>EDUCATION</strong></td>
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<tr>
<td>11.00am–11.10am</td>
<td>J. N. Nguli</td>
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<tr>
<td></td>
<td>Strategic Orientation, Innovative Culture and Financial Inclusion among Small and Medium Women Entrepreneurs</td>
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<td>L. N. Namiinda and B. M. Namiinda</td>
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<td>Legal Risks Faced by Banks in their Social Media Engagement and their Effect on Bank Risk Management Practices</td>
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<td>Benard Okelo</td>
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<td>Characterizations of Properties of Normal Operators on Hilbert Spaces</td>
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<td>11.10am-11.20am</td>
<td>M. Kwambai, F. Chai, W. Nabea and D. Bowen</td>
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<tr>
<td></td>
<td>Matumizi ya udhahania katika Walenisi na Majuta</td>
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<td>L. Mangoa</td>
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<td>Effects of Risk Management Practices on Timely Completion of Projects</td>
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<td>P.M. Omode</td>
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<td>Characterization of Norm Inequalities for Commutators</td>
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<td>11.20am-11.30am</td>
<td>S. Mutie, N. Kamau-Goro, A. M. Rutere</td>
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<td></td>
<td>Nicholas V.Z. and T. Olweny</td>
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<td></td>
<td>The Impact of Financial Sector Development on Agricultural Production in Kenya</td>
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<td>H. Imboga, G. O. Orwa, R.O. Otieno</td>
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<td>Optimal Nonparametric Regression Estimation of Finite Population Total using Nadaraya Watson Incorporating Jackknifing</td>
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<td>11.30am-11.40am</td>
<td>Mwangi B. A.</td>
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<td>D. Musuya, K. Wanyama, B. Singoro, Otiso .N. K., M. Muganda, J. S. Matete, R. S Fwamba, S. Steven</td>
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<td></td>
<td>Equity Securities for Credit Unions; A Kenyan Case</td>
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<td>Kangogo W, N. B. Okelo, O. Ongati</td>
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<td>Properties of Local Automorphisms of Commutative Banach Algebras</td>
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<td>C. W. Recha, G. L. Makokha, C. A. Shisanya</td>
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<td>Is Climate Variability a Problem in Semi-Arid Eastern Kenya?</td>
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<td>Time</td>
<td>Speaker</td>
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<td>L.O. Mogaka</td>
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<tr>
<td>12.00pm-12.10pm</td>
<td>Mwangi B. A.</td>
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<tr>
<td></td>
<td>Z.M. Chantal, F. U. Ngesa, M. N. Mutinda</td>
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<tr>
<td>12.10pm-12.20pm</td>
<td>Boaz K Koech, Ivy N Kimani and Dishon G. Kweya</td>
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</tbody>
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**CLOSING SESSION**

**VENUE**

FACULTY OF EDUCATION THEATRE II (ET 2)

**SESSION COORDINATORS**

Prof. Bockline O. Bebe/ Prof. Mwangi Ndirangu

**11.40am-11.50am**

Presentation of the Awards

**11.50am-12.00noon**

Presentation of the Awards

**12.00pm-12.10pm**

Presentation of the Awards

**12.10pm-12.20pm**

Presentation of the Awards

**12.30pm-12.45pm**

**CLOSING REMARKS:** Prof. Rose A. Mwonya, Vice Chancellor, Egerton University

**12.45pm-1.00pm**

**VOTE OF THANKS:** Prof. Alfred C. Kibor, Ag. DVC (Research & Extension), Egerton University

**1.00PM – 1.10PM**

**CLOSEING PRAYER:** Rev. S. K. Nduati Egerton University Chaplain

**LUNCH AND DEPARTURES**
Knowledge and Innovations: Opportunities and Challenges of Re-inventing the Kenyan Education System to Transform Our Society, under the sub-theme of Education and Capacity Development.

Bitange Ndemo
Associate Professor
University of Nairobi, Business School

The Nexus Between Knowledge and Opportunity.

• Sources of Knowledge
  ✓ Sources and origins of knowledge are so numerous to count. We take in information and ideas from our lecturers, books, TV, the internet, our family (the old and experienced), our friends, and several other sources. But how does it become ‘knowledge’? Think about reason, emotion intuition and language.
  • “The only source of knowledge is experience.” Albert Einstein.
  • “It is the supreme art of the teacher to awaken joy in creative expression and knowledge.” Albert Einstein.

• Sources of Opportunity
  • Look at Problems
Where Does Knowledge Come From?

• Aristotle came up with five categories or sources of knowledge including:
  1) scientific knowledge (or epistêmè),
  2) practical knowledge (or phronesis),
  3) intellectual knowledge (or sophia),
  4) perceptual knowledge (or nous) - and
  5) productive knowledge (technê)

Where Does Opportunity Come From?

Research shows that many opportunities arise from social problems

However…..

Key issue: Favorable characteristics to opportunity often “exist” in the objective sense, but rarely do opportunities exist in fully developed form (Casson, 2003).
Sources of Opportunity: Environmental Forces

- Economic Forces (Growth/Recession)
- Technological Forces (Internet)
- Political & Legal Forces (Devolution)
- Sociocultural Forces (Health/Fitness)
- Demographic Forces (Kenya - Youth)

Sustainable Development Goals

- SDGs offer a ‘supremely ambitious and transformational vision’ for our common future till 2030.
- 17 goals; 169 sub-goals
Changing Problems Into an Opportunity

• The Business Case for SDGs: Research shows that achieving the Global Goals in Africa could open market spots worth an estimated $1.1 trillion by 2030 in business, savings and revenue, out of the Global prize of $12 trillion. Pursuing the opportunities will create 85 million jobs in Africa by 2030. Key areas include:
  ✓ Agriculture $367 billion
  ✓ Reducing food waste $57 billion
  ✓ Technology in farming $70 billion
  ✓ Low income food markets $67 billion

The Triple Helix and Social Transformation

• To convert opportunity into a commercial product, the private sector, research institutions and Government must work together.
• Enabling Policy - Government
• Research and Development – Universities
• Commercializing Research – Private sector
Transformational Capacity Building and Inclusive Innovation

- Drastic review of the current university curriculum to focus on applied courses to provide innovative training path, involving action learning, outdoor team training, simulating the real world through games, and soft personal skills development.
- Focus on inclusive innovation

Strathmore University Leads The Way
Building Solar Powered Cargo Bike

Different Models of the Solar Cargo Bike
Role of Technology in Transforming Society

- Big Data Analytics
- Mobility
- Broadband
  - Social Media
  - Education
  - Entertainment
- Mechanization of farming

Conclusion

*We have the opportunities, the knowledge and the resources. Let’s blame ourselves for not succeeding.*

*Thank You.*
I

Among the many foundational elements of culture, whether they are material or intangible, language is without doubt the most crucial. In fact, it would be nearly impossible to think of culture in absence of the sign systems that we call language, both, because thought is primarily semantic and because cultural systems approximate very closely the linguistic systems through which they circulate in manifest forms.

There is in our time a worldwide concern about the alarming rise in the incidence of language disappearance. As the global south moves into a new phase of densely urbanized way of life, a somewhat willing concealment of indigenous languages has become a common occurrence. Schools in every country are increasingly engaging in training pupils to use one or the other global language. These global languages or ‘mega-languages’ have become or are being perceived as threat to the local languages (Lukanovic 2010; Meierkord 2012). In a similar way, the idea of nation state, within which is implicit the idea of a language or languages for preserving national unity, has put stress on sub-national languages for a somewhat forced alignment. The sub-national languages or the ‘regional languages’ in turn have learnt to expect the migration of yet smaller language communities within their fold as a natural result of ‘development’, while they themselves feel uneasy in the face of the increasing influence of the ‘mega-languages’ and the ‘national languages’. Thus, quite a hierarchy of fears and anxieties seems to have besieged languages all over the world.

The fear and anxiety have taken in their grips even the mega-languages, for distinct continental varieties of these languages are emerging and beginning to become increasingly dissimilar (Barber, et al.1993; Bragg 2003; Williams 2010). The concern for ‘disappearing language’ has touched every mind on a scale never before experienced in human history. It is argued that while languages always go through the ‘natural cycle’ of rise and decline, in our time the incidence of a very rapid decline of
natural languages has assumed worrisome proportions. (Crystal 2000; Florey 2010; Nettle 2000). In recent years, as never before in the history of the discipline of language study and Linguistics, books on language endangerment and language decline have been appearing in a rapid succession. The discussion on language endangerment and the conservation of threatened languages has received endorsement from UNESCO too. (Wurn, 2005; Mosley, 2010)

**The Global Diversity Crisis**

Over the last two decades, scientists have come up with mathematical models for predicting the life of languages. (Braggs and Freedman 1993) These predictions have invariably indicated that the human species is moving rapidly close to extinction of a large part of its linguistic heritage. These predictions do not agree on the exact magnitude of the impending disaster; but they all agree on the fact that close to three quarters or more of all existing natural human languages are half in grave. There are, on the other hand, advocates of linguistic globalisation. The processes of globalisation have found it necessary to promote homogenized cultures. The idea has found support among the classes that stand to benefit by the globalisation of economies. They would prefer the spread of one or only a few languages all over the world so that communication across national boundaries becomes the easiest ever. Obviously, the nations and communities that have learnt to live within only a single language, whose economic well-being is not dependent on knowing languages other than their own, whose knowledge systems are well-secure within their own languages, will not experience the stress of language loss, at least not immediately, though the loss of the world’s total language heritage, which will weaken the global stock of human intellect and civilisations, will have numerous indirect enfeebling effects on them too. Since it is language mainly of all things that makes us human and distinguishes us from other species and animate nature (Blench 2012; April 2013), and since the human consciousness can but function given the ability for linguistic expression, it becomes necessary to recognise language as the most crucial aspect of the cultural capital.

It has taken human beings continuous work of about half a million years to accumulate this valuable capital. (Cornballis, 2011) In our time we have come close to the point of losing most of it. Historians of civilisation tell us that probably a
comparable, though not exactly similar, situation had arisen in the past some seven or eight thousand years ago (Crystal 2000). This was when the human beings discovered the magic of nature that seeds are. When the shift from an entirely hunting–gathering or pastoralist economies to early agrarian economies started taking place, we are told, the language diversity of the world got severely affected. (Blench and Spriggs 2012; Cornballis2011) It may not be wrong to surmise that the current crisis in human languages too is triggered by the fundamental economic shift that has enveloped the entire world, north or south, west or east. This time, though, the crisis has an added theme as a lot of the human activity is dominated by man-made intelligence.

The technologies aligned with artificial intelligence have all been depending heavily on modeling the activity of the human mind along the linguistic transactions. The intelligent machines modeled after entirely neurological or psychological systems are still not commonly in use. The language based technologies are now well entrenched partners in the semantic universe(s) that bind human communities together. (Gillespie 2007) Therefore that universe is being re-shaped. Language today is as much a system of meaning in the cyberspace effecting communication between a machine and another machine as much as it has been a system of meaning in the social space achieving communication between a human being and another human being.

Neurologists explain the current shift in man’s cognitive processes by pointing to the rapidly changing ways in which the brain stores and analyzes sensory perceptions as well as information. Linguists have raised alarm about the sinking fortunes of natural languages through which human communication has taken place over the last seven millennia. They have started noticing that the use of man-made memory-chips fed into intelligent machines make heavy dents in the human ability to remember and even the tense patterns of natural languages.

Technologists, particularly those astride the leading glory of technology—the ICT—have been talking of network communities as a substitute for civilizations. All in all, there is excitement in the air, and there is alarm in the minds. This is so on all fronts of knowledge, in all aspects of social organizations and all branches of human experience. Collectively, for all nations, all ethnic and cultural groups of humans, the vision of a life well beyond our imagination has started appearing on the horizon even
if it has not become fully manifest, making mockery of all that the human brain and mind have so far held as being natural and permanent.

In the new experience of the world waiting for all of us, memory as we have so far used (Rossi, 2006) is expected to be of little use, and imagination as we have so far exercised is predicted to get entirely transformed. The homo-sapiens, it is believed, moving out of memory, imagination and even language, are poised to enter a post-human phase of the natural evolution (McMohan, A. &McMohan R, 2013). Man and the intelligent machine, together, are expected to develop a new image-based system of communication, a new post-human and predominantly externalized memory and a sphere of imagination where multiple frames of existence seamlessly collide.

This image of the things to come-- call it a utopia, call it a dystopia—is profoundly unnerving, not because it involves fundamental challenges to the things established; not also because our sense of beauty, ethics and truth will get entirely transformed, but because a lot many communities—ethnic, linguistic, cultural—and an innumerable groups on economic fringes shall have to pay the cost of the transformation by having to face misery, deprivation and extinction.

Probably just as the Industrial Revolution and the associated rise of capitalism in European countries placed the traditional agrarian society at risk, giving rise to the long drawn conflicts between labour and capital, this great transition facing us globally will create strife and, consequently, violence of an unprecedented order. This time too the post-human societies are likely to get divided between those with access to the digital and those without it.

Already, some linguistic laboratories have started publishing lists of ‘digitally dead languages’, with over 98 percent of Indian languages included in the list. Already, the communities not networked are being described as ‘non-civil’. The economies of the world seem to have already resolved that the citizens without unique identities can be written off, like characters in Sadat Hassan Manto’s stories, as the nowhere people. In our excitement for the utopia of the ‘beyond imagination’ life and world, it would be tragic if we forgot to look at the struggles and the plight of those who are on the digital fringes. Aphasia, therefore, appears to be spread out for the future of Memory.
Language Erosion & Conservation

The future scenario that I have drawn up in the previous section pertains to a long term future, probably yet several centuries far from us; and at present we are not even equipped to grasp the array of effects it will unleash on nations and communities. If one were to think in terms of a relatively shorter time-span, say, of a quarter of a century or so, it may be possible to make somewhat tenable a statement about the changes to come. The short-term future implications for the global language crisis for African and Asian countries will be, first and foremost, an increased migration of the economically less privileged classes from one geographical area to another, a marked change in the perception of identity, a more deep-cutting social segregation and, the most regrettablly, the alienation of the traditional knowledge, ecological as well as sociological. The social, cultural and economic imbalances created by these projected conditions can well be imagined. And that kind of imagined future is already an important part of the activist rhetoric in vogue (because of its international presence) at present. What is, however, not yet imagined is that the massive language-migration may offer many of these coutries an opportunity to re-imagine the urban habitat. This point calls for some elaboration.

I will argue this point with reference to the case of India. When the state organization was carried out during the two decades after independence and linguistic states were proposed, the assumption was that language would help in keeping the people of a linguistically conceptualized state emotionally bound together (Schwartzberg, 2009; Sarangi, 2009). For reasons that had roots in the idea that ‘matri-bhumi’ (motherland) and ‘matri-bhahsa’ (mother tongue) are closely analogous, such a state was seen as a ‘homogenous’ state. However, owing to the economic and demographic histories of the capital cities of many of the states, a typical mega-city has emerged as being at a fundamental variance from the rest of the state. Thus the linguistic composition of Mumbai is not at all like the linguistic composition of the rest of Maharashtra. The same is the case with Bangalaru, Hyderabad, Kolkata, Chandigarh and Ahmadabad. Yet, the school boards and the text-books boards in the states continue to look at the mega-polis and the rest of the state as being one or alike. The language decisions of governments and educational regulatory bodies have ceased
to be realistic and appropriate. When in near future, the larger cities start recognizing their essentially multilingual character, despite their being capitals of a given linguistic-state, a more congenial atmosphere shall emerge for preservation and perpetuation of diverse languages. Capital cities of most of the states would have to be de-linked from the states in some ways and probably they will have to be given the status of union territories. The de-linking will not be called for merely because of the linguistic composition of the mega-cities, as language remains far low in the hierarchy of priorities of any over-populated country. Yet, the economic realities such as the cost-benefit ratio and revenue-efficiency, energy consumption and production abilities, global-market-space and global-skilled-labour available in the key urban centres, all will push the public opinion in the direction of a relatively greater autonomy for such cities.

By 2047, a century from the date of India’s independence, the cities like Delhi, Mumbai, Hyderabad and Bangalore are likely to have strong presence of over 10 international languages---English (also American?), Korean, Chinese, Arabic, French, Spanish, German, Russian, Italian, Japanese--- over 30 scheduled languages ( the likely number in 2047)--- over 8 to 10 Asian languages and quite a hundred or more minor and tribal languages. Thus, these cities will be home to nearly 150 or more languages, each of these with their individual ‘network communities’—wired and economically productive. Sheerly out of economic realism and political pragmatism, the big Indian cities will learn to acknowledge the ‘multilingual’ nature of their demographic composition and make moves in the direction of establishing multilingual schools, knowledge parks, libraries, book malls, TV channels, radio broadcast, and such. The cities in all probability will play out the ‘multicultural phase’ of development that European nations studded with migrant labourers have gone through in recent past (Bianco,2012). But, given the Indian tradition of ‘traditionalism’, our lasting love for the past and memory that glorifies the past, and the hardening of the sense of identity bruised by the big-cities, the rest of the state/s, made of small towns and deserted villages, tourist resorts and temple towns may return to flashing-points in linguistic chauvinism and cultural jingoism. In this imagined future probably the nation may appear to assuage itself for a while of the mournful awareness that humans have started departing from natural languages a bit too rapidly( Cru, 2010). Yet, in the process, perhaps, India will learn to respect what
has always been an essential feature of Indian society for the last five millennia, namely, a single language as a ‘mother tongue’ is but an abstract notion without any substantial evidence in the social reality. We may wake up to the realization that India has always nurtured and worshiped languages, welcomed languages from foreign lands and tamed even the mightiest of languages (such as Sanskrit and Persian) in the interest of the voice of small communities. We may wake up to this realization when natural language itself will be facing a threat to its continuation as never before.

One needs to address a common misgiving that seems to have pervaded the popular sentiment. It relates to the place of the English language. Ever since the English language was introduced in the higher education in India as the main language of knowledge, a slow process (Mayhew, 9126) flagged off by Lord T. B. Macaulay’s ‘Minutes’ (1835), there have been undercurrents within Indian languages that have looked at English as a challenge to Indian languages. In the years immediately following independence, there have been protest movements in the south against Hindi and an active anti-English campaign in the northern parts of the country. As a result of the epidemic-scale growth in the number of English medium schools in the country in recent years, one notices eruption of ‘bhasha-bachao’ (save our language) movements in several states, most particularly in Maharashtra, Gujarat, Karnataka and Punjab. It is easy to understand that the anti-English protests and campaigns shape up as the English language has played several key roles in the history of India since the eighteenth century, apart from being just a natural language that came here like many other natural languages. It has been the language of the people who had colonized India. It has been the language through which a lot of what we call ‘modernity’ is supposed to have reached the Indian shores. It has been the language of the twentieth century Imperialism which the political sentiment in India did not favour so much. Besides, English is today the language of a powerful communication technology and the language associated with the flow of international capital. Being thus so many of the above, and more, it continues to draw anger from a variety of quarters from time to time.

Yet, it is a language that has brought to Indian languages a very huge range of lexical items adding to their power of expression. It is the language which has continued to enrich the literary and dramatic expression in Indian languages by bringing to them literature from all parts of the world. Besides, it is today probably the most effective
link language for the Indian republic and a language which brings employment and business more easily than other languages do. Given this extremely complicated and entrenched place of the English language in India, what is in store for us in near future? More specifically, what may be the condition of the Indian languages such as Bangla, Telugu, Marathi, Gujarati and so on? Will English manage to replace all of them completely? Or, will English one day beat a quiet retreat to the lonely island from where it came to India? It is but natural that these and such other questions should continue to exercise the minds of the nation-loving Indians.

Obviously, there are no easy answers to these questions since human languages are known to have behaved in the most surprising manner in the past. Some very mighty languages are known to have disappeared in the face of some minor challenges; some others have grown taller precisely because they faced threats of extinction. Yet, if one were to try predicting the fortunes of the English language in India, one would have to look at the history of its fortunes in similar situations elsewhere. It is necessary to recall that the English language travelled with the colonial rules to several other continents. It managed to almost entirely replace the indigenous languages in North America, Australia and New Zealand. That did not however, happen exactly so in African countries like Nigeria, Kenya and South Africa. In India, just as the fortunes of the English language continued to improve, numerous Indian languages too witnessed a remarkable literary and linguistic growth in the same period. Based on this comparative perspective, one can perhaps propose that there had been something in the making of the Indian languages prior to the arrival of English which allowed them to face the encounter in a far more mature way than the languages of the Atlantic and Pacific areas had managed to do. What was this peculiar strength?

If one were to step back in history, one notices that the Indic and the Dravidic languages had previously negotiated the encounter with Arabic and Persian with an equal maturity, themselves surviving in the encounter and linguistically gaining in the process. Given such a history, it is reasonable to assume that the innate multilingualism of the colonized culture(s) will see them through in the current encounter with the English language. As a result of the intimacy between the English and the indigenous languages, they are likely to get suffused with English vocabulary. But so long as the grammars are their own, they need not fear a total annihilation at the hands of English.
The fear of decline should arise from another quarter, namely, the neglect of the minor languages, the dialects, the speech patterns of the indigenous, the forest dwellers, the hill communities and the coastal communities. These ‘other’ languages have been like the roots of the main languages in Asia and Africa. In the past, they have provided the main languages semantic resource and expressive power. Those roots have started drying up as the speakers of the ‘other’ – the non-recognised, the oral, the economically less privileged – languages are driven to outward migration in search of livelihood. Already the erosion of the supporting indigenous languages has started showing an adverse impact on the main languages of Africa and Asia. The situation would be predictably far worse some thirty years from now. So, if the great language diversity of the world has to be preserved, promoted and carried forward to the future generations, it would be necessary to turn attention to the indigenous and minor languages.

Language is not only a social system of verbal icons, arbitrarily assembled through ages, it is also a ‘means’ of carrying forward the cumulative human experience of millennia to the future generations. When language trajectories are snapped, the accumulated wisdom in those languages too gets submerged and continues to survive in severely truncated, irreparable and insensible forms. Therefore, only if a perceptible shift takes place in our attitude to what knowledge is, how it is to be transmitted to new generations and how it is to be harnessed for improving sustainability of the planet earth, the continuation of some of the potentially languages can be ensured. That shall also contribute significantly to the deepening of democracies in a people-friendly and ecology-friendly form. In human history, language was created as a ‘surplus’ of man’s cognitive and emotive transactions, a product of the ‘labour of the mind’. For a very long span of the human history, language continued to retain its character as a predominantly ‘free’ system that is sturdily resistant to government controls, market regulations and cultural oppressions.

However, over the last few centuries, particularly since the rise of technologies that function to assist language transactions—printing, photography, electronic-language-storage-and-reproduction, digital-encoding-and-decoding of human language—language acquisition, languages-transmission and language use have started getting
rapidly monetized. Today, as never before, the economically disposed classes all over the world are finding it difficult to access language acquisition as per their needs and desires. Thus, throughout the world, we now notice a digit-powered linguistic class and another print and digit deprived linguistic class. The divide is too deep to bridge by following any conventional or prevailing economic ideologies. A technological reversal in the evolution of languages too is a hugely unrealistic proposition. The only hope for ensuring any future for ‘linguistic homo-sapiens’ is to envision together and integrate economic development and linguistic federalism. If the rural landscapes and marginalized communities can be safeguarded, the currently threatened languages will find a safe passage to the future; and only if those languages continue to survive shall we have access to the knowledge that helps us to build a sustainable future society. The two are so intimately interlocked.

It was a remarkable foresight of the makers of the Indian Constitution that they thought of creating a dedicated Schedule of Languages—the 8th Schedule—which initially included 14 languages as the languages of administration. The list was subsequently enlarged so as to adjust the intent of the Schedule to the linguistic realities in the country. At present the Schedule holds a list of 22 languages. These languages, popularly known as the ‘Scheduled Languages’ are Assamiya, Bangla, Boro, Dogri, Gujarati, Hindi, Kannada, Kashmiri, Konkani, Maithili, Malayalam, Manipuri, Marathi, Nepali, Oriya, Punjabi, Sanskrit, Santali, Sindhi, Tamil, Telugu and Urdu. The Constitution has empowered individual States by vesting in them the authority to identify any language/s as official language/seven if it is not in the 8th Schedule. Thus, though not in the Schedule, Kokborok (Tripura), Khasi and Garo (Meghalaya) and Mizo (Mizoram) enjoy the status of ‘official’ languages of administration. Further, a state has the powers to offer primary school education in any language irrespective of its official status. Under this provision, a number of languages of Adivasi communities have been introduced in primary schools in Orissa, Chattisgadh, Andhra Pradesh, Maharashtra and Gijarat where the population speaking those languages is significant. In some states, new link-languages are conceptualized and promoted in order to keep the linguistically diverse states together. Rajasthani (Rajasthan), Pahari (Himachal Pradesh) and Nagamese (Nagaland) are the instances of such state-promoted ‘binding’ languages.
During the last hundred years, the print media has reached to a number of languages that are not officially recognized or promoted. Though it is not widely known, the number of little magazines, pamphlets and small-circulation books produced in the non-scheduled languages is quite large, a phenomenon that led the National Book Trust (NBT) to making tribal language publications the central theme for the NBT’s International Book Fair in 2014. The official radio service—the All India Radio (AIR)—offers slots to nearly 120 languages in its regional programmes. In addition to the languages mentioned so far, there are numerous other major languages in India. Some are native such as Kutchhi (Gujarat), Tulu (Karnataka), Bhojpuri (U.P.-Bihar) and Bagadi (Rajasthan), while others have come from other countries and cultures and were accepted in the course of history as ‘our languages’. The ‘foreign’ languages which are still in use in different parts of the country include English, French, Portuguese, Bhoti, Iranian/Iranian, Arabic, Persian/Farsi and Pashto.

Archaeological and historical researches during the last two centuries have made it possible for us to know something about the complex linguistic transitions and migrations that took place over the last five millennia, roughly from the early Harappan times to our time. During this long period, the Indian subcontinent accepted language legacies as distinct as the Avestan of the Zoroastrians, the Asu-Astro-Asiatic of the Pacific the Tibeto-Burman of the East and the Northeast Asia. The Indic (or the Indo-Aryan) languages in the northern states together with the Dravidic languages in the south and the Tibeto-Burman languages in the Northeast, each with a great variety of sub-branches—make for the larger bulk of the Indian languages. Throughout the known history of the subcontinent, there has been an active exchange and cultural osmosis between the indigenous languages and the migratory languages, producing in the process great literature in many tongues.

The People’s Linguistic Survey of India has estimated that there are nearly 780 living languages in the country at present. Scholars claim that there are approximately 6000 living languages in the world. Thus, India is home to 1 out of every 8 languages on earth. The diversity is impressive not only in numerical terms. A language is not just a communication system, it is a unique world-view. Thus, though one can translate a given meaning from one language to another, there are always shades of meaning and nuances in any language that simply cannot be translated into other languages. Hence,
the great diversity of languages in India needs be seen as the diversity of world-views, of the unique ways of perceiving the world.

Despite the vast range of the existing linguistic diversity in India, and the official support that is being given to a relatively large number of languages, the language stock in the country has started showing signs of a rapid decline (Sengupta, 2005). Several historical factors appear to be responsible for the decline. The print technology impacted Indian languages profoundly during the nineteenth century. The languages that were printed acquired importance (Austen, 2009), the ones that remained untouched by it came to be seen more as dialects than as languages, though that was not the case in every instance. Subsequently, the process of state reorganization in the country invoked the principle that a language is a language only if it has printed literature in it. Obviously, the languages like Bhojpuri or Gondi, despite having large number of speakers were never considered for statehood. The reorganization of Indian states mainly as linguistic states turned the already marginalized and ‘non-printed’ languages into ‘minority’ languages. Thus, Bhili, a major language in itself with speakers over 20 million, got divided into four states and became a minority language in all of them, namely, Maharashtra, Madhya Pradesh, Gujarat and Rajasthan.

The list of ‘Mother Tongues’ reported by the 1961 Census had 1652 names. Beginning with the 1971 census, the government decided to include in the list only the languages having more than 10,000 speakers. The list of 1971 had a total of 108 names, with a 109th entry of ‘all others’ (Nigam, 1971). The policy of using a cut-off figure further eliminated the already marginalized and minor languages. They stared becoming increasingly invisible in social practice or political discourse. The relative lack of livelihood possibilities in the areas where the minor and marginalized languages are spoken has led to an exodus to areas where major and main-stream languages are spoken. This too has accelerated the rate at which the Indian language diversity is shrinking. The number of languages that may have disappeared during the last fifty years was estimated to be 250 by the People’s Linguistic Survey. India seems to have lost nearly a quarter of its ‘world views’ since independence. The grave crisis is confined not to India alone. A similar situation of language loss is being experienced by most countries and in all continents. My discussion of the situation in India may be specific for a single sub-continent; but the symptoms of the linguistic and the cultural crisis in India are not very different from the ones in the linguistic and cultural
situation in other Asian countries, Australia and New Zealand and Africa. I shall conclude by saying that a discussion of culture in the present has to focus primarily on the language question, for if language declines, discussion itself may get endangered.

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Mio-Pliocene palaeoenvironments of the Gregory and Albertine Rifts, the ape-human dichotomy, and the earliest phases of hominid evolution

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From 1974 until 2000 the dominant paradigms concerning hominin origins were :-

Chronology of African Ape - Human (AA-H) dichotomy : ca 5 Ma, range of estimates 2.5 to 6 Ma

Palaeoenvironment of earliest hominids : savannah

Locomotion of precursor : quadrupedal, terrestrial ape, often said to be a knuckle-walker

Body plan of precursor : often said to be chimp-like (long face, thin molar enamel etc.)

Evolutionary pathway : Last Common Ancestor was ancestral to *Australopithecus* which was ancestral to *Homo*

Predominant role played by molecular biology in these paradigms
Fossils relegated to second place, but in any case biased dating and concepts
Discovery of *Orrorin tugenensis* in 2000 changed all that:
Now the dominant paradigms concerning hominin origins are:-

**Chronology of AA-H dichotomy**: substantially older than 6 Ma, perhaps as much as 12 Ma

**Palaeoenvironment of earliest bipeds (hominids)**: forest or well wooded (Miombo Woodland?)

**Locomotion of precursor**: arboreal quadruped with orthograde posture in the trees, opposable thumb, climbing adaptations

**Body plan of precursor**: not chimp-like (short face, thick enamel, human-like incisor/molar relations, no diastema, platymeric femur, differential molar wear, opposable thumb, etc)

**Evolutionary pathway**: *Australopithecus* not ancestral to *Homo*: *Orrorin* was in a more direct line to *Homo via Praeanthropus*

Weakness of phylogenetic and chronological arguments based solely or mainly on neontologic data revealed that fossils are essential for phylogeny reconstructions, but identifications and interpretations of fossils need to be accurate
Humans

Pan paniscus

Gorilla gorilla

Pongo pygmaeus

Gagneux et al., 1999

Calibration age not specified

Pan troglodytes central & eastern

Pan troglodytes western

Pan paniscus

Gorilla gorilla eastern

Gorilla gorilla western

Pongo pygmaeus Sumatra

Pongo pygmaeus Borneo

Some of the *Orrorin* specimens

Kapsomin hominid: 6 Ma

Kiptalam Cheboi

*Orrorin tugenensis*
Kabarnet Trachyte 6.1 Ma
Kaparaina Basalt 5.7 Ma
Lukeino Formation ca 6.0-5.8 Ma

KAPSOMIN
Type locality of ORRORIN

KAPCHEBEREK
Palaeoenvironment of *Orrorin*
Fossil leaves from the Lukeino Formation
Obsolete theory of origins of bipedalism

Il ya 20 millions d’années
... 10 millions d’années
... 1 million d’années
Lukeino Terrestrial Palaeoenvironment

- Dry evergreen forest – dominant
- Papyrus swamps – littoral
- Woodland with grasses - minor

Cyperus (papyrus)
_Hymenaea verrucosa_ Caesalpiniaceae
Another Caesalpiniaceae
_Trimeria grandifolia_ Flacourtiaeae
_Strychnos cf scheffleri or mellodora_ Loganiaceae
_Zizyphus sp. Rhamnaceae_
Fauna associated with *Orrorin*

Hindlimb morphology, locomotion and posture of *Orrorin*
Myth of the knuckle-walking, chimp-like last common ancestor
Orrorin proximal femur: obturator externus groove

Lucy, Australopithecus antiquus
Homo sapiens

Position of lesser trochanter

Anterior view

Posterior view
Forelimb morphology of *Orrorin*

*Ridge for insertion of brachio-radialis muscle: main muscle used in climbing*
Summary of why we consider *Orrorin* to be closer to *Homo* than *Australopithecus* is, and why we think *Australopithecus* may not have given rise to *Homo*

**Hindlimb**
*Femur*: *Orrorin*’s is more human-like than that of *Australopithecus*

**Forelimb**
*Terminal thumb phalanx*: *Orrorin*’s is more human-like than that of *Australopithecus*

**Dentition and body size**
*Cheek tooth/body size proportion*: *Orrorin* is more human-like than *Australopithecus* is
*Incisor/molar proportion*: *Orrorin* is more human-like than *Australopithecus* is
Chronology and phylogeny of Hominidae avoiding evolutionary reversals in dental and locomotor features

- **Ardipithecus**
  - (Thin enamel, bipedal?)
  - *A. r. kadabba*
- **Sahelanthropus**
- **Paranthropus**
- **Australopithecus**
- **Praeanthropus**
- **Orrorin**
  - Slightly microdont, normal incisors, More human-like hind limbs
- **Homo**

Megadont, reduced incisors australopithecine limb pattern

- Microdont, normal incisors, human limbs

Major changes in hominid origin paradigms

**OLD**
- AA-H dichotomy 5-6 Ma based on molecules
- Savannah hypothesis
- Australopithecines were ancestors of humans
- Terrestrial quadruped ancestor (knuckle-walker)
- Common ancestor chimp-like

**NEW**
- AA-H dichotomy 8-9 Ma if not more
- Dry forest or moist woodland
- Australopithecines are a side branch
- LCA not a terrestrial quadruped
- Common ancestor not chimp-like
Future lines of research to throw light on the earliest phases of hominid evolution and the AA-H dichotomy

Period of interest: 12-6 Ma.
Geographic area of interest: All of Africa as well as Eurasia.
Palaeoecosystem of interest: Miombo Woodland, Mopane Woodland, dry evergreen forest and other non-tropical forest areas. Also savanna, semi-desert and desert.
Search for additional Neogene fossil African apes (*Samburupithecus, Otavipithecus, Nakalipithecus, Chororapithecus, Sahelanthropus, Niger proto-chimp*) as well as early hominids (*Orrorin*).
Bio-geochemistry (stable isotope studies to understand diet, palaeoclimate etc).

Where to look for this kind of evidence

Kenya – Tugen Hills has the most complete Neogene (20-5 Ma) sequence known in Africa.
Western Rift, Uganda – tropical to sub-tropical forest
Miombo woodland – covers ca 10% - 15% of the surface of Africa south of the Congo Forest.
Mopane woodland – southern Africa covers ca 10% of the continent.
Within Africa

Miombo Woodland

Severe selection for adaptation for locomotion in trees with predominantly vertical supports (good hand-eye coordination, opposable thumb, vertical spine and hind leg posture, development of instep), trees far apart (requiring descent, walk across ground to climb next tree, big toe non-opposable, head high off the ground, poor sense of smell), seasonal fruiting, occasional drought & famine (thick enamel in molars), sleep on the ground, hairs short and fine (to minimise seed sticking), body weight increase (predator avoidance), delayed maturation, hidden oestrus, subcutaneous fat (reserves during famine, especially for lactating females), increase in longevity and intelligence (remembrance of places to obtain alternative foods during famines, not forgetting water)
New Pliocene hominid fossils from the Tugen Hills

Mabaget site
Mabaget hominid: 5 Ma
Zaphania Chetalam

*Ardipithecus* sp.
Right mandible with p/4-m/1
Sinibo hominid site
Sinibo hominid: 3.2 Ma
Rosalyn Cheptumo

Sinibo hominid site: 3.2 Ma

Australopithecus afarensis
left & right mandible fragments
Thanks

Egerton University
Orrorin Community Organisation
Muséum National d’Histoire Naturelle, Paris
French CNRS

Pan troglodytes
Individual MU Mahale
SK 87 *Australopithecus africanus*  
Stern & Susman, 1991

**Thumb of *Orrorin***

Bar 1901’01  
Lukeino Formation  
ca 5.8 Ma
11th Egerton University International Conference

Knowledge and Innovation for Food security in Africa

Hedwig Bruggeman – Wageningen Centre for development Innovation
One Wageningen for Global Impact
To explore the potential of nature to improve the quality of life
Global context in which we work...
Our stakeholders include:

- Dutch government ministries, provinces, and municipalities
- International governments, such as China and Chile
- The business community
- Non-profit organisations
Creating impact through:

Research  Education  Value creation
Wageningen University

9,840 BSc/MSc students from >100 countries
>1,900 PhD candidates
2,529 FTE of faculty and staff
Revenue in 2015: €635 million
WUR ranking in Higher Education Selection Guide in full-time university education 2017: 1 (12 consecutive years)
Wageningen University

Wageningen Research

- 2,410 FTE of faculty and staff
- Revenue in 2015: €635 million
The Wageningen approach

- No one-dimensional solutions for urgent challenges, therefore: multidisciplinary approach and open connections between scientific and social science disciplines
- Cooperation between university and market-oriented research institutes
- Close collaboration with government authorities, the business community, research institutes and other universities
The challenge: two times

More  Less  Better

Towards sustainable food systems that deliver food and nutrition security for 9 billion people in 2050 within the carrying capacity of our planet
A changing world

The world is rapidly changing and this poses great challenges to science within our domain:

- The global population is growing rapidly (to 8.5 billion in 2030), prosperity is increasing and with this, the demand for food, especially high-protein food

- Environment, nature, and climate is under major pressure

- Fossil fuels and other raw materials are being depleted

- Much of the global population lacks access to adequate or sufficiently nutritious food
How will food systems nutritiously and sustainably feed 8.5 billion people in 2030?

- Developing inclusive, sustainable, efficient, nutritious and healthy food systems will be essential to achieve the Sustainable development goals SDG’s (WEF 2017)
Agrifood system development model
4 major transitions highlighted  

(van der lee 2017)

Subsistence Smallholder farming  
Emerging farming  
Commercial farming  
Industrial farming

Production system capable of supplying to a range of market systems  
Production systems capable of providing food for specific market system

INFORMAL  
LOCAL CHAIN  
FORMAL CHAIN  
HIGH-END CHAIN

Entering informal market  
Expanding chain  
Formal supply chain development  
High-end chain development

Home consumption  
Fresh food markets  
Wholesale markets  
Retail markets / Out of home consumption  
High-end markets / convenience
Scenarios for the Future of Food Systems

For questions on this document please contact:
Lorin Fries, Head of Food Systems Collaboration, World Economic Forum: Lorin.Fries@weforum.org
To answer “How will food systems nutritiously and sustainably feed 8.5 billion people in 2030?” experts chose demand & markets as the critical uncertainties.

Global food systems experts identified the two most critical uncertainties that will shape food systems by 2030, emphasizing interlinkages with trade, technology, geopolitics, environment, health and other areas.

Rationale for demand shift as a critical uncertainty

- Experts agreed that future changes in demand shift are a fundamental uncertainty that will shape the entire food system by 2030.
- Uncertainties related to the nature of demand shift were particularly focused on the environmental impact and health implications of consumer choices. It is important to note that such choices are shaped by several accessibility factors and that healthy diets and environmental sustainability are not necessarily correlated but considered in tandem given their critical importance.

Rationale for markets as a critical uncertainty

- Experts identified critical uncertainties and significant risks and vulnerabilities related to the connectivity of markets.
- This axis captures questions pertaining to the relative openness of trade, trust in and resilience of commodity markets, and inclusivity of technological innovations.
The World Economic Forum and its partners have developed a scenarios analysis for the future of global food systems, launched in Davos in Jan 2017.

The World Economic Forum’s System Initiative on Food Security and Agriculture conducted a scenario-building exercise on the future of global food systems in collaboration with Deloitte.

Scope and focal question considerations

- The question is framed globally to provide a “big picture” outlook for global leaders, with regional dimensions taken into consideration within the scenarios.
- Nutrition and sustainability are highlighted because they represent key challenges facing global food systems.
- The timeframe of 2030 was chosen to align to the UN’s Sustainability Development Goals (SDGs), generate urgency among current leaders, and identify strategic actions required in the near future to set a strong foundation for the following decades.

Objectives of this food systems scenarios analysis

- **Provoke and challenge leaders** to think in new ways about food systems.
- Provide new and actionable insights on potential disruptions and trends.
- **Motivate action** to strengthen food systems.
- Identify and enable new partnerships and alliances.

Scenario analysis methodology

- Scenarios are a tool for broadening perspectives about alternative future environments in which today’s decisions might play out.
- Typically, scenarios are presented as rich, dialogue-driven stories that allow leaders to think productively about contingencies, alternatives and robust strategies.

Focal question

How will food systems nutritiously and sustainably feed 8.5 billion people in 2030?
While each scenario is complex and nuanced, the essence of each potential future can be captured in a few key ideas.

### Unchecked Consumption
- High growth, with consequences
- Consumers are king; markets boom and trade accelerates
- Technology spurs efficiencies in food production and distribution; yield is priority #1
- Obesity and health costs skyrocket as billions transition to a Western-style diet
- The "foodprint" expands; natural resources are severely depleted

### Open-Source Sustainability
- The world’s currency is trust; there is a rise of a “mutual benefit” philosophy
- A proliferation of food sources reduces over-reliance on a few bread baskets
- Open platforms improves tech accessibility, but long-term R&D is disincentivized
- Consumers know the real cost of food; markets and policies enable “sustainable” choices
- A rural transformation attracts youth to data-driven agriculture; older farmers struggle to keep pace

### Survival of the Richest
- Broad distrust in globalization results in slow economic growth and volatile markets
- Multiple Least Developed Countries are in crisis, with accelerating poverty and hunger
- Fear and market volatility prompt nationalist sentiment and isolationist policies
- Income gaps widen
- Climate change continues unabated
- Population growth and food prices prompt increased conflict and migration
- Technology innovation is defined by broad disparity of access and adoption

### Local Is the New Global
- In a disconnected global market, nations turn inward; comparative advantage is lost
- Food movements thrive, with a focus on traditional diets and local production
- Progressive policies have reduced the price point for healthier diets
- Shorter supply chains and increased plant-based diets reduce environmental strain
- Import-dependent nations suffer; hunger hotspots proliferate
- Country-specific innovation flourishes but diverse standards hamper scale
The scenarios elevate key overarching messages that require urgent attention from executives, policy-markers, social sector leaders and consumers.

Any of these scenarios is possible. Early signs of all four futures are present in our world today, and any of them could become a reality by 2030. Together, they demonstrate that today’s food systems require a fundamental transformation to meet human needs within planetary boundaries in 2030. Additional insights from the report include:

- **Consumption – as shaped by context – will make or break global health and sustainability.** The scenarios emphasize the importance of incentivizing, enabling and encouraging consumers to eat more resource-efficient diets in their respective contexts.

- **Putting nutritious and sustainable food on every plate requires a fundamental redesign of food production systems.** Such a transition would put greater focus on the quality, rather than solely quantity, of agricultural production.

- **Climate change will affect all future scenarios and poses an significant threat.** Climate change and natural resource degradation may compromise the long-term productive capacity of food systems, compromising social stability and economic well-being.

- **Food system dynamics are likely to exacerbate inequality within and between nations.** Growing inequality will affect all possible futures. Each scenario has winners and losers; the disparity between them is most evident in a disconnected world of more resource-intensive demand.

- **Fourth Industrial Revolution technologies and other innovations can revolutionize food systems but will introduce new challenges.** Technology innovations will dramatically reshape how we produce, manage and demand food in select markets, but their effects will be unevenly distributed.

- **Our choices – through action or inaction – will determine our path.**
Action recommendations recognize the need to galvanize a global transformation in food systems towards the achievement of the SDGs.

The analysis recognizes opportunities for leaders to pursue food systems transformation:

**Business: A new era of business**
- Capture market opportunities for investing in health and nutrition
- Contribute to greater resiliency in global markets
- Increase the resource efficiency of business operations
- Leverage technology to address social and environmental challenges in food systems

**Government: New and bold “smart policies”**
- Adopt a “whole of government” approach to integrate the true costs of food systems
- Link food, agriculture and environmental policies to healthy diets
- Create an enabling environment for inclusive technologies

**Civil society: Social and ecological priorities**
- Address structural inequality and meet basic needs
- Influence new dietary norms and aspirations
- Elevate the needs of future generations

**All sectors: Responsive and responsible leadership**
- Secure inclusive, sustainable, efficient, nutritious and resilient food systems
- Build greater levels of transparency, trust and collaboration within food systems
The fourth industrial Revolution
### ICT4ag for different stages farming cycle

<table>
<thead>
<tr>
<th>PRE-CULTIVATION</th>
<th>CROP CULTIVATION &amp; HARVESTING</th>
<th>POST HARVEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop &amp; Land Selection</td>
<td>Land Preparation &amp; Sowing</td>
<td>Marketing and Packaging</td>
</tr>
<tr>
<td>Calendar Definition</td>
<td>Input Management</td>
<td>Transport</td>
</tr>
<tr>
<td>Access to Credit</td>
<td>Crop Harvest</td>
<td>Sale and Repayment</td>
</tr>
</tbody>
</table>

- land title deeds information
- market info & trends
- crop suitability for land
- soil testing
- credit facilities
- service provider rates (seeds, fertilizer, irrigation, implements)
- biz planning support
- licences & subsidies
- training
- Q&A services

- early warning & weather systems
- online order placement inputs
- water management from providers
- online payment
- credit related services
- crop forecasts
- Q&A services

- procurement prices at various POSs
- quality certification services
- loan repayment services
- commerce & payment systems
- scheduling delivery
- transportation & packaging services
- access to storage facilities

---

Deloitte: Transformation-Ready: The Strategic Application of ICTs in Africa - Impact of ICTs in Agriculture
http://www.slideshare.net/etransform/etransform-africa-ict-and-agriculture
Information Services and Networks for Knowledge Exchange

Service

- Input information
- Agronomic Information
- Weather forecasts
- Market information

Benefits

- + choice on inputs
- + sustainable agro practices
- Improved productivity
- Higher crop quality
- Higher prices received
- Horizontal + vertical information flow

Value Chain Linkages

- Aggregation of farmers for purchase and sale
- Connection with input providers and buyers

Financial Services

- Mobile banking
- Micro-credit/saving
- Micro-insurance

- Purchase cheaper
- Access to buyers
- Less product loss
- Access to new products and markets

- Reduced risks and transaction costs
- Access to credit
- Reduced vulnerability to risks and shocks

Sustainable Agriculture: a mobile landscape (Batchelor et.al. 2014)
Efficient
Inclusive
Sustainable
Nutritious & Healthy

World Economic Forum
Knowledge in action
Lead Compounds from African and European Plants: From Discovery to Commercialisation

Dulcie A Mulholland
Natural Products Research Group,
Department of Chemistry,
University of Surrey, Guildford,
United Kingdom.

Egerton University, March 2017
Knowledge and Innovation for Social and Economic Development.

WHY DO PLANTS PRODUCE SECONDARY METABOLITES?
1. Development of an organic agrochemical for the treatment of grapevine downy mildew (*Plasmopara viticola*).

2. Investigations of members of Asparagaceae (Hyacinthaceae) for medicinal uses

3. Neurite growth potential of compounds from Gentianaceae.

Grapevine Downy Mildew (*Plasmopara viticola*)

One of the most harmful diseases in European wine growing regions

**Oomycete**
- Oospores propagate through water
- Symptoms include oil spots on leaves and sporangia coated grapes

**Problem for viticulture**
- Numerous infections during season
- Infection of young berries causes high fruit loss (up to 100%)
- Australian figures: Can cost Aus $22.5 million (£13 Million) in "good" year and Aus $64 million (£37 million, 4.8 billion Kenyan shillings, ZAR 750 million) in wet year.
Copper treatment

Current treatment
- Copper containing agrochemicals (Bordeaux mixture)

Problems
- Environmental & toxicological concern
- Banned in Denmark, Sweden, Norway, Netherlands
- Maximum use: 6 kg/ha/year

Alternatives
- Reduce application
- Copper often only available effective control
- Other products have poor activity

The development of modern, environmentally friendly technologies, processes, materials and products to utilise abundant sources of wood waste and humic substances as raw materials for value-added products.
Sample Extraction & Purification

**MARSXpress™ microwave extraction**
Reveleris® X2 Flash Chromatography System

*Larix gmelinii*, *Larix sibirica*, *Larix decidua*
*Pinus sylvestris*, *Populus tremula*, *Abies nephrolepis*
*Picea jezoensis*, *Picea abies*

**Collection sites:** Finland and northern and far eastern Russia during 2009 & 2010

For each plant, 10.0 g of plant material was packed into each of 40 Teflon vessels together with a magnetic stirrer and solvent (25 mL). The vessels were capped, placed in a turntable and the appropriate method was loaded (voltage: 1600 W, power: 100%, time: 10 min hold: 20 min, temp. 50°C for DCM, 50°C for *EtOAc* and 110°C for *MeOH*).

---

Screening of bark extracts

Efficacy of methanol (A), ethyl acetate (B) and dichloromethane (C) extracts against *Plasmopara viticola* on grapevine seedlings under semi-controlled conditions.

Extracts were tested at two concentrations: high (0.9-1 mg mL⁻¹) and low (0.1 mg mL⁻¹ (LD, LS) or 0.21-0.26 mg mL⁻¹ (all other species)). The figures show means ± SD (n=6).

Disease severity of the non-treated control in the three experiments was 84±1% (mean±SD), efficacy of the copper control was 97±2% (0.03 mg mL⁻¹ Cu²⁺) and 83±13% (0.003 mg mL⁻¹ Cu²⁺).


Asterisks indicate significant differences to the non-treated control (Dunnett’s test, p<0.05), distinct lower case letters indicate significant differences between treatments at 1 mg mL⁻¹ (Tukey’s HSD, p<0.05).
Screening of pure compounds

Dose-response curves of compounds isolated from bark extracts of Larix decidua / Larix gmellini / Larix sibirica (A) Pinus sylvestris (B) or Picea abies (C) against Plasmopara viticola on grapevine seedlings under semi-controlled conditions. Each data point represents the mean of six replicate plants. The total of 36 data points originates from six distinct experimental sets, with a mean disease severity of the non-treated control of 89\%±4\%, and mean efficacy of a copper control of 97\%±2\% (0.03 mg mL\(^{-1}\) Cu\(^{2+}\)) or 78\%±10\% (0.003 mg mL\(^{-1}\) Cu\(^{2+}\)), respectively. The figure shows log-linear curve fits.

15-Hydroxydehydroabietic acid (1)
7-Oxo-15-hydroxydehydroabietic acid (2)
7α,15-Dihydroxydehydroabietic acid (4)
Larixyl acetate (16)
Larixol (17)
Lariciresinol acetate (30)
Lariciresinol (29)
Rhaponticin (72)
Piceatannol-5-O-glucopyranoside (73).

Structures of pure compounds screened against Plasmopara viticola on grapevine seedlings
Active compounds

Analysed 153 compounds
- Larixyl acetate and larixol identified as most promising
- 99% efficacy in initial tests on seedlings at high concentration (1g/L)
- Low conc.=0.1g/L

![Larixyl acetate and Larixol structures]

<table>
<thead>
<tr>
<th>Concentration active</th>
<th>% leaf area not infected after 6 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>![Graph showing results for low concentration]</td>
</tr>
<tr>
<td>High</td>
<td>![Graph showing results for high concentration]</td>
</tr>
<tr>
<td>Control</td>
<td>![Graph showing results for control]</td>
</tr>
</tbody>
</table>

Copper reference  | Natural product

Botanical plant protection agent from Larix by-products
Analysis: Oleoresin of Larix decidua has larixol 3.1%; larixyl acetate 33%
Larch oleoresin vs larixyne – $^1$H NMR Spectrum

Larch bark extract vs larixyne – $^1$H NMR Spectrum
Quantification of Active Compounds.

**HPLC and GC-FID methods**
- Separation of primary impurity

![HPLC and GC-FID methods](image)

**Instrument** Varian 920-LC RP-HPLC
**Column** Ascentis® Express F5 column, pentafluorophenylpropyl (PFP), 10cm, 4.6 ID, particle size 2.7 µm
**Isocratic** 48% MeCN: Water
**Runtime** 15 minutes
**Flowrate** 1 mL/min
**Temperature** 40 °C
**Injection volume** 4 µL

<table>
<thead>
<tr>
<th>Sample type</th>
<th>mg (131 mg)</th>
<th>% composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraction 6 - 8</td>
<td>3.6</td>
<td>0.535988</td>
</tr>
<tr>
<td>Fraction 9 - 12</td>
<td>7.8</td>
<td>5.972435</td>
</tr>
<tr>
<td>Fraction 14-15</td>
<td>5.0</td>
<td>0.513508</td>
</tr>
<tr>
<td>Epimanoool</td>
<td>16.4</td>
<td>12.32772</td>
</tr>
<tr>
<td>Fraction 42 - 43</td>
<td>1.3</td>
<td>0.995406</td>
</tr>
<tr>
<td>Fraction 44 - 47</td>
<td>2.1</td>
<td>1.967968</td>
</tr>
<tr>
<td>Fraction 48 - 51</td>
<td>2.3</td>
<td>1.768103</td>
</tr>
<tr>
<td>Fraction 52 - 62</td>
<td>3.0</td>
<td>2.295709</td>
</tr>
<tr>
<td>Fraction 69 - 86</td>
<td>0.6</td>
<td>0.459420</td>
</tr>
<tr>
<td>Larixyl acetate</td>
<td>88.1</td>
<td>67.45789</td>
</tr>
<tr>
<td>Larixol</td>
<td>40.0</td>
<td>3.828464</td>
</tr>
<tr>
<td>Larixyl acetate + Larixol</td>
<td>93.1</td>
<td>71.38637</td>
</tr>
<tr>
<td>Larixyl acetate + Larixol + epimanoool</td>
<td>109.2</td>
<td>83.61469</td>
</tr>
</tbody>
</table>

% composition of compounds in Larixyne

![% composition of compounds in Larixyne](image)
Where are the highest yielding bark sources?

50 *Larix* samples from Central and Northern Europe
- Bark, twig & heartwood samples
- Batch extraction

![Graph showing % active compound in bark sample.](image)

**Methods** for large scale extraction and purification of active compounds from *L. decidua* were optimised.
How effective is the product in the field?

- 3 experimental vineyards Switzerland, Greece, Italy.
- 8-12 spray treatments per year

![Graph showing efficacy of Larixyne® against Plasmopara viticola](image)

The Impact of Larixyne®

Proven efficacy of Larixyne® against grapevine downy mildew under field conditions.

No other copper-free product on the market can compete
- Other products inconsistent, low activity & phytotoxic

Registration and Licencing in progress
- Larixyne® patent protected
- Market launch in 2022
Phytochemistry and Pharmacology of the Hyacinthaceae

- Use in treatment of retinopathy of prematurity and age-related macular degeneration
- COX-2 inhibitor activity
- Anti-proliferative activity
- Vasodilatory activity

Compounds from Ledebouria ovatifolia (Hyacinthoideae)

Ngoya Protocol
### Cyclooxygenase-2 activity of Compounds 1-3 and 5Ac-13

<table>
<thead>
<tr>
<th>Compound</th>
<th>COX-2 % activity at 10µM</th>
<th>COX-1 % activity at 10µM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>101.1% ± 32.6%</td>
<td></td>
</tr>
<tr>
<td>2(R)</td>
<td>66.7% ± 17.5%</td>
<td></td>
</tr>
<tr>
<td>2(S)</td>
<td>89.0% ± 29.2%</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>54.4% ± 25.7%</td>
<td></td>
</tr>
<tr>
<td>5 acetate</td>
<td>0% ± 7.8%</td>
<td>57% ± 10.2%</td>
</tr>
<tr>
<td>6</td>
<td>0% ± 21.3%</td>
<td>56% ± 10.7%</td>
</tr>
<tr>
<td>7</td>
<td>0% ± 5.4%</td>
<td>54% ± 15.1%</td>
</tr>
<tr>
<td>8</td>
<td>73.8% ± 21.4%</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>62.2% ± 21.4%</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>0% ± 8.3%</td>
<td>73.8% ± 8.0%</td>
</tr>
<tr>
<td>11</td>
<td>13.3% ± 13.3%</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>20.9% ± 13.0%</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>71.4% ± 20.0%</td>
<td></td>
</tr>
</tbody>
</table>

Controls:

- DuP-697: 47.0% ± 15.5% 83.8 ± 0.9%
- SC-560: 76.7±16.0% 56.7 ± 3.5%

---

### Retinopathy

Of the most common forms of blindness, two are caused by retinopathy:

- Damage to the retina of the eye caused by unwanted blood vessel growth
- Sight impairment and blindness

The light-sensitive layer of cells (rods and cones) in the eye that allow you to see.

Retina

[Image of retina structure with new blood vessels]
Ocular Neovascularization: ROP & AMD

- **Retinopathy of Prematurity:** Most common cause of blindness in infants; 6–18% of childhood blindness
- **Age-related Macular Degeneration:** Most common cause of blindness in the elderly; 1.75 million sufferers.
- **Diabetes:** Growing concern

Retinopathy in diseases

- "Wet" age-related macular degeneration
- Healthy eye
- Retinopathy of prematurity
- Diabetic retinopathy
Antiangiogenic Therapies

- **Photocoagulation**
  - Vision loss

- **Photodynamic therapy**
  - Does not reverse disease

- **Anti-VEGF biologics**
  - Side effects
  - High cost
  - Refractory populations

- **Critical need for novel therapies**

---

**Cremastranone**

- EtOH extract of bulb of *Cremastra appendiculata* (Orchidaceae) shows antiangiogenic activity *(Shim et al. Planta Med 2004)*

- Cremastranone (1) isolated as active component

- Also found in *Muscari armeniacum* *(Adinolfi et al. Phytochemistry 1987)* and *Scilla natalensis* *(Crouch et al. Phytochemistry 1999)*

---
Cremastranone in Animal Models

+ Cremastranone

HUVEC Tubes

Oxygen-Induced Retinopathy

Laser Photocoagulation


Human Retinal Endothelial Cell Proliferation SAR Study:

Gi50 (μM)

(Unpublished: Seung-Yong Seo & Dulcie Mulholland)

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Stop cell proliferation → stop blood vessel formation → stop retinopathy

- Cell proliferation assays
  - Main target: HRECs – Human Retinal Endothelial Cells
  - Specificity testing: ARPE-19 – Human Retinal Pigmented Epithelial Cells
- Cell migration assays
- Tube formation assays

Results

Testing against HREC’s – Human Retinal Endothelial Cells

<table>
<thead>
<tr>
<th>Name</th>
<th>HRECs GI_{50} (µM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA-1</td>
<td>10.03</td>
</tr>
<tr>
<td>LF2-4/9</td>
<td>17.73</td>
</tr>
<tr>
<td>LF2-12/15</td>
<td>2.48</td>
</tr>
<tr>
<td>LF1-7/8</td>
<td>3.58</td>
</tr>
<tr>
<td>HW-1</td>
<td>2.20</td>
</tr>
<tr>
<td>HW-1a</td>
<td>0.035</td>
</tr>
<tr>
<td>HW-1b</td>
<td>2.143 x10^{-4}</td>
</tr>
<tr>
<td>HW-1c</td>
<td>0.205</td>
</tr>
<tr>
<td>HW-2M1</td>
<td>0.258</td>
</tr>
<tr>
<td>LF3-19/25</td>
<td>0.108</td>
</tr>
<tr>
<td>CC-SLS-1</td>
<td>3.94</td>
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</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>HRECs GI_{50} (µM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RC.B-1</td>
<td>0.134</td>
</tr>
<tr>
<td>RR.B-4</td>
<td>0.49</td>
</tr>
<tr>
<td>EA-1</td>
<td>15.8</td>
</tr>
<tr>
<td>EA-2</td>
<td>11.7</td>
</tr>
<tr>
<td>EA-3</td>
<td>329</td>
</tr>
<tr>
<td>EA-4</td>
<td>531500</td>
</tr>
<tr>
<td>EA-5</td>
<td>63.8</td>
</tr>
<tr>
<td>EA-6</td>
<td>60.3</td>
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<td>EA-7</td>
<td>87.3</td>
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<tr>
<td>EB-1</td>
<td>64</td>
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<tr>
<td>EB-2</td>
<td>64.5</td>
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</table>

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<td>0.49</td>
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<td>EA-1</td>
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<td>531500</td>
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<td>EA-5</td>
<td>63.8</td>
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<tr>
<td>EA-6</td>
<td>60.3</td>
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<td>EA-7</td>
<td>87.3</td>
</tr>
<tr>
<td>EB-1</td>
<td>64</td>
</tr>
<tr>
<td>EB-2</td>
<td>64.5</td>
</tr>
</tbody>
</table>

Compounds with GI_{50} ≤ 5 µM taken on for further testing

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**Results (cont.)**

- **TESTED AGAINST ARPE19** – Human Retinal Pigment Epithelial cells

- **Selectivity for HREC cells desired**

- **14 compounds with at least 10-fold selectivity for HRECs**

- **Most potent taken on for further tests**

<table>
<thead>
<tr>
<th>Name</th>
<th>GI (µM)</th>
<th>ARPE19 (µM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW-1a</td>
<td>3.609</td>
<td>2.48</td>
</tr>
<tr>
<td>HW-1b</td>
<td>2.877</td>
<td>3.58</td>
</tr>
<tr>
<td>HW-1c</td>
<td>1.288</td>
<td>2.2</td>
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<tr>
<td>HW-1d</td>
<td>0.00680</td>
<td>0.035</td>
</tr>
<tr>
<td>HW-1e</td>
<td>&gt;4.070x10^4</td>
<td>&gt;100</td>
</tr>
<tr>
<td>HW-1f</td>
<td>1.907</td>
<td>0.205</td>
</tr>
<tr>
<td>HW-1g</td>
<td>0.1466</td>
<td>0.258</td>
</tr>
<tr>
<td>HW-1h</td>
<td>0.07752</td>
<td>0.108</td>
</tr>
<tr>
<td>CC-SLS-1</td>
<td>3.94</td>
<td>&gt;100</td>
</tr>
<tr>
<td>CC-SLS-2</td>
<td>1.34</td>
<td>0.8515</td>
</tr>
<tr>
<td>LA-1</td>
<td>0.49</td>
<td>40</td>
</tr>
<tr>
<td>LA-2</td>
<td>11.7</td>
<td>59</td>
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<tr>
<td>SH-16001</td>
<td>0.0267</td>
<td>0.18</td>
</tr>
<tr>
<td>SH-16002</td>
<td>0.00324</td>
<td>4.75</td>
</tr>
<tr>
<td>SH-16003</td>
<td>0.131</td>
<td>&gt;100</td>
</tr>
<tr>
<td>SH-16004</td>
<td>0.179</td>
<td>42.62</td>
</tr>
<tr>
<td>SH-16005</td>
<td>0.0962</td>
<td>23.23</td>
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<tr>
<td>SH-16006</td>
<td>0.018</td>
<td>0.052</td>
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<td>SH-16007</td>
<td>0.107</td>
<td>1.156</td>
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<tr>
<td>SH-16008</td>
<td>0.205</td>
<td>0.2365</td>
</tr>
<tr>
<td>SH-16009</td>
<td>0.0175</td>
<td>0.3953</td>
</tr>
<tr>
<td>SH-16010</td>
<td>0.0199</td>
<td>0.1815</td>
</tr>
<tr>
<td>SH-16011</td>
<td>1.45</td>
<td>9.5456</td>
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<tr>
<td>SH-16012</td>
<td>1.5</td>
<td>34</td>
</tr>
<tr>
<td>SH-16013</td>
<td>0.568</td>
<td>0.2425</td>
</tr>
<tr>
<td>SH-16014</td>
<td>0.0339</td>
<td>&gt;100</td>
</tr>
<tr>
<td>SH-16015</td>
<td>&gt;100</td>
<td>&gt;100</td>
</tr>
</tbody>
</table>

**Most potent (and selective) compounds**

**RR.B-1**

- **SH-16002**
- **SH-16003**
- **SH-16004**
- **SH-16005**
- **SH-16013**
- **SH-16014**

**Most potent taken on for further tests**

- **SH-16001**
- **SH-16007**
- **SH-16008**
- **SH-16009**
- **SH-16010**
- **SH-16011**
- **SH-16012**
- **SH-16013**
- **SH-16014**
- **SH-16015**

Most potent (and selective) compounds

Synthetic compounds

HW-1a

HW-DM1

Rhodocodon cryptopodus

Rhodocodon rotundus

SYNTHESIS OF HOMOISOFALVONOIDS-Use of Friedel-Crafts reaction:

\[
\begin{align*}
\text{H}_2\text{CO} & \quad \text{OH} \\
\text{H}_2\text{CO} & \quad \text{OCH}_3 \\
11 & \\
\text{H}_2\text{CO} & \quad \text{OCH}_3 \\
\text{H}_2\text{CO} & \quad \text{OCH}_3 \\
12 & \\
\text{BF}_3\cdot\text{Et}_2\text{O}, 80^\circ\text{C}, 90\ \text{min} & \\
13 & \\
\text{CH}_3\text{N}-\text{CH(OCH}_3)_2 & \text{reflux/toluene} & \\
14 & \\
\text{Yield 60%} & \\
\end{align*}
\]
COMPOUNDS SYNTHESIZED USING THIS METHODOLOGY

NORLIGNANS FROM *Drimiopsis burkeii* and *D. maculata*.

Screening for anti-inflammatory activity-25 µg/ml.

<table>
<thead>
<tr>
<th></th>
<th>Inhibition of Microsomal Cells (%)</th>
<th>Inhibition of COX 2 (%)</th>
<th>Inhibition of COX 1(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100 (±2.2)</td>
<td>100 (±0.5)</td>
<td>19 (±2.4)</td>
</tr>
<tr>
<td>2</td>
<td>72 (± 4.5)</td>
<td>-</td>
<td>23(±8.9)</td>
</tr>
<tr>
<td>3</td>
<td>81 (± 8.9)</td>
<td>43 (±2.1)</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>83 (±6.3)</td>
<td>26(± 8.9)</td>
<td>-</td>
</tr>
</tbody>
</table>
Synthesis of (E)-Hinokiresinol

\[
\text{HO-} + \text{HO-} \xrightarrow{\text{ALDOL}} \text{HO-}
\]

Vinyl Grignard

Dehydration

Reduction
The number reported for the One-dose assay is growth relative to the no-drug control, and relative to the time zero number of cells. This allows detection of both growth inhibition (values between 0 and 100) and lethality (values less than 0).

For example, a value of 100 means no growth inhibition. A value of 40 would mean 60% growth inhibition. A value of 0 means no net growth over the course of the experiment. A value of -40 would mean 40% lethality. A value of -100 means all cells are dead.
Compounds screened for vasodilating properties using the rat aorta technique:
Effects of 1-7 on rings precontracted with K60

Effect of 1-7 on endothelium-denuded rings depolarized with K60. Ordinate scale: relaxation reported as % of initial tension induced by K60, taken as 100%
Data points are mean (n=3-5)

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Effects of 1-7 on rings precontracted with phenylephrine

Concentration-response curves for 1-7 in endothelium denuded rings.

Ordinate scale: relaxation reported as % of initial tension induced by phenylephrine, taken as 100%
Data points are mean (n=3-7)

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The scillascillin-type homoisoflavanones exhibit **SIGNIFICANT VASODILATING EFFECTS** on rat aortic rings.

They show both **ANTISPASMODIC** and **SPASMOLYTIC** activity via a negative modulation of plasmalemmal Ca\(^{2+}\) influx responsible for the contraction of vascular musculature.

Blockers of channels were tried and it was shown that this occurs via the **voltage-operated Ca\(^{2+}\) channels (VOCCs)** - 2,3, & 4 work at same level as Ca\(^{2+}\)-channel blocking drug **nifedipine**.

Scillascillin-type compounds can be considered as promising pharmacological and maybe therapeutic tools for the management of impaired vasodilating capacity.


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**Chemical constituents from *Tachiadenus longiflorus* (Gentianaceae) – Madagascar.**
Reported uses of *Tachiadenus longiflorus*

The entire plant is reported to be toxic but is used as a tonic and purgative and for stomachache.

An infusion of the leaves is used against bile ailments

The roots are employed to counter pyrosis

Sweroside: C\textsubscript{16}H\textsubscript{22}O\textsubscript{9} (Iridoid glycoside)

Langaside: HRMS: C\textsubscript{28}H\textsubscript{28}O\textsubscript{11} 12 degrees of unsaturation!
Figure 1. Chemical structures of langaside (1), sweroside (2) and gentiopicrin (3).

Figure 4. Experimental ECD spectrum (light blue), conformationally averaged calculated ECD spectrum (dark blue) of 1 and (red) of 1a. Units for the y-axis are $(\Delta \varepsilon)$ and $\lambda$ (nm) for the x-axis.
Neurite outgrowth assay—Potentiating nerve growth factor (NGF) which causes neurite outgrowth necessary for treatment of neurodegenerative diseases

Using PC12

Control: 25ng/mL of nerve growth factor

6.25μg/mL of TL-L-LCL plus 25ng/mL of nerve growth factor

Langaside

Figure 1. Chemical structures of littoralisone (I) and brasoside (II).
WHAT IS THE FUNCTION OF THESE SECONDARY METABOLITES IN THE PLANT?
Provide leads to their uses.
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- Dr Moses Langat
- Emily James
- Dr Catherine Waller
- Dr Linda Langat
- Dr Dorota Nawrot
- Hannah Whitmore
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- Dr Walter Knirsch
- Prof Wolfgang Wetschnig, U of Graz
- Dr Fabio Fusi, University of Siena
- Dr Alfred Thumser, University of Surrey
- Dr Timothy Corson, Glick Eye Institute, University of Indianapolis Medical School.
- Dr Milijaona Randrianarivelojosia, Pasteur Institut, Madagascar

ForestSpecs/ProLarix
Dr Dr Barbara Thürig, Hans-Jakob Schärer, Dr Lucius Tamm FiBL
Ina Kleeberg, Dr Jonas Treutwein TriFolio

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ABSTRACT

Corruption poses a serious challenge in Kenya since it undermines economic, political and social development. According to the Transparency International, corruption has been defined as the misuse of public power for private benefit. Corruption therefore undermines democratic institutions and good governance, reduces accountability and negates representation and overall policy making. Today in Kenya, corruption has been perfected by crafty government officials and local rent-seeking software merchants by manipulating an accounting package referred to as Integrated Financial Management Information System (IFMIS), for example, the Auditor-General found in the special audit report on the National Youth Service how some civil servants had user rights that allowed them to siphon and commit funds from the Ministry of Devolution and Planning even when they were not employees of the ministry. Corruption has therefore lead to slow growth of the economy, sufferings of many Kenyans, and disparities in standard of living as it diverts effective use of public resources for private gain. The methodology used involves an empirical analysis that is conducted with a regression analysis, using data on democracy, fertility rate, life expectancy, education and the Initial GDP per capita that are also considered to affect GDP. The empirical results show that corruption does have a significant effect on economic growth after multicollinearity has been dealt with. This paper therefore recommends that appointment to government offices should be based on individual’s integrity test, the organs fighting corruption should be empowered and filled in by qualified people, and citizens should not elect leaders with histories of corruption.

Key Words: Accountability, Corruption, Economy, Integrity, Poverty and Wealth.
Introduction

While the consequences of corruption on certain aspects of the economy have frequently been investigated, attempts to quantify the overall costs of corruption on the economy have only recently been made (Dreher, Kotsogiannis and Mccorriston 2004a, 2004b, 2005). What are the quantitative costs of corruption? This is the question our paper attempts to answer. The paper presents cross-section regressions estimating the implication of corruption on the Kenyan economy.

• Corruption in Kenya has been on the rise to the new technology called the Integrated Financial Management Information System (Ifmis). For example, Kenya’s Auditor-General found in the special audit report on the National Youth Service. First, some civil servants had user rights that allowed them to siphon and commit funds from the Ministry of Devolution and Planning even when they were not employees of the ministry.
Empirical analysis

- This section begins with an introduction of the chosen variables and the regression model followed by the explanation of the variables and the expected signs. The last section contains the results.

Introduction to the regression model and variables

- For the empirical analysis we used a linear regression model. The dependent variable in the regression model is average GDP per capita growth ($GDP$). The independent variables are perceived level of corruption (CPI), primary completion rate (EDU), level of democracy (DEM), fertility rate (FER), life expectancy (LIFE) and Initial GDP ($GDP$). The experimental variable in this case is the perceived level of corruption (CPI) and is the only variable that will change. The rest of the independent variables are control variables, which are held constant in order to assess the relationship between the independent variable and the experimental variable. This will then of course be followed by the results of the regression model.
• Regression Model
  \[ GDP = \alpha + \beta_1 CPI + \beta_2 EDU + \beta_3 DEM + \beta_4 FER + \beta_5 LIFE + \beta_6 GDP + \varepsilon \]

• Explanation of variables and expected signs
  • GDP = Average GDP per capita growth
  • \( \alpha \) = Intercept
  • \( \beta_i \) = Correlation coefficient
  • CPI = perceived level of corruption
  • EDU = Primary completion rate
  • DEM = Level of democracy
  • FER = Fertility rate
  • LIFE = Life expectancy
  • GDPVI = Initial GDP
  • \( \varepsilon \) = Error term

• GDP per capita growth
  • The dependent variable used in our model is GDP per capita growth. GDP per capita growth is measured as the annual percentage growth of GDP per capita. This variable is used because it is a measurement of national income growth, which makes it an appropriate dependent variable.

• Perceived level of corruption
  • The perceived level of corruption is taken from Transparency International. The Corruption Perceptions Index (CPI) is defined as the misuse of public power for private benefit. The CPI ranks 176 countries on a scale from 0-10 where 0 is highly corrupt and 10 is very clean. Earlier empirical results have proved that the CPI and economic growth are negatively correlated.
Level of education

- We measure years of education as the total primary completion rate. This is the number of new entrants in the last grade of primary education, regardless of age, which is expressed as a percentage of the total population. This indicator is also known as the “gross intake rate to the last grade of primary.” The ratio can sometimes exceed 100% due to that over or underaged people can enter primary school late or early and also repeat grades. One problem we face with this measurement is that we cannot measure the quality of education. Barro claimed that with respect to education, growth is positively related to the starting level of average years of school attainment of adult males at the secondary and higher levels (Sall saliou, et al 2014). It would probably be better to measure the quality of education rather than the quantity. We expect this sign to be positive because a higher level of education should have a positive effect on economic growth.

Level of democracy

- We measure the level of democracy as the overall polity score from the Polity IV dataset, which is calculated by subtracting an autocracy score from a democracy score. It is a measurement of a country’s democratic and free nature. -10 is the lowest value and 10 is the highest value. We believe that the sign should be positive because a higher level of democracy should assumingly correlate with a higher level of economic growth. Barro (1997) claimed that the overall effect of democracy on growth is weak and that there is a suggestion of a non-linear relationship in which more democracy enhances growth at low levels of political freedom but reduces growth when a moderate level of freedom already has been achieved.
• **Fertility rate**
  • Fertility rate is measured as the average amount of children per woman. We expect this sign to be negative because we believe that the more children a woman has, the less she can work hence, society misses out on means of production. Barro (1997) provided empirical evidence, which verified that lower fertility rates stimulate economic growth.

• **Life expectancy at birth**
  • Life expectancy at birth is the expected number of years that a newborn baby will live.
  • We expect this sign to be positive because a longer life means a larger labor force in the country, which consequently should leads to a higher level of production and economic growth. However, Acemoglu and Johnson claimed that life expectancy has a positive but not very large effect on economic growth.

---

**Initial GDP per capita**

• The main reason for the inclusion of this variable is to test for conditional convergence.

• This means that a lower initial level of GDP should mean more rapid growth, also known as the catch-up effect. Barro (1997) concluded that the general notion of conditional convergence was strongly supported in his empirical results.
## Regression variables, sources, expected signs and results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Source</th>
<th>Expected sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>GDP per capita growth</td>
<td>World Bank</td>
<td>Dependent variable</td>
</tr>
<tr>
<td>CPI</td>
<td>Perceived corruption</td>
<td>Transparency International</td>
<td>+</td>
</tr>
<tr>
<td>EDU</td>
<td>Level of education</td>
<td>World Bank</td>
<td>+</td>
</tr>
<tr>
<td>DEM</td>
<td>Level of democracy</td>
<td>Polity IV</td>
<td>+</td>
</tr>
<tr>
<td>FER</td>
<td>Fertility rate</td>
<td>World Bank</td>
<td>+</td>
</tr>
<tr>
<td>LIFE</td>
<td>Life expectancy</td>
<td>World Bank</td>
<td>+</td>
</tr>
<tr>
<td>GDP Initial</td>
<td>Initial GDP</td>
<td>World Bank</td>
<td>+</td>
</tr>
</tbody>
</table>

Table A: Overview of regression variables, sources and expected signs

## Dependent variable: GDP \textsubscript{Growth} (Average 2000-2013)

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Std. error</th>
<th>t-ratio</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Const</td>
<td>3.94471</td>
<td>4.10275</td>
<td>0.9615</td>
<td>0.3431</td>
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<td>CPI</td>
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<td>0.379292</td>
<td>0.02927</td>
<td>0.02768 ***</td>
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<tr>
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<td>0.0183724</td>
<td>0.0260728</td>
<td>0.7047</td>
<td>0.4858</td>
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<td>DEM</td>
<td>0.164744</td>
<td>0.0648542</td>
<td>2.440</td>
<td>0.0158**</td>
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<td>FER</td>
<td>0.589651</td>
<td>0.289255</td>
<td>2.384</td>
<td>0.0218**</td>
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<td>LIFE</td>
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<td>0.0598192</td>
<td>0.4104</td>
<td>0.6841</td>
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<td>GDP Initial</td>
<td>0.00036976</td>
<td>0.000377982</td>
<td>1.590</td>
<td>0.1002</td>
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<tr>
<td>R2</td>
<td>0.444700</td>
<td>F-statistic</td>
<td>4.528025</td>
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<tr>
<td>R2Adj.</td>
<td>0.346806</td>
<td>P-value (F)</td>
<td>0.001662</td>
<td></td>
</tr>
</tbody>
</table>

Table B: Regression results. Notes:***, ** and * represent significance at the 1%, 5% and 10% levels respectively.
Results of regression analysis

- According to the results, corruption does have a significant effect on economic growth. This can be seen in the p-values and t-values in the table above which tells us that the coefficient is significantly different from zero. The model does not have a very good fit, which is evident when looking at the low R2 values.
- When using the significance level of 5%, the variables that show a significant effect on economic growth are the level of democracy and the fertility rate. This can once again be seen in the table above by looking at the significant t-values and p-values.
- The variable Democracy exhibited a positive sign, which was in line with our expectations. A higher level of democracy should lead to higher economic growth. Some empirical results have exhibited different results and claim that countries with an authoritarian political system are predicted to grow at least as fast, if not faster than democracies. They state that democracy may have some positive, indirect effects on economic growth such as greater stability or more extensive property and copyright laws but that the econometric results suggest that these positives are balanced by negatives such that the net effect of democracy on economic growth over the last five decades is negative or null.

- The Variable Fertility received a significant result and the sign was in line with our expectations and earlier empirical findings such as Barro (1997) who provided empirical evidence verifying that lower fertility rates augment economic growth. This is in line with exogenous growth theory as fertility decisions are seen as exogenous factors that affect economic growth.
- The variable GDP Initial does not show a significant result, which means that the conditional convergence theory is not supported. However, with a slightly larger sample, or the omission of certain variables that correlate with Initial GDP, the conditional convergence theory should be supported when using the significance level of 10%. The sign of the coefficient matched the expectations.
• The coefficient of education received an insignificant result and we feel that it is necessary to emphasize one shortcoming of the data. Education is set as the primary completion rate, expressed in percent of the population, which only measures the number of new entrants in the last grade of primary education. It does not measure the quality of education, which has been shown to have a significant effect on economic growth. However, the estimated coefficient is positive which is in line with Schumpeterian growth theory which states that increased education leads to an increase in technological progress which in turn leads to economic growth. Life expectancy does not have a significant effect on economic growth. The sign matched the expectations, which is in line with earlier empirical findings such as Acemoglu, and Johnson who found that life expectancy has a positive but weak effect on economic growth most of the coefficients are significant.

Results of regression and concluding remarks

• According to our empirical results, corruption does seem to have a significant effect on economic growth. Corruption undermines the free market system by removing protection from property rights and contract enforcement, increasing the incentive for rent-seeking and creating business uncertainty, which also means a lower probability for successful innovations.
• In the theoretical analysis of the principal-agent model and what role institutions play in that model are represented by the interaction between agents and principals in game form. Given this game representation, principal agent theory seems to be a flexible approach when attempting to interpret the effects of institutional actions on accountability of policy makers (Sall saliou, et al 2014).
Results of regression and concluding remarks .........

• According to our empirical results, corruption exists where other forms of institutional inefficiencies also are prevalent. This tells us that there exists an incentive for being corrupt. Like public choice theory tells us regarding corruption; public officials are corrupt because they believe that the potential benefits of being corrupt exceed the potential costs. This must be of concern for a nation where the public people depend on the government who use their entrusted power for private gains. Corruption hurts everyone who depends on people in a position of authority. The major question these countries face for the future is will the nations available resources be subject to creating wealth or subject to the redistribution of wealth?

• The decision lies in the hands of the nation (Elliot, 1997)
THE CORRUPTION MENANCE: IS THE CONSTITUTION AN ENABLER OR A HINDRANCE TO THE FIGHT AGAINST CORRUPTION?

A PAPER PRESENTED BY NZAMBA KITONGA (SC)

AT

THE 11TH EGERTON UNIVERSITY INTERNATIONAL CONFERENCE
HELD ON 29TH – 30TH MARCH 2017
AT EGERTON UNIVERSITY
THE CORRUPTION MENACE: IS THE CONSTITUTION AN ENABLER OR A HINDRANCE TO THE FIGHT AGAINST CORRUPTION?

The question posed in this presentation is: - is the Constitution an Enabler or a Hindrance to the Fight against Corruption? Let us however first address the various categories of corruption and how Kenyans have responded to them

Corruption may be categorized as petty, mid-level and mega corruption.

PETTY CORRUPTION

Some examples are in order. You park your car in a car park in town. The security officer guarding a shop nearby suddenly comes slams the car and assures you that “usijali, gariyakoikosalama”, unknown to you, you have just entered into a contract to pay him when you re-enter the car. Then the County car park attendant approaches you with parking tickets. You give her Kshs. 50/= no official ticket is issued and you are assured that the car will not be clamped. If you do not comply, your car will be vandalized and clamped. The consequences are so dire that one does not even think twice when giving a bribe. But most disturbing is the fact that Kenyans do not even regard this as corruption or criminal. It is just a way of life-
ndiohaliyadunia.

MID-LEVEL CORRUPTION

This normally starts with junior civil servants in Government offices and Registries. For me the best examples are at the court registries. A file that was missing is suddenly found when you produce Kshs. 1000/= And you have to pay more for quicker service once the file is found.

To jump the queue while waiting for service in public offices Kenyans are in fact the ones who insist on bribing – “nifanyieharakaikokitu”.

Again there is a disturbing perception and acquiescence that this is not corruption. It is just “facilitation”, “chai”, “shukurani” or “kitukidogo”. These are words which we have invented to assuage our consciences and to camouflage the truth.

The size of the bribes escalates as you climb up the ladder of seniority in the Public Service. When it comes to top public servants the amounts run into millions. And of course the stakes are high.
MEGA-CORRUPTION

This is the publicly spoken of corruption involving billions of shillings. It is to be found in the public procurement of services and goods. It is located in big public works projects. Most of it goes undetected because both the investor or contractor and the Public Servant are co-conspirators.

The corruption money is factored in right during the bidding. The successful bidder in the tender has already been identified and told in advance what information to provide. The amount to be shared is then factored in. Everybody in the chain has a stake and unless there is a fall out among thieves the corruption will not be detected. This also enables, the contractor to provide sub-standard goods and services because the supervisor has been compromised being part of the chain.

Mega corruption is also called looting because the amount involved are so obscene that they do not make sense. Shell shocked citizens ask what can one do with Kshs. 20 Billion? Occasionally mega-corruption is discovered accidentally when a whistle blower or a participant who did not get his share makes public disclosures.

This is how the Goldenburg, Anglo-leasing and the National Youth Service scandals became public.

There were public outcries. The public was enraged, leaders were shocked in disbelief. A moralistic and sanctimonious public condemned the scandals. But wait a minute is this not the same public which is daily willing to pay small bribes for services. Here then lies the dichotomy of our hypocrisy. Are we saying that corruption is fine if the amount involved is meagre?

LAWS

Kenyans love and are obsessed with making laws to provide for almost every situation. While we were framing the Constitution Kenyans would call to tell me “ongezahii clause nausipoongezasahauhiyokatibakabisa”.

This over zealousness has led to the enactment of many laws on corruption. They include:

1. The Constitution itself which has a whole chapter on integrity requirements and creates the Anti-Corruption and Ethics Commission.

2. The Anti-Corruption and Economic Crimes Act 2003,

3. The proceeds of Crimes and Anti-Money Laundering Act 2009

4. The Leadership and Intergrity Act 2013
5. The Bribery Act 2016
6. The Public Procurement and Disposal Act.
8. The Penal Code
9. The Criminal Procedure Code
11. The Public Officer Ethics Act 2003
12. The State Corporations Act

Therefore corruption does not exist because of a shortage of Laws. It exists in spite of many laws.

**ANTI-CORRUPTION STRUCTURES**

These may be tabulated as follows:-

1. The Presidency and the Executive
2. The Judiciary
3. Parliament – The National Assembly and The Senate
4. The Anti-Corruption and Ethics Commission
5. The National Police Service
6. The Office of The Inspector-General
7. The Directorate of Criminal Investigations
8. The Directorate of Public Prosecutions
9. The Hon. The Attorney-General
10. The Auditor General
11. The Controller of Budget
12. The Central Bank of Kenya
13. The National Anti-Corruption Campaign Steering Committee
14. The Directorate of Procurement
15. The Procurement Review Board
16. The Public Accounts Committee of the Senate and the National Assembly
17. The Public Investments Committee of the Senate and the National Assembly
18. The Legal and Justice Affairs Committee of the National Assembly.
19. The Executive County Government
20. The County Assemblies
21. The Kenya National Human Rights Commission
22. The Commission on Administrative Justice
23. The National Land Commission
24. The Asset Recovery Agency

There are also several other bodies which assist in the fight against corruption so there is no shortage of structures to fight corruption. Corruption thrives despite the existence of these structures. Therefore to answer the question posed the Constitution and the Laws made under it are enablers and not a hindrance in the Fight against Corruption. What are the actual pitfalls?

THE PIT FALLS

A joke is told that when the outcry against corruption started many Government heads of departments simply put up a sign board proclaiming "This is a corruptionFree Zone". They then declared that "Magendohapaimekwisha corruption is finished". This amounted to trashing and trivializing a very serious matter.

I cannot also help disclosing a personal experience. A young lawyer who had a very good job in a bank asked me whether I can help to get him employed in the Ethics and Anti-Corruption Commission. I was surprised at why he would want to leave a job where he was earning more. He was blunt – "there are a lot of huge bribes being paid at the Commission and one can retire in two years". It is a
strange twist of irony that one wants to join the Commission not to fight corruption but to be corrupted.

It is however a true depiction of what has gone gravely wrong with the fight against corruption.

The institutions set up to Fight Corruption are themselves the victims of corruption, lack of goodwill, incoherence, laxity, ineptitude, inefficiency and delays. They also constantly blame each other for the failure in the fight against corruption.

Typically there is a great hullabaloo announcing the commencement of investigations or releasing the names of suspects to Parliament and to the Public. Then the circus begins where the players begin pushing the buck then all is quiet. Lately we have witnessed the strange phenomena where prosecution witnesses testify to help the defence by saying that the deal was clean.

GENERAL ELECTIONS 2017

God willing on 8/8/2017 we shall go to the polls to elect leaders in all political cadres. The season of elections in Kenya is the season of corruption and greed. The voters want money-period. They have said it in the streets and in the villages that they are waiting for money from politicians. There is no secrecy. These pronouncements are made loudly.

The Politicians themselves are assembling war chests of money to give to voters. They are also not hiding the fact. They are very audacious. Recently they passed a law awarding themselves public money as alleged gratuity.

That is a sick joke. They are simply taking your money to bribe you. Regrettably most of those who should educate voters against bribery are themselves corrupt. Pastors conduct fake prayers in campaign rallies to “bless” politicians contesting in the elections. The pastors are then paid. Teachers see themselves as special category to be given their bribes separately from the rest of the public. Chiefs and police officers providing security during rallies demand their bribe in advance “ilitudumisheamani”.

It is a free for all. We have already witnessed an era of fake degrees, fake secondary school results, fake prayers, fake pastors and fake title deeds, During this election season we shall begin witnessing fake opinion polls.

POLITICAL WILL AND LEADERSHIP

President Dutarte of Philippines campaigned on the platform that if elected he would have drug dealers killed. Upon his election he has kept his promise and despite an international outcry the drug problem is slowly subsiding in the Philippines.
In Tanzania President John Magufuli has been at the forefront in fighting corruption and inefficiency. He is accused of creating a personality cult instead of empowering institutions.

President Kagame of Rwanda has given his citizens a direct mobile telephone line on which to call him to report any public officer seeking a bribe. And he picks the calls and acts.

I am not saying that we should copycat the Philippines or any other situation. However our political leadership needs to formulate creative ways with which to fight corruption. It must constantly and not occasionally be at the forefront. It must be seen as the foremost face of anti-corruption. It must be livid and decisive. It must not appear to be reluctant, unwilling, unable or cosmetic in fighting corruption.

And ultimately it must inspire citizens against corruption. It must make them hate corruption. We want the citizen of 2003 when President Kibaki came to power. Citizens for the first time in Kenyan history arrested police officers seeking bribes. That is the model citizen we should create. The citizen must be constantly reminded that he is not helpless. He can help himself. He must be told constantly that if a matatu is over speeding, he and other passengers can order the driver to stop and take him to the nearest police station.

Inspiration is not enough. It must be followed by swift justice against the corrupt. The current merry-go-round where big names are mentioned, then some are arrested and charged in court, followed by endless court proceedings without any visible results only attract public cynicism. Corruption trials must be fast and the punishment must be severe – the message being that corruption does not pay.

CONCLUSION

I have not painted a gloomy picture of a nation afflicted by corruption. The picture is actually gloomy. We were recently ranked as number 145 in the Transparency International Index of Corrupt Countries. We are said to be among the 20 most corrupt countries in the world. Corruption in Kenya is a cancer like malaise which has spread to every sector of our Nation. It has gripped the very soul of our nation. The nation is a captive of corruption. The fight against corruption requires a renewed approach and new strategies. It is not enough to install Arch Bishop Wabukala as the new Chairman of the Ethics and Anti-Corruption Commission.

We have seen that in the majority of cases many Kenyans are active participants in the crime of corruption. Ultimately all of us must take responsibility for our actions and decide whether we are the villains or the victims of corruption.

21/3/2017
NAIROBI
NZAMBA KITONGA (SC)
PREVALENCE OF SUBCLINICAL MASTITIS AND ASSOCIATED RISK FACTORS IN DAIRY FARMS IN URBAN AND PERI-URBAN AREAS OF THIKA SUB-COUNTY, KENYA

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ABSTRACT

A cross-sectional study was carried out to determine the prevalence of subclinical mastitis in intramammary infections and associated risk factors in the urban and peri-urban cattle in Thika sub-county, on 13 smallholder farms. Milk samples from 172 animals and 688 udder quarters were tested for subclinical mastitis using a California mastitis test kit and those testing positive were subjected to bacteriological analysis. Subclinical mastitis was positive for 64% of the cows and 55.8% of the udder quarters. For the risk factors, Prevalence was higher for Ayshires cattle breed (80.6%) and mid lactation (77.8%) and multiporous cows (70.1%). Subclinical mastitis was associated with poor hygiene, dirty udder and muddy floor housing, therefore improving hygiene in the cowsheds is a highly recommended intervention.

Key words: California mastitis test, floor type, lactating dairy cows, Staphylococcus aureus

INTRODUCTION

From a global perspective, the dairy industry is massive and of major importance in economic growth. Today approximately over 150 million households around the globe are engaged in milk production. In East Africa, Kenya is the leading milk producer, producing an estimated 3.2 billion litres per year by approximately 600,000 smallholder farmers (FAO, 2011). The performance of dairy industry is driven by rising human population, ease of access to technology input, increased demand for products from animal and better buying power in urban centers. Despite the rapid expansion of the dairy sector, milk production often does not meet the country's milk requirements due to a horde of associated constraints such as poor animal genetics, animal diseases, small size of dairy enterprises, poor quality feed in the market and fluctuating seasonal forage availability because of high dependence on rain fed agriculture (FAO, 2011). Among these factors, production disease particularly mastitis, is a multifaceted and expensive disease of dairy cows, which significantly reduces milk production and performance of dairy sector (Katsande et al, 2014). Many studies have clearly shown that subclinical mastitis (SCM) is more important economically than clinical mastitis (Mdegela et al, 2009). This is because SCM is more difficult to detect making it persists longer in the herds and eventually causing more production losses. It results in reduced milk yield, unwanted changes in the milk's composition, and increased cost of veterinary services and medicine (Ogola et al, 2007; Abrahmsén et al., 2014; Ayano et al., 2013).

Infectious agents commonly associated with mastitis in cattle are Streptococcus agalactiae and Staphylococcus aureus (Hawari and Dabbas, 2008), whereas coliforms and environmental Streptococci that are commonly found in the cows' environment are linked to environmental mastitis (Gitau et al, 2014).

The Modified White Side test, catalase test, California mastitis test (CMT), pH and somatic cell count tests are some of the diagnostic methods that can be used to indirectly diagnose subclinical mastitis. They are preferred screening tests for subclinical mastitis due to their ease of use and ability to yield rapid and satisfactory results (Alebachew and Alemu, 2015).

In urban and peri-urban parts of Kenya, subclinical mastitis is not adequately investigated and data relating to its scale, risk factors and distribution is scarce. The information is essential when planning suitable mitigation that would help decrease its prevalence and effects. To bridge the identified gaps, the study investigated the prevalence of SCM in lactating dairy cows, determined the frequency of intramammary infections and evaluated associated risk factors.
affecting SCM in the urban and peri-urban areas of Thika sub-County.

MATERIALS AND METHODS

Study Area
Data for this study was collected in the Thika sub-County during the wettest month of April 2014. Thika sub-County is located in Kiambu County, 40km from the Nairobi, Kenya. Its elevation is approximately 5,351 ft. above sea level. It covers an area of about 217.60 km² and is situated between Latitude 1°1’S, and longitudes 37°5’E. The area experiences bimodal rains with long rains being experienced between March and May and the short rains coming between September and November. The average annual rainfall in Thika and its environs ranges between 900 mm and 1,250 mm per annum. The average annual temperature is 19.8 °C in Thika. A cold spell is experienced during July and August. Dairy farming forms bulk of the main economic activities in the peri-urban areas of Thika sub-County.

Study Animals and Sample Size Determination
A list of all small holder dairy farms (herd size ranging from 1 to 46 cows) in Thika sub-County was compiled with the assistance of the area animal health assistant. Using a random number table 13 dairy farms were selected. Lactating dairy cows (172) of different ages, parities and lactation stages were purposively sampled proportion to the size of the dairy farms on the 13 small holder farms. The dairy cows were distributed according to breed (90Friesian, 18 Jersey,28 Guernsey and 36 Ayrshire), age (116 cows aged less than 6 years young and 56 cow aged greater than 6 years old). All dairy cows had no clinical symptoms. The animals lived under closely similar conditions of breeding habitat and feeding system. Clinical and physical examination were carried out in all animals with major focus on the cow’s udder. At the same time data on the age of the cow, udder hygiene (good/poor). Good udder hygiene was considered as physically clean udder on observation, teat dipping after milking, milking mastitis cow last, using warm water to clean the udder, washing hand before and after milking each cow, using different towels to wipe dry the udder for different animal), breed of the cow, the stage of lactation, milk production, parity, floor type and the respective farm names were also recorded.

California Mastitis Test (CMT)
The study performed California Mastitis Test (CMT) at the farm following the guidelines of the National Mastitis Council, 1999. A small sample of milk, about 2 ml was collected from each quarter into a plastic paddle that had 4 shallow cups corresponding to the 4 udder quarters. The CMT reagent of an equal amount was added to the milk and the paddle rotated to form a CMT reagent-milk mixture. After approximately 10 seconds, the score was read while continuing to rotate the paddle. Results were recorded as 0 (negative/trace), +1 (weak positive), +2 (distinct positive), and +3 (strong positive) basing on the thickness of the gel formed by CMT reagent-milk mixture. Cows with at least one CMT-positive quarter were defined as CMT-positive

Milk Sample Collection, Handling and Transportation
Following Ayano et al., (2013), the study applied aseptic procedures for collecting a composite of all quarter milk samples. Milk samples were collected before milking. Just before sample collection udders and especially teats were cleaned and dried. The first 3-milking streams were discarded and thereafter approximately 10 ml of milk collected in to sterile test tube. After collection, the sample was placed in an icebox transported to the laboratory and stored at refrigerated temperature of 4°C for a maximum of 24 hours until inoculated on a standard bacteriological media.

Identification of Mastitis-Causative Micro-Organisms
The study examined milk samples for bacteriology following the protocol described by Gitau et al., (2014). A 10 µl aliquot of each milk sample was streaked on 5% sheep blood and MacConkey agar plates. This was followed by incubating the plates at 37°C for 18–24 h in aerobic incubators. The growth of microorganism was examined on the plates after 24 h and those without growth were further incubated for up to four days before examination. For Staphylococcus aureus and Streptococcus agalactiae, at least one colony-forming unit (CFU) was needed for them to be classified as positive bacterial growth and at least three CFUs for the other genera. The bacterial cultures were gram-stained and then examined under a microscope. This was followed by biochemical test to determine the genus and species of the bacterial isolates in the sample. The colonies that were gram-negative rod after staining using their growth morphology on MacConkey agar were classified into lactose and non-lactose fermenters. To differentiate between E. coli and Klebsiella, lactose fermenters were further tested by citrate fermentation test with citrate negative classified

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as *E. coli* while citrate test positive classified as *Klebsiella*. Gram-positive cocci with small to medium-sized colonies that were haemolytic or non-haemolytic on 5% sheep blood agar were tested by catalase and coagulase tests. Catalase negative were identified as *Streptococci*. The catalase positive were examined further with rabbit plasma for coagulase activity. Those with coagulase activity were identified to be *S. aureus* while those without coagulase activities were identified to be coagulase-negative *Staphylococci*. Bacitracin was used to test catalase-negative *Streptococci* and those testing negative classified as *S. agalactia*.

**STATISTICAL ANALYSIS**

Prevalence of subclinical mastitis was calculated by dividing the total number of samples that were positives by the total number of samples examined and then multiplied by 100. The association of the breed of the cow, age of the cow, udder hygiene (good/poor), the stage of lactation, milk production, parity, and floor type with the CMT positivity was determined by Chi-square test using SPSS statistical package version 20 and 95% was used as the confidence interval.

**RESULTS**

**Prevalence of Subclinical Mastitis at Individual Cow and Quarter Level**

Out of 172 lactating cow examined, 110 representing 64% were CMT positive (at least one CMT-positive quarter) for subclinical mastitis in the study area. At the quarter level of 688 active quarters tested for subclinical mastitis, 384 (55.8%) were positive to CMT test as shown in table 1.

<table>
<thead>
<tr>
<th>Types</th>
<th>Number of samples</th>
<th>CMT positive</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lactating cows</td>
<td>172</td>
<td>110</td>
<td>64%</td>
</tr>
<tr>
<td>Quarters</td>
<td>688</td>
<td>384</td>
<td>55.8%</td>
</tr>
</tbody>
</table>

**Table 1: Subclinical mastitis at individual cow and quarter level in urban and peri-urban areas of Thika sub-county, Kenya detected by CMT**

The highest prevalence of subclinical mastitis (at cow level) was observed in Ayrshire breed (80.6 %) followed by Friesian (65.6%), Guernsey (57.1%), and Jersey (33.3%) (Table 2). At the quarter level, Jersey had the highest prevalence of subclinical mastitis of 87.5% while Friesian had the lowest prevalence (Table 3). Analysis of association using χ² showed that breed had significant influence on the prevalence of subclinical mastitis both at the cow and quarter level. Prevalence of subclinical mastitis was shown to increase with age with advancing age (>6 years) showing a higher prevalence (73.2%) than lower age (<6 years) which had (59.5%). However, age had no significance effect on the prevalence of subclinical mastitis.

**Prevalence of Bovine Mastitis across Different Cow Breeds**

The prevalence of subclinical mastitis was significantly higher in cows with poor udder hygiene (88.6%) compared to cows with good udder hygiene (Table 2). Cows in mid lactation stage (90-180 days) had a significant higher prevalence of subclinical mastitis (77.8%) compared to cows in late lactation (>180 days) and early lactation stage (<90 days) (Table 2). Milk production had no significant influence on prevalence of subclinical mastitis. Cow producing more than 15 litres had a higher prevalence compared to cow producing less than 15 litres (Table 2). At the quarter level, cows producing between 7 and 15 litres had a higher prevalence (58.2%) compared to cows producing less than 7 litres and more than 15 litres (Table 3). Primiparous cows had a lower prevalence of SCM than multiparous cows. The prevalence of subclinical mastitis was higher (82.1 %) in lactating cows housed on muddy soil floors compared to the cows that were kept in house with concrete floors and bad concrete floors (Table 2).
Table 2: Prevalence of bovine subclinical mastitis based on various factors at the cow level

<table>
<thead>
<tr>
<th>Risk factors</th>
<th>Type</th>
<th>Number of Cows tested</th>
<th>CMT Positive</th>
<th>Prevalence (%)</th>
<th>$\chi^2$</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breed</td>
<td>Friesian</td>
<td>90</td>
<td>59</td>
<td>65.6</td>
<td>12.3</td>
<td>0.0065</td>
</tr>
<tr>
<td></td>
<td>Jersey</td>
<td>18</td>
<td>6</td>
<td>33.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Guernsey</td>
<td>28</td>
<td>16</td>
<td>57.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ayrshire</td>
<td>36</td>
<td>29</td>
<td>80.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>172</td>
<td>110</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>&lt;6years</td>
<td>116</td>
<td>69</td>
<td>59.5</td>
<td>3.09</td>
<td>0.079</td>
</tr>
<tr>
<td></td>
<td>&gt;6years</td>
<td>56</td>
<td>41</td>
<td>73.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>udder hygiene</td>
<td>Good</td>
<td>128</td>
<td>71</td>
<td>55.5</td>
<td>15.6</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>44</td>
<td>39</td>
<td>88.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stage of lactation</td>
<td>&lt;90 days</td>
<td>47</td>
<td>21</td>
<td>44.7</td>
<td>14.7</td>
<td>0.0006</td>
</tr>
<tr>
<td></td>
<td>90-180 days</td>
<td>81</td>
<td>63</td>
<td>77.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;180 days</td>
<td>44</td>
<td>26</td>
<td>59.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk production</td>
<td>&lt;7lts</td>
<td>54</td>
<td>32</td>
<td>59.3</td>
<td>0.76</td>
<td>0.684</td>
</tr>
<tr>
<td></td>
<td>7-15lts</td>
<td>82</td>
<td>54</td>
<td>65.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;15lts</td>
<td>36</td>
<td>24</td>
<td>66.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parity</td>
<td>Primiparous</td>
<td>28</td>
<td>9</td>
<td>32.1</td>
<td>14.7</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>Multiparous</td>
<td>144</td>
<td>101</td>
<td>70.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor Type</td>
<td>Good concrete</td>
<td>101</td>
<td>56</td>
<td>55.5</td>
<td>9.03</td>
<td>0.011</td>
</tr>
<tr>
<td></td>
<td>Bad concrete</td>
<td>32</td>
<td>22</td>
<td>68.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Muddy Soil</td>
<td>39</td>
<td>32</td>
<td>82.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P<0.05 reject null hypothesis of no association
Table 3: Prevalence of bovine subclinical mastitis based on various factors at the quarter level

<table>
<thead>
<tr>
<th>Risk factors</th>
<th>Type</th>
<th>Number of Quarters tested</th>
<th>CMT Positive</th>
<th>Prevalence (%)</th>
<th>$\chi^2$</th>
<th>P- value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Breed</strong></td>
<td>Friesian</td>
<td>360</td>
<td>198</td>
<td>55</td>
<td>21.0</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>Jersey</td>
<td>24</td>
<td>21</td>
<td>87.5</td>
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</tr>
<tr>
<td></td>
<td>Guernsey</td>
<td>64</td>
<td>40</td>
<td>62.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ayrshire</td>
<td>116</td>
<td>86</td>
<td>74.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>&lt;6years</td>
<td>464</td>
<td>239</td>
<td>51.5</td>
<td>2.25</td>
<td>0.134</td>
</tr>
<tr>
<td></td>
<td>&gt;6years</td>
<td>224</td>
<td>129</td>
<td>57.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Udder hygiene</strong></td>
<td>Good</td>
<td>512</td>
<td>278</td>
<td>54.3</td>
<td>13.1</td>
<td>0.0003</td>
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<tr>
<td></td>
<td>Poor</td>
<td>176</td>
<td>123</td>
<td>69.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Stage of lactation</strong></td>
<td>&lt;90 days</td>
<td>188</td>
<td>81</td>
<td>43.1</td>
<td>0.889</td>
<td>0.641</td>
</tr>
<tr>
<td></td>
<td>90-180 days</td>
<td>324</td>
<td>137</td>
<td>42.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;180 days</td>
<td>176</td>
<td>82</td>
<td>46.6</td>
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<td></td>
</tr>
<tr>
<td><strong>Milk production</strong></td>
<td>&lt;7lts</td>
<td>216</td>
<td>122</td>
<td>56.5</td>
<td>0.164</td>
<td>0.921</td>
</tr>
<tr>
<td></td>
<td>7-15lts</td>
<td>328</td>
<td>191</td>
<td>58.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;15lts</td>
<td>144</td>
<td>83</td>
<td>57.6</td>
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<tr>
<td><strong>Parity</strong></td>
<td>Primiparous</td>
<td>112</td>
<td>33</td>
<td>29.5</td>
<td>4.69</td>
<td>0.0303</td>
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<tr>
<td></td>
<td>Multiparous</td>
<td>456</td>
<td>185</td>
<td>40.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Floor Type</strong></td>
<td>Good concrete</td>
<td>404</td>
<td>207</td>
<td>51.2</td>
<td>8.31</td>
<td>0.0157</td>
</tr>
<tr>
<td></td>
<td>Bad Concrete</td>
<td>128</td>
<td>71</td>
<td>55.5</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Muddy Soil</td>
<td>156</td>
<td>101</td>
<td>64.7</td>
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<td></td>
</tr>
</tbody>
</table>

P<0.05 reject null hypothesis of no association

Bacterial Isolates from Milk Samples with Subclinical Mastitis

A summary of the cow-level results of the bacteria isolates from cultured samples in the current study are provided in table 4. *Staphylococcus aureas* was the highest prevalent organism at 35.5%; followed by Coagulase negative *Staphylococcus* (25.5%), negative growth (12.7%), *Streptococcus agalactiae* (11.8%) and *Streptococcus spp* (11.8%), mixed growth (1.8%) and *Escherichia coli* (0.91%).

Table 4: Bacterial isolates from subclinical mastitis milk samples n=110

<table>
<thead>
<tr>
<th>Bacterial isolates</th>
<th>Number of isolates</th>
<th>Prevalence rate</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Escherichia coli</em></td>
<td>1</td>
<td>0.91%</td>
</tr>
<tr>
<td>Coagulase negative <em>Staphylococcus</em></td>
<td>28</td>
<td>25.5%</td>
</tr>
<tr>
<td>Negative growth</td>
<td>14</td>
<td>12.7%</td>
</tr>
<tr>
<td><em>Streptococcus spp</em></td>
<td>13</td>
<td>11.8%</td>
</tr>
<tr>
<td>Mixed growth</td>
<td>2</td>
<td>1.82%</td>
</tr>
<tr>
<td><em>Staphylococcus aureas</em></td>
<td>39</td>
<td>35.5%</td>
</tr>
<tr>
<td><em>Streptococcus agalactiae</em></td>
<td>13</td>
<td>11.8%</td>
</tr>
</tbody>
</table>

DISCUSSION

In this study, the overall prevalence of subclinical mastitis was 64% in lactating cows. The finding in this study is different from that of Gitau et al., (2014), who reported subclinical mastitis of 30.5% and 34.3% during the first and second visits in different parts of Kenya. The difference in prevalence could be ascribed to different geographical location and season of sampling. A study by Rahman et al., (2009) in Bangladesh showed that prevalence of mastitis and of mild mastitis is significantly higher in wet than in dry conditions.
season. However, the prevalence in this study was lower than that reported by Abrahmsén et al., (2014) in Uganda of 86.3% of the tested cows. At quarter level, the prevalence of SCM was similar to that reported in Uganda at 55.4 % compared to this study 55.8%. The high prevalence of sub-clinical mastitis in this study could be attributed to poor udder hygiene practices such as lack of post milking teat dipping, lack of washing hand before and after milking each cow, use of same towel to wipe dry the udder for all animals, absence of order in milking of mastitis animals before the healthy ones as well as poor type of floor, all of which might have increased the prevalence.

In this study breed (at cow level) influenced the prevalence of subclinical mastitis with Ayrshire showing the highest prevalence of 80.6%. This study agrees with Alebachew and Alemu (2015) who reported breed had a significant influence on prevalence of mastitis. However the study reported Holstein-Friesian and Jersey with high prevalence of mastitis at 71.7% and 70% respectively as compared to Cross (local X HF) and local which had a prevalence of 48.5% and 66.5%, respectively. At the quarter level Jersey had the highest prevalence of SCM of 87.5% which agrees with the finding by Alebachew and Alemu (2015). In the present study, age had no significant influence on the prevalence of subclinical mastitis, which disagrees with study in Bangladesh by Islam et al (2012) in which advancing age had an influence on prevalence of subclinical mastitis.

Several studies agreed with the present findings of increased subclinical mastitis with the advancing parity (Rahman et al., 2009; Mekibib et al., 2010; Abrahmsén et al., 2014). The prevalence of SCM at quarter level was significantly higher in multiparous animal as compared to primiparous animals. This association was significant at animal level also. Lactation stage had an influence on prevalence of mastitis with 90-180 days having the highest prevalence of 77.8%. The animal is at peak production at this stage. Studies have shown that high-yielding dairy cows are more prone to subclinical mastitis, as the glandular tissues are more susceptible to infection (Radostits et al., 2000). However, in the current study milk production was close to significant influence on subclinical mastitis at the cow level. Interestingly, high parity cows are more productive, and are likely to be prone to subclinical mastitis.

The prevalence of subclinical mastitis was significantly influenced by floor type and udder hygiene. Muddy soil floor type had a high prevalence of subclinical mastitis compared to good concrete floor. Poor udder hygiene or dirty udder had a higher prevalence of subclinical mastitis as compared to clean udder. The finding agrees with study by Mekibi et al., (2010), who also found a high prevalence of subclinical mastitis in soil floor and dirty udder. In the current study the high prevalence can be due to the fact that a dirty floor would be a potential source of mastitis organism.

In the present study, bacterial isolates were similar to those found by Gitau et al., (2011). The most predominant bacterium isolated (Table 4) was S. aureus (35.5%). This finding was similar to the 36.0% of bacterial isolates found by Haftu et al., (2012) in Ethiopia, but lower than the finding by Gitau et al., (2014) of 72.9%. Staphylococcus aureus, the most prevalent mastitis organism, may have been spread by milk man from one animal to other or from the environment to the animal depending on the floor type and udder hygiene of the animal.

CONCLUSIONS

The study concludes that there is a high prevalence of subclinical mastitis in smallholder dairy farms in urban and peri-urban regions of Thika sub-county. The findings suggest that in order to reduce high prevalence of subclinical mastitis, smallholder farmers require to keep the udder clean, particularly in the wet season, improve floor conditions through regular cleaning of the floor or upgrade to concrete floor. The risk factors for subclinical mastitis can be addressed by practical management of dairy cows following effective knowledge transfer especially through field days and provision of veterinary extension services.

ACKNOWLEDGEMENT

The authors are grateful to the dairy farmers for agreeing to participate in this study. We also appreciate the animal health assistant for assisting in identifying all dairy farmers in the sub county.

REFERENCES


ABSTRACT

Farm level postharvest milk losses (PHL) in smallholder dairy cow and pastoral camel herds that may be associated with milking practices which may influence the spread of mastitis in the herds. This study investigated: (i) the relationship between milking practices, intra-mammary infections and milk somatic cell counts (SCC); and (ii) the effects of high SCC on milk production and post-harvest losses (PHL) in smallholder dairy (n=64) and pastoral camel (n=15) herds in Kenya. Data collection included record of milking practices, mastitis test on udder quarters (n=1236) and collection of milk samples for laboratory analyses: SCC, detection of Staphylococcus aureus and Streptococcus species. Estimates of production losses were computed as a proportion of cows and herds with SCC (> 200,000 cells/ml) and for PHL as quantity of milk exceeding 4x10^5 cells/ml. Milking practices included hands, udder washing and drying, and milk let down stimulation with calves suckling or manually. Pastoralists did not apply hygienic milking practices. The odds of mastitis positive cases was 1.68 times higher in rural smallholder herds than in peri-urban. On the other hand in the pastoral herds, the odds of mastitis positive cases was 1.56 times higher in the rangelands than in peri-urban herds. Mastitis positive samples had higher incidences of Staphylococcus aureus than of Streptococcus species in both smallholder (57.9% vs 23.7%) and pastoral (41.6% vs 36.5%) herds. SCC in both smallholder and pastoral herds was affected by intra-mammary infections and presence of Staphylococcus aureus (p<0.001). The smallholder herds with high SCC (>3.0×10^5 cells/ml) was 40% among rural and 35% among peri-urban, which respectively was associated with 10.6% and 11.6% of preharvest milk loss. Milk PHL from high SCC was higher in smallholder rural herds (27%) compared to peri-urban (7%) and in pastoral peri-urban (81%) compared to rangelands (76%). Milking practices did not influence SCC but may have contributed to maintain mastitis pathogens in herds, hence causing high mastitis and pathogen prevalence. Therefore teat dipping, dry cow period and herd level mastitis treatment may complement current practices for lower SCC and milk PHL.

Key words: Herd level therapy, Milk handling, Mastitis, Teat dipping.

INTRODUCTION

Milk consumed in Kenya is from cattle, camels and goats reared in smallholder or pastoral herds (Muriuki and Thorpe, 2001; Noor et al., 2013). On-farm hygienic practices are important in assuring quality and safety of milk for consumers and for reducing losses at production and at post-harvest. Hygiene practices of importance include cleanliness of animals (udder), milking environment, milking person and milk harvesting and storage containers (Younan, 2004). Mastitis is a complex disease causing significant reduction in milk yield and quality (Hortet and Seegers, 1998). The inflammation severity depends on the causative agent and the host response whose somatic cells play an essential role in immediate defense against local infection (Carillo-Casas, 2012). Somatic cell count (SCC) provides good indications of infected and uninfected quarters. The assessment of udder inflammation has therefore been based on detection of elevation of SCC either in individual quarter milk or in bulk milk from farms (Cervinkova et al., 2013, Pantoja et al., 2009). The most common mastitic pathogens identified in cow and camel milk and presenting high risk of pathogenicity to humans are Streptococcus agalactiae and Staphylococcus aureus (Younan, 2004, Matofari et al., 2005).

This study determined the: relationship between milking practices, intra mammary infections and milk somatic cell counts (SCC) as well as effects of high SCC on milk production and post-harvest losses in a
sample of smallholder dairy cows and pastoral camel herds which are the two major milk producing species in Kenya.

METHODOLOGY

Milk samples were obtained from lactating cows and camels in smallholder dairy (62 farms, 32 each) and pastoral herds (15 herds) respectively in Nakuru and Isiolo Counties in Kenya. The two Counties were selected because they are representative of typical smallholder dairy cow and pastoral camel production systems in Kenya. Smallholder dairy herds were categorised into two groups: rural and peri-urban herds. Farmers in Olenguruone Division in the highlands of Nakuru County represented rural herds while those in Bahati and Dundori Divisions represented the peri-urban dairy farmers. Pastoral camel herds, were sampled from those willing to participate in the study and accessibility of grazing fields where the herds had been moved to. Local country livestock and veterinary offices aided identification and access to the herds.

Udder quarters (n=1236) of all milking animals (n=94 and 222 in smallholder and pastoral herds respectively) were tested for mastitis using California Mastitis Test (CMT) (KENOTEST, Belgium). Individual quarter milk samples were collected when found positive for mastitis; otherwise a composite milk sample of the four quarters was collected in a sterile sampling bottle for laboratory analysis. These included direct microscopic somatic cell count in accordance with Sarikaya, (2006) and microbiological identification of Staphylococcus aureus and Streptococcus. Data was analyzed using chi-square test, logistic regression and generalized linear model with SAS (2008).

RESULTS

Milking was done manually and routinely twice a day (morning and evening) in both smallholder and pastoral herds, but milking in pastoral herds was performed in the morning (5:00 to 6:00 am and 9:00 to 10:00 am) without a pre-milking hygiene practice of hand and udder washing, unlike in smallholder herds. In both rural and peri-urban smallholder herds, hand washing was a practice in the pre-milking hygiene routine (93.8 -100%) and udder washing a practice too (95 -98.8%) (Table I). In contrast, hand and udder washing before milking was not a practice in pastoral herds. Teat drying before milking was a common practice in herds in the peri-urban but not in rural and pastoral herds. Pre-milking palpation to stimulate milk let down by allowing calves to suckle prior to milking was a common practice in herds grazed in the smallholder rural (68.8%) and in pastoral rangelands (93.3%).

Udder quarters tested in smallholder peri-urban herds had a high mastitis prevalence (11.1%) corresponding to 36.2% of cows tested with at least one quarter infected compared to samples from smallholder rural herds where mastitis prevalence was 7.0% of infected quarters corresponding to 23.5% of cows with at least one quarter infected by mastitis(Table II). Odds of mastitis in cows in smallholder rural herds were 1.68 times lower than in smallholder peri-urban herds. The odds of finding a cow positive for mastitis were 1.18 times higher in pastoral rangeland camel than in peri-urban camels.

Results in Table III are somatic cell scores according to the threshold. Herd type, presence of mastitis and Staphylococcus aureus had a significant influence (P< 0.0001) on somatic cell count. Presence of cowshed (P=0.116) and farm practices did not affect SCC in the herds. Herd effect was also found not significant (P=0.056). Presence of Streptococcus species did not influence SCC (P=0.922).

There was no significant difference in log10 SCC of cows’ milk between smallholder rural and peri-urban herds (Table IV). The difference was significant between infected and uninfected quarters tested with 4.9 vs 5.8 cells/ml for mastitis negative and positive respectively in peri-urban herds and 5.0 vs 5.6 cells/ml in rural herds. Camels positive for mastitis in rangelands herds had higher log10 SCC (7.5 cells/ml) than those found negative (7.2 cells/ml). In peri-urban herds there was no difference in SCC between camels positive and negative for mastitis.

DISCUSSION

In smallholder herds, higher mastitis risk (Odds Ratio = 1.68 at quarter and 1.75 at cow level) of peri-urban herds than in rural was reflected in slightly higher log10 SCC (5.4 vs 5.3 cells/ml). Constraints of maintaining hygiene of zero grazing units may partly explain the difference since overall cleanliness of cowshed in smallholder peri-urban (78.6%) was average. Indeed Barnouin et al., (2005) and Chassagne et al., (2005) have highlighted the importance of clean cow housing for higher milk quality. However the overall SCC levels in both herds were high probably because
of inadequate hygienic milking practices which may have contributed to the mastitis prevalence of 71% in rural and 53% peri-urban.

Although most farmers practiced hand washing and udder washing with warm water prior to milking, there was no pre- or post-milking teat dipping. The use of warm water (55-60°C) and drying udder with individual towels prior to milking has been demonstrated to reduce microbial loads in milk (Hubaety et al., 2013). However, drying of teats prior to milking was only practiced in peri-urban herds and individual towels for drying teats were only used in farms with one milking cow. Also, no farmer used cleaning agent for udder washing, yet it has proven more efficient in reducing microbial loads on teat surface than warm water only (Gleeson et al., 2009). Though in most rural farms practicing free grazing, use of cleaning agents for udder washing may not be economical in dry seasons when the cows’ udders are relatively clean and dry. They are of more importance in rainy seasons in rural herds and throughout the year in zero grazed herds, such as peri-urban herds where teats are heavily soiled (mud floors in 40% of peri-urban farms’ cowsheds) and risk of mastitis is high (Morton et al., 2014, Kashongwe et al., 2017).

There was no significant difference in SCC in milk from pastoral rangelands and peri-urban herds and the level of SCC in camels was high (7.4 cells/ml) in both of these pastoral herds. Hygienic milking practices may have contributed to the increase of SCC in camel milk because pastoralists did not apply any hygienic practice due to lack of water.

A relatively high proportion of camels in pastoral (37%) and cows in rural (36.7%) herds were milked continuously without a dry-off period (Kashongwe et al., 2017). The dry-off period is important because it contributes to cell turnover in the mammary gland and optimization of milk production in the next lactation (Hou et al., 2016;Steenveld et al., 2013). It is also used to eliminate existing intra-mammary infections and preventing new infections with appropriate antibiotic treatment at the end of lactation (Leeahapongsathon et al, 2016). However, chronic _Staphylococcus aureus_ infection can be lingering lifelong and success in curing chronic _Streptococcus_ species infection is low (Keefe, 1997).

Public health concerns may be raised if the milk is not properly handled along the marketing chain. Also, improper handling with heat treatment may not limit the action of spoilage and pathogenic microorganisms in milk (Hassan et al 2009). Risks are higher with milk from pastoral camel herds because a reasonable amount is fermented into ‘suusa’ along the marketing channel without boiling (Mwangi, 2015).

### CONCLUSION AND RECOMMENDATIONS

Somatic cell counts were not affected by milking practices, but by intra-mammary infections. Milking practices such as hand washing, udder washing and udder drying are strongly associated with production herds and may contribute to high mastitis prevalence in herds. There is high prevalence of _Staphylococcus aureus_ and _Streptococcus_ species in smallholder and pastoral herds. Since these pathogens are hardly eradicated from the herds, pre- and post-milking teat dipping, using of cleaning agents to wash the udder, keeping cowsheds cleaner and a dry off cow period (35 to 60 days) are recommended.

### ACKNOWLEDGEMENT

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### REFERENCES


Lore T, Omore A, Staal S. 2005. Types, levels and causes of post-harvest milk and dairy losses in


You can find the full texts of the references provided in the references section of the conference proceedings.
Table 2: Prevalence risk of mastitis in smallholder dairy and pastoral herds

<table>
<thead>
<tr>
<th>Herds</th>
<th>Mastitis positive cases (%)</th>
<th>Mastitis negative cases (%)</th>
<th>Odds ratio</th>
<th>95% C.I.</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Udder quarters by herds</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Smallholder herds</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peri-urban (n=172)</td>
<td>11.1</td>
<td>88.9</td>
<td>1.68</td>
<td>1.4 - 2.0</td>
<td>0.0001</td>
</tr>
<tr>
<td>Rural (n=204)</td>
<td>6.9</td>
<td>93.1</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total smallholder herds</td>
<td>8.8</td>
<td>91.2</td>
<td><strong>1.00</strong></td>
<td>1.006-1.007</td>
<td>0.0001</td>
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<td><strong>Pastoral herds</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rangelands (n= 666)</td>
<td>31.1</td>
<td>68.9</td>
<td>1.18</td>
<td>1.1 – 1.2</td>
<td>0.0001</td>
</tr>
<tr>
<td>Peri-urban (n= 184)</td>
<td>34.8</td>
<td>65.2</td>
<td>Ref</td>
<td></td>
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</tr>
<tr>
<td>Total pastoral herds (n= 850)</td>
<td>31.5</td>
<td>68.5</td>
<td><strong>Ref</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cows/camel with ≥1 quarter infected</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Smallholder herds</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peri-urban (n= 43)</td>
<td>32.6</td>
<td>67.4</td>
<td>1.75</td>
<td>1.36- 2.28</td>
<td>0.0001</td>
</tr>
<tr>
<td>Rural (n= 51)</td>
<td>23.5</td>
<td>76.5</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total smallholder herds</td>
<td>27.7</td>
<td>72.3</td>
<td><strong>0.65</strong></td>
<td>0.58-0.71</td>
<td>0.0001</td>
</tr>
<tr>
<td><strong>Pastoral herds</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rangelands (n= 175)</td>
<td>34.3</td>
<td>65.7</td>
<td>1.09</td>
<td>0.94 – 1.26</td>
<td>0.2799</td>
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<tr>
<td>Peri-urban (n= 47)</td>
<td>36.2</td>
<td>63.8</td>
<td>Ref</td>
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<tr>
<td>Total pastoral herds (n= 222)</td>
<td>34.7</td>
<td>65.3</td>
<td><strong>Ref</strong></td>
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<td></td>
</tr>
</tbody>
</table>

*Mastitis positive= CMT ≥+1; Prevalence risk computed for the odds of finding mastitis positive cases over the total cases (positive + negative)

Table 3: Final model for outcome variable Log_{10} SCC, parameter β, standard error and probability for characteristics and practices

<table>
<thead>
<tr>
<th>Variable</th>
<th>β</th>
<th>S.E. (β)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.758</td>
<td>0.030</td>
<td>0.0001***</td>
</tr>
<tr>
<td>Herd (pastoral vs smallholder)</td>
<td>0.324</td>
<td>0.056</td>
<td>0.0001***</td>
</tr>
<tr>
<td>Hand washing (No vs Yes)</td>
<td>-0.006</td>
<td>0.051</td>
<td>NS</td>
</tr>
<tr>
<td>Dry udder (No vs yes)</td>
<td>-0.001</td>
<td>0.029</td>
<td>0.95 NS</td>
</tr>
<tr>
<td>Milking container (aluminium vs plastic)</td>
<td>-0.014</td>
<td>0.043</td>
<td>0.740 NS</td>
</tr>
<tr>
<td>Pooling container (aluminium vs plastic)</td>
<td>-0.007</td>
<td>0.025</td>
<td>0.762 NS</td>
</tr>
<tr>
<td>Calves suckling before milking (No vs yes)</td>
<td>-0.008</td>
<td>0.022</td>
<td>0.721 NS</td>
</tr>
<tr>
<td>Presence of cowshed (No vs yes)</td>
<td>0.005</td>
<td>0.026</td>
<td>0.840 NS</td>
</tr>
<tr>
<td>Lactation stage (early/mid vs late)</td>
<td>0.012</td>
<td>0.025</td>
<td>0.642 NS</td>
</tr>
<tr>
<td>Parity (1 to 2 vs 3 and above)</td>
<td>-0.017</td>
<td>0.047</td>
<td>0.708 NS</td>
</tr>
<tr>
<td>CMT test (Positive vs Negative)</td>
<td>-0.065</td>
<td>0.012</td>
<td>&lt;0.0001***</td>
</tr>
<tr>
<td>Staph aureus presence (Positive vs Negative)</td>
<td>-0.021</td>
<td>0.011</td>
<td>0.045 **</td>
</tr>
<tr>
<td>Strep spp presence (Positive vs Negative)</td>
<td>-0.025</td>
<td>0.014</td>
<td>0.076 NS</td>
</tr>
</tbody>
</table>

***P ≤0.01, **P ≤0.05, NS= P>0.05
Table 4: Effects of animal characteristics on SCC in smallholder dairy and pastoral herds

<table>
<thead>
<tr>
<th>Variable</th>
<th>Smallholder herds</th>
<th>Pastoral herds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Peri-urban</td>
<td>Rural</td>
</tr>
<tr>
<td>Herd group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peri-urban</td>
<td>5.4 ±0.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.3 ±0.1&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Rural</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactation stage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early/mid</td>
<td>5.3±0.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.2±0.1&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Late</td>
<td>5.1±0.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.5±0.2&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Udder inflammation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mastitis negative</td>
<td>4.9±0.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.0±0.1&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mastitis positive</td>
<td>5.8±0.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.6±0.1&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Presence of Staph. aureus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>5.1±0.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.2±0.1&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Present</td>
<td>5.6±0.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.7±0.1&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Within each production herd, means followed by different letters for one variable are different at 5%.
GENERATION MEAN ANALYSES FOR STEM RUST (*Puccinia graminis f. sp. tritici*) RESISTANCE IN WHEAT (*Triticum aestivum* L.)

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ABSTRACT

Stem rust (*Puccinia graminis f. sp. tritici*) is a major disease of wheat (*Triticum aestivum* L.) worldwide. A study was conducted to determine the gene action and inheritance of stem rust resistance in wheat. Two wheat genotypes, AR24 and UR108, resistant to stem rust were crossed with susceptible genotype, Cacuke, to develop six basic generations for the study of action of genes involved on stem rust resistance. The Final Disease Severity (FDS) and the Area Under Disease Progress Curve (AUDPC) were used to elucidate the gene action. The generation mean analyses in the six generations, P₁ (Donor), P₂ (Recurrent), F₁, F₂, BC₁F₁ (backcross to donor parent), and BC₁F₁ (backcross to recurrent parent), revealed that stem rust resistance is controlled by additive, partial and complete dominance genes. The additive effects were high and significant in AR24 × Cacuke and UR108 × Cacuke, 36.87 and 38.53, respectively for FDS. Furthermore, the additive effects were high for AUDPC with 331.40 and 428.70 in AR24 × Cacuke and UR108 × Cacuke, signifying their importance in stem rust resistance. The results further indicated that stem rust resistance was highly heritable with narrow sense heritability values ranging from 59% to 79%. The presence of additive gene effects will potentially enhance progress to selection for stem rust in the breeding programme. Further, AR 24 and UR 108 could be used as donor parents in breeding for wheat resistant genotypes to stem rust.

Key words: Wheat, Stem rust, Additive gene effect, Generation mean analysis.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a major cereal crop in Kenya, and is only after maize (*Zea mays*) in acreage cultivated (FAO, 2013). It is an important source of energy and protein in human diet. In spite of its dietary relevance, Kenya’s average wheat production of about 350,000 tonnes per annum is far below demand of 900,000 tonnes (FAO, 2013). This low production poses a great challenge to food security in Kenya (FAO, 2013). The low yield is attributed to biotic (pests and diseases) and abiotic (low rainfall and soil factors) stresses (Mudasir et al., 2013; Tolessa et al., 2014; Kimani et al., 2015).

Among the most devastating diseases in wheat that significantly reduce production are those caused by rust, stem rust (*Puccinia graminis*) in particular (Mudasir et al., 2013). Stem rust interrupts the normal growth of wheat, reduces the photosynthetic area and destroy vessels for translocation of assimilates meant for plant, thereby reducing the yield (Leonard and Szabo, 2005). It is widely acknowledged that this disease can cause up to 100% yield loss in susceptible genotypes (Wanyera et al., 2006). The principal method used by farmers in controlling stem rust is the use of fungicides, but this increases the cost of production, consequently reducing profit (FAO, 2013). A previous study shows that all the varieties grown in Kenya are susceptible to stem rust (Wanyera et al., 2006). Occurrence of different races of stem rust which are more virulent and resistant to fungicides encourages research on resistance breeding (Rahmatov et al., 2015). Development of genotypes with heritable resistance to stem rust is deemed to be more effective and economical in managing the disease especially in its ‘hot spot’. Moreover, understanding the mode of inheritance and genetic characteristic of a target trait is critical in formulating a successful breeding programme, and in its utilization in superior genotypes (Samineni et al., 2011).

Stem rust resistance is categorized into seedling and adult plant resistance (Messmer et al., 2000; Kaur et al., 2009). Seedling resistance (race specific) is characterized by hypersensitive response, and follows the gene for gene concept (Navabi et al., 2004). It is usually expressed throughout the plant growth stages. Due to the short life cycle and large population sizes of plant pathogens, selection of rare but virulent alleles
occur often leading to very devastating disease epidemics (Prakash and Heather, 1988). Use of single Sr gene is considered inefficient since this confers selective advantage to virulent races and such single gene break down shortly (Singh et al., 2008). Breeders therefore need to continuously introgress combination of resistance genes into existing and newly released genotypes (Jin et al., 2007). Due to the limitations of using race specific resistance genes, combination of identified Sr genes to create durable resistance is a feasible alternative (Gupta et al., 2008).

Plants with adult plant resistance (APR), which is characteristically non-race specific appears susceptible at seedling stage but are resistant as adults (Imtiaz et al., 2011). APR is characterized by non-hypersensitive response and is controlled by additive effects (Singh et al., 2009). When adult plant resistant genes are combined with several minor genes, near immunity could be achieved (Singh et al., 2008). Non-race specific genes form durable resistance and is therefore emphasized in breeding for stem rust resistance (Imtiaz et al., 2011).

In wheat, resistance to stem rust is a simple inherited trait which is conferred by one or few genes (Hamada, 1993; Abd-Latif and Boulot, 2000; Nzuve et al., 2013). However, other findings indicate that it is a quantitative trait that is controlled by many genes with additive effects hence influenced by environmental conditions (Mahgoub, 2001; Navabi et al., 2004). The choice of an appropriate breeding method for improvement of quantitative character is enhanced by knowledge of gene action (Singh et al., 2008). Since the effect of individual gene cannot be measured, generation mean analysis provides a suitable procedure for obtaining genetic information for quantitative traits (Samineni et al., 2011). Information on the nature and magnitude of gene actions involved in resistance for stem rust can be useful for breeding wheat genotypes that are resistant to the disease. Understanding the nature of inheritance is useful for making decision on appropriate selection procedure effective (Samineni et al., 2011). The objective of this study was to determine the gene action, broad and narrow sense heritability of stem rust resistance in two selected wheat genotypes.

**MATERIALS AND METHODS**

**Experimental Site and Land Preparation**

The experiment was carried out at the Kenya Agricultural and Livestock Research Organization (KALRO-Njoro) (0.3316° S, 35.94449° E). This location has a minimum and maximum temperature of 9 and 24 °C, respectively. Njoro is characterized with mollic andosols type of soil (Jaetzold et al., 2010). The land, previously under soya bean (Glycine max), was prepared by ploughing and harrowing using hand implements to produce a fine till.

**Genotypes**

In a preliminary stem rust screening experiment conducted in 2012 at Food Crop Research Institute (FCRI) Njoro, wheat genotypes AR24 and UR108 resistant to stem rust at adult stage while Cacuke, variety susceptible to stem rust were used in this experiment. Wheat genotypes used in this study were selected from CIMMYT nurseries.

**Development and Evaluation of the Basic Generations**

Planting of the crossing block was done in plots of 100 cm row with a spacing of 20 cm × drill. Crossing was done between AR24 × Cacuke and UR108 × Cacuke in the first season, to generate the F₁ generation. Some of the F₁ plants were back-crossed to each of the parents to develop backcrosses and some F₁ allowed to self-pollinate to give rise to the F₂ generation, in the second season. Seeds were harvested and threshed separately to avoid mechanical mixing. The six basic generations used were P₁ (Donor), P₂ (Recurrent), F₁, F₂, BC₁F₁ (Donor) and BC₁F₁ (Donor parent (P₁)) and BC₁F₁ (Recurrent) = Backcross to the recipient parent (P₂).

The six generations were evaluated for stem rust resistance in the field, in plots of 1 m × 0.2 m and 20 cm spacing between plants in a row. The experiment was laid out in a randomized complete block design (RCBD) with two replications for one season. Spreader rows of susceptible variety Cacuke were planted around the experiment in which artificial inoculation was done using inoculum collected from a nursery planted with trap wheat plants.

**Preparation and Inoculation of Inoculum in the Field**

Inoculum was prepared from plants collected from trap plants and the collection composed of a mixture of stem rust races. The plants were cut into pieces, suspended in water, filtered and drained in a dispenser. The inoculum mixture was applied on the spreader row using syringe technique, at growth stage GS41 (Zadock, et al., 1974). Inoculation was repeated at growth stage GS45 to create a high disease pressure in the experimental plots.
Field Management
At planting, diamonium phosphate (D.A.P 18.46.0) fertilizer was applied at the rate of 125 kg ha\(^{-1}\). This supplied 22.5 kg ha\(^{-1}\) of nitrogen and 57.5 kg ha\(^{-1}\) of phosphorus. Calcium ammonium nitrate (CAN) was used for top dressing at the growth stage GS30 (Zadok et al., 1974) at the rate of 125 kg ha\(^{-1}\) to supply 33.7 kg ha\(^{-1}\) of nitrogen. Weed control was done manually while insect pests were managed by spraying Thundereb OD 145 (Imidacloprid + Beta-Cyfluthrin) at the rate of 300 g per hectare (g ha\(^{-1}\)). Supplementary irrigation was applied to achieve optimal crop establishment.

Data Collection and Analyses
Stem rust severity was observed based on modified Cobb scale (Peterson et al., 1948) on 0-100% scale where 0% was considered immune while 100% was completely susceptible. Data collection for stem rust began when the susceptible spreader depicted 50% susceptibility with three sets of reading at 7 days interval. Observations were done on individual plant bases in all the plots. The number of plants scored in non-segregating generations (P\(_1\), P\(_2\) and F\(_1\)) was twenty, and forty two in segregating generations (BC\(_1\)F\(_1\) (Donor), BC\(_2\)F\(_1\) (Recurrent) and F\(_2\)). The Final Disease Severity (FDS) and Area under Disease Progress Curve (AUDPC) were used for analysis. The FDS was considered as the last reading when the spreader was 100% diseased. The AUDPC was calculated following the equation suggested by Wilcoxson et al. (1975) as highlighted below.

\[
\text{AUDPC} = \frac{1}{2} \sum_{i=1}^{N} [(C_{i+1} + Y_i)(T_i+1 - T_i)]
\]

where \(Y_i\) is the proportion of the host tissue damaged in the \(i^{th}\) observation, \(T_i\) is the time (days) after appearance of the disease in the \(i^{th}\) observation, and \(N\) is the total number of observations.

Generation mean analysis was conducted using Genstat computer software (15\(^{th}\) edition, 2012). The additive-dominance model was fitted as given by Kearsey and Pooni (1996) (Table 1). The multiple regression model was as follows.

\[
i = m + (a) x_{i1} + (d) x_{i2} \quad (i=1...6)
\]

where \(i\) is \(i^{th}\) generation mean, \(m\) is the intercept, \((a)\) is the additive effect, \((d)\) is the dominance effect, \(x_{i1}\) is the coefficient of mean corresponding to additive effect and \(x_{i2}\) is the coefficient of mean corresponding to dominance effect.

Broad sense heritability, narrow sense heritability and ratio of \(d_A\) to \(a_A\) were computed as follows:

\[
H^2 = \frac{\delta_A^2 + \delta_D^2}{\delta_A^2 + \delta_D^2 + \delta_E^2}
\]

\[
h^2 = \frac{\delta_A^2}{\delta_A^2 + \delta_D^2 + \delta_E^2}
\]

\[
a = d_A/a_A
\]

where \(H^2\) is broad sense heritability, \(h^2\) is narrow sense heritability, \(\delta_A^2\) is the variance due to additive gene effect, \(\delta_D^2\) is the variance due to dominance effect and \(\delta_E^2\) is the environmental error variance, \(a=\) dominance ratio, \(a_A=\) additive effect, \(d_A=\)dominance effect.

RESULTS
Means for the Six Generations
The quantity of stem rust inoculum was adequate, which enabled effective screening of wheat genotypes during the experiment, with the infection on spreader cultivar showing reaction of 100S. There was a significant difference in disease pressure between the resistant and susceptible parents (Table 2), which is prerequisite for generation mean analyses (Mather and Jinks, 1971). P\(_1\) had the highest disease severity of 85.50 in AR24 × Cacuke and 93.50 in UR108 × Cacuke while P\(_1\) had the lowest with 14.50 and 15.50, respectively, for FDS. Similarly, in the AUDPC, P\(_2\) had the highest mean disease severity of 743.75 in AR24 × Cacuke and 967.75 in UR108 × Cacuke while P\(_1\) had 114.97 and 110.43, respectively. The P\(_2\), F\(_2\) and BC\(_1\)F\(_1\) (Recurrent) showed extreme severity to stem rust as compared to P\(_1\) and F\(_1\) in cross AR24 × Cacuke for both FDS and AUDPC. In UR108 × Cacuke however, F\(_1\) had no difference from F\(_2\) and BC\(_1\)F\(_1\) (Recurrent) for both FDS and AUDPC. Individuals in BC\(_1\)F\(_1\) (Donor) expressed lower disease scores than the susceptible parents, Cacuke, but higher than the resistant parents, AR24 and UR108 for FDS and AUDPC.

Effects of genes and heritability estimates for FDS and AUDPC
The estimates of additive effect were significant with negative values in both crosses for the FDS and the AUDPC (Table 3). Estimates of dominance were only significant in UR108 × Cacuke for the FDS. However, they all had negative values. The additive gene effects were relatively larger than the dominance gene effect in both crosses for parameters, FDS and AUDPC.
High heritability values ranging from 79 to 90% were realized in AR24 × Cacuke for both parameters in FDS (Table 4). Moderate to high heritability values ranging between 59 and 92% were determined for AUDPC. Dominance ratios were below unity except for population derived from UR108 × Cacuke for AUDPC which was near unity.

**DISCUSSION**

FDS and AUDPC are some of the parameters that can be used to study the resistance levels in wheat (Broers et al., 1996; Li et al., 2006; Tolessa et al., 2014; Galamat and El-sawi, 2015). In this study, it was clear that genes controlling stem rust resistance in the two wheat crosses are different. The FDS ranged from 5% in resistant parents to 100% in susceptible parent. The susceptible checks had very high AUDPC values and high FDS because, Cacuke, does not have gene for resistance to stem rust race Ug99. No plant showed hypersensitive reaction, suggesting the possibility of having minor adult plant resistant genes in resistant parents. Because adult plant resistance is controlled by additive gene effects (Singh et al., 2008), stem rust resistance in the test genotypes is controlled by additive gene effect. Similar results were observed by Bernardo et al. (1992) who found out that resistance to head smut in Maize (Zea mays) was controlled by additive gene effect, and Gamalat and El-Sawi (2015) who observed that resistance to stem rust in wheat was controlled by additive gene effect. The dominance in both parameters was negative and less than the additive gene effect signifying the direction of stem rust resistance towards the resistant parents, AR24 and UR108.

Additive gene effect also known as the breeding value is important in breeding since it determines the amount of genes retained by the progeny from the parents (Erin, 2002). As indicated by generation mean analysis, additive effects were significant with large values. In addition, dominance effect was also present. The wide range of degree of dominance suggested presence of both partial and complete dominance. Therefore, stem rust resistance in the crosses under study is controlled by additive gene action, partial and complete dominance. The findings were in agreement with the results by Gamalat and El-Sawi (2015), who reported additive and partial dominance in stem rust resistance on wheat genotypes tested in Egypt. The results of this study suggest that the Sr genes contained in the resistant parents are probably of adult plant resistance (APR) category. Since APR was controlled by more than one major gene, this type of resistance is most favoured in developing durable resistant varieties and in reducing chances of cyclic epidemics of stem rust.

Partitioning the genetic variance enables the determination of inheritance of stem rust resistance in wheat (Kearsey and Pooni 1996). High broad sense heritability values were realized as compared to narrow sense heritability. The higher values of the broad sense heritability are probably as a result of the inclusion of dominance genetic variance. However, narrow sense heritability is more important compared to broad sense heritability, since it measures the proportion of the additive effects of genes in a population. Moderate to high inheritance in the present study suggests that transfer of stem rust resistant genes from the resistant parent to the recipient parent is possible. The high heritability values implied that large proportion of the phenotypic expression in AR24 × Cacuke is heritable while the remaining 21% is environmental in nature and non-heritable. Furthermore, about 59% of the variation in UR108 × Cacuke is heritable while 41% is due to environment, and is not heritable. The prevalence of a trait under selection can be increased by high heritability values (Erin, 2002).

The high rates of heritability estimates increases the success of recovering the desired genes for stem rust resistance in tested crosses. In addition, good progress in selection can be achieved considering that stem rust resistance was found to be controlled by additive gene which was highly heritable. Although selection of stem rust resistance in early generation is possible, delaying it to a later generation would be more advantageous (Boulot and Gad-Alla, 2007).

**CONCLUSION**

Resistance to stem rust in wheat crosses studied was controlled primarily by additive gene effects. Although there was partial and complete dominance, additive effects were predominant. Heritability estimates obtained suggested that it is possible to transfer resistant genes from the resistant parents to recipient parents. Therefore, the resistant parents, AR24 and UR108 could be used as donor of stem rust resistant genes in wheat breeding programmes. However, further work needs to be done to map the regions in the genome conferring resistance to enable application of marker assisted selection.
Table 1: The coefficients for additive-dominance model fitting for stem rust resistance in wheat (*Triticum aestivum* L.)

<table>
<thead>
<tr>
<th>Generation</th>
<th>m</th>
<th>(a) coefficients X₁</th>
<th>(d) coefficients X₂</th>
<th>δ²ₑ</th>
<th>δ²ₐ</th>
<th>δ²₉</th>
</tr>
</thead>
<tbody>
<tr>
<td>P₁(Donor)</td>
<td>1.0</td>
<td>1.0</td>
<td>0.0</td>
<td>1.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>P₂(Recurrent)</td>
<td>1.0</td>
<td>-1.0</td>
<td>0.0</td>
<td>1.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>F₁</td>
<td>1.0</td>
<td>0.0</td>
<td>1.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>F₂</td>
<td>1.0</td>
<td>0.0</td>
<td>0.5</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>BC₁F₁(Donor)</td>
<td>1.0</td>
<td>0.5</td>
<td>0.5</td>
<td>1.0</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>BC₁F₁(Recurrent)</td>
<td>1.0</td>
<td>-0.5</td>
<td>0.5</td>
<td>1.0</td>
<td>0.5</td>
<td>1.0</td>
</tr>
</tbody>
</table>

P₁, Parent 1 (Donor), P₂, Parent 2 (Recurrent), F₁, Filial generation 1, F₂, Filial generation 2, BC₁F₁, backcross to donor parent (P₁), BC₁F₁, backcross to recurrent parent (P₂), δ²ₑ, environmental variance, δ²ₐ, additive variance, δ²₉, dominance variance, δ²₉ₐ, additive-dominance variance.

Table 2: Means for the six generations for the final disease severity (FDS) and area under disease progress curve (AUDPC) in AR24 × *Cacuke* and UR108 × *Cacuke* crosses

<table>
<thead>
<tr>
<th>Generation</th>
<th>Final Disease Severity</th>
<th>Area Under Disease Progress Curve</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AR24 × <em>Cacuke</em></td>
<td>UR108 × <em>Cacuke</em></td>
</tr>
<tr>
<td>P₁(Donor)</td>
<td>14.50±1.4</td>
<td>15.50±1.0</td>
</tr>
<tr>
<td>P₂(Recurrent)</td>
<td>85.50±2.8</td>
<td>93.50±2.2</td>
</tr>
<tr>
<td>F₁</td>
<td>39.50±2.7</td>
<td>69.50±2.0</td>
</tr>
<tr>
<td>F₂</td>
<td>54.40±4.1</td>
<td>62.14±3.5</td>
</tr>
<tr>
<td>BC₁F₁(Donor)</td>
<td>19.79±2.4</td>
<td>38.13±3.0</td>
</tr>
<tr>
<td>BC₁F₁(Recurrent)</td>
<td>62.14±3.8</td>
<td>74.76±2.7</td>
</tr>
</tbody>
</table>

P₁, Parent 1 (Donor), P₂, Parent 2 (Recurrent), F₁, Filial generation 1, F₂, Filial generation 2, BC₁F₁, backcross to the donor parent (P₁), BC₁F₁, backcross to recurrent parent (P₂).

Table 3: Estimates of additive and dominance effects for FDS and AUDPC in AR24 × *Cacuke* and UR108 × *Cacuke* crosses

<table>
<thead>
<tr>
<th>Parameter</th>
<th>FDS</th>
<th>AUDPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>m</td>
<td>AR24 × <em>Cacuke</em></td>
<td>UR108 × <em>Cacuke</em></td>
</tr>
<tr>
<td>a</td>
<td>-36.8±4.32*</td>
<td>-38.53±2.39**</td>
</tr>
<tr>
<td>d</td>
<td>-10.87±8.11ns</td>
<td>13.53±4.49*</td>
</tr>
</tbody>
</table>

**Significant at P ≤0.01,*Significant at P ≤0.05, ns = insignificance at P ≤0.05, m = mean, a = additive effect, d = dominance effect.

Table 4: Estimates of variance, heritability and dominance ratio for FDS and AUDPC in AR24 × *Cacuke* and UR108 × *Cacuke* crosses

<table>
<thead>
<tr>
<th>Parameter</th>
<th>FDS</th>
<th>AUDPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>δ²ₐ</td>
<td>638.00</td>
<td>526.00</td>
</tr>
<tr>
<td>δ²₉</td>
<td>58.00</td>
<td>71.90</td>
</tr>
<tr>
<td>δ²ₑ</td>
<td>111.10</td>
<td>65.70</td>
</tr>
<tr>
<td>H²</td>
<td>0.86</td>
<td>0.90</td>
</tr>
<tr>
<td>h²</td>
<td>0.79</td>
<td>0.79</td>
</tr>
<tr>
<td>a</td>
<td>0.43</td>
<td>0.52</td>
</tr>
</tbody>
</table>

δ²ₐ = additive variance, δ²₉ = dominance variance, δ²ₑ = environmental variance, H² = heritability in broad sense, h² = heritability in narrow sense a = dominance ratio.
REFERENCES


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UTILIZING THE OLD TO FIGHT THE NEW: SEEKING RESISTANCE TO WHEAT STEM RUST RACE UG99 FROM OLD KENYAN ACCESSIONS

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ABSTRACT

Stem rust race Ug99 continues to evolve and invade new territories. Three years ago, only seven variants of the race were known and to date 13 variants have been identified. The new races have acquired virulence to genes that were recently deployed to protect the wheat cultivars against it, namely SrTmp. Among the latest variants, TTKTT, TTKTK and TTHSK, were detected from a recent survey in Kenya in 2014. The variants are considered single step mutations. It is paramount that continuous work is done to discover new sources of resistance. A panel of 19 old Kenyan accessions, either released as varieties or bred between 1962 and 1975 were screened at seedling stage for undetected genes of resistance. The accessions were screened at the Cereal Disease Laboratories at United States Department of Agriculture, University of Minnesota in 2015 against six wheat stem rust pathotypes including the original race of Ug99 (TTKSK) and the new pathotypes. The accessions exhibited varied infection types to the pathotypes at seedling stage. These accessions also exhibited high to moderate levels of resistance when screened under field conditions, suggesting that new genes of resistance that could be used to fight the stem rust epidemic could exist in them. Accessions Tama, 1012.B1 (L), and Bonza 63 consistently exhibited low infection types to the pathotypes used for screening. Lines identified to exhibit moderate to high levels of resistance to stem rust will be vital in breeding for wheat varieties with rust resistance to combat the looming threat posed by Ug99 and its lineage of races.

Keywords: Wheat, Stem rust, Resistance

INTRODUCTION

The Ug99 lineage of stem (black) rust races continues to pose a threat to global bread baskets, Kenya’s own included. The fungus, Puccinia graminis f.sp. tritici, is the etiological agent of stem rust. As of 2016, 13 variants/races of the Ug99 lineage of stem rust had been identified and detected in 13 countries (Patpour et al., 2015). Breeding priorities in Kenya have since the early 1900s revolved around breeding for cultivars that are high yielding, widely adapted and, resistant or tolerant to prevailing biotic and abiotic stresses with good end user qualities (Macharia and Waweru, 2017). Among the fiercest of the biotic constraints to global wheat production is the rust diseases, and in Kenya stem rust is of utmost importance economically. Breeding for host-based resistance is deemed the most economical and sustainable strategy to combating the wheat rusts, stem rust included. Control methods involving chemicals i.e. use of fungicides are expensive and environmentally inauspicious (http://www.globalrust.org/). It is therefore imperative that breeding efforts continue to diversify sources of resistance being used in the breeding programmes.

Diversity in resistance genes to wheat stem rust occurs within the wheat population and its related species or genera (Singh and Rajaram, 2002). A good example is Aegilops tauschii from which the resistance genes Sr33 and Sr45 were derived and transferred to bread wheat Triticum aestivum (http://maswheat.ucdavis.edu/protocols/sr33/).

Historically, Kenyan wheat varieties among them Kenya Farmer, Kenya 117 and Kenya 58 were used around the world as sources of resistance to wheat programmes breeding for rust resistance (Wanjama et al., 2001).

Rust resistance in wheat is expressed as major or minor gene resistance. Major gene resistance is characterized by race-specific qualitative type of resistance that offers resistance to the pathogen through all stages of the plant life i.e. both at seedling and adult stages (McIntosh et al., 1998). Minor gene resistance is characterized by race non-specific qualitative type of resistance controlled by genes with minor to intermediate effects that confer near immunity type of
resistance when 3 to 4 of them are accumulated in a one background (Singh et al., 2003)

Race Ug99 of stem rust and races in its lineage possess combined virulence to a large number of catalogued resistance genes that are present in germplasm that is currently grown widely in Kenya and the global wheat production zones (Singh et al., 2015). This study therefore aimed at identifying sources of resistance to race Ug99 of stem rust and other emerging races of stem rust by evaluating a panel of old Kenyan accessions under greenhouse and field conditions.

MATERIALS AND METHODS

Plant Materials
A panel of 19 old Kenyan accessions donated by Dr. Godwin Macharia (Kenya Agricultural Livestock and Research Institute, Food Crops Research Institute, Njoro), were used for this study. A list of the names, pedigrees and year of release of the accessions is provided in Table 1.

Seedling Resistance Testing
Evaluation of seedling resistance was undertaken at the Cereal Disease Laboratories, USDA-ARS at the University of Minnesota in St. Paul, Minnesota, United States. The tests were performed with six isolates of Puccinia graminis f. sp tritici. Table 2 shows the races used and their virulence/avirulence profiles. All isolates were from single pustules that were increased on susceptible checks (wheat variety Morocco) in isolation and then stored at -80°C to maintain viability for future use.

Five seeds of each accession and a set of North American stem rust differentials were planted in pots and placed in a growth chamber of the greenhouse. Urediniospores of the stem rust race isolates were retrieved from -80°C storage and heat shocked at 45°C for 15 minutes then placed in a rehydration chamber and maintained at 80% relative humidity for 3 h using potassium hydroxide solution. They were then mixed with a light weight Soltrol mineral oil (Chevron Phillips Chemical Company, The Woodlands, TX) and used to inoculate 8 day old seedlings with the primary leaves emerged. Inoculated seedlings were air dried for thirty minutes for the oil to dry then placed in a dew chamber for 14 h at 18°C in darkness then 3 h with fluorescent light. The seedlings were then moved to a growth room in the green house and maintained at 18 to 20°C with a 16-h photoperiod. Seedling responses to stem rust races were recorded 14 days post inoculation following a 0-4 scale described by Stackman et al., (1962), as illustrated in Table 3.

Field Evaluation of Stem Rust
Evaluation of the reaction of the accessions at the adult plant stage to stem rust was conducted at the Kenya Agricultural Livestock Research Organization (KALRO), Njoro International wheat screening nurseries between the years 2010 and 2014. Plots were cultivated as 0.5m double rows 20cm apart with 0.5 m pathway. Hill plots of stem rust disease spreader plants (a mixture of the highly susceptible wheat cultivars Thatcher, Morocco, and Cacuke) were planted perpendicular to the rows on one side of each plot. To further boost disease infection, several continuous rows of spreader plants were planted around the whole block to facilitate uniform disease infection. To initiate artificial stem rust epidemic, spreader rows and plants were inoculated twice prior to booting and during stem elongation. A solution of fresh urediniospores collected from the KALRO-Njoro trap nurseries was used. Urediniospores were suspended in water then injected into 3-4 individual spreader plants every one meter (growth stage Z35-37; Zadoks et al., 1974). Spreader plants were also sprayed with a suspension of urediniospores suspended in a lightweight mineral oil Soltrol 170 (Chevron Phillips Chemical Company, The Woodlands, TX) twice during stem elongation. Wheat test plants reaction to stem rust infection was scored as a percentage infestation of disease on the plant (total area of stem and leaves covered by the disease, 0-100) (Peterson et al., 1948,) and host plant infection type response (Table 3) recorded as described by Knott (1989).

Genotyping
DNA was extracted from 4 week old seedlings using the CTAB nucleic acid extraction protocol described by Doyle and Doyle (1990). Polymerase chain reaction was performed using Taq PCR Master Mix Kit (250 U) from Qiagen (Hilden, Germany). The final solution consisted of 6.25µl Taq PCR Master Mix, 0.25µl each of forward and reverse primers (10pmol), 0.75µl of 25mM MgCl$_2$, 4µl of double distilled de-ionized water (ddH$_2$O) and 2µl of template DNA to make a final volume of 12.5µl. The PCR was performed on a thermo cycler from Applied Biosystems (Foster City, California, United States) (model number 2720) at 94°C for 5 minutes initial denaturation, 45 cycles of 94°C for 30seconds, annealing temperatures 63°C for Xbarc71 (Sr24) and 61°C for Xwmec477 (Sr36), 72°C for 60seconds, and a final extension at 72°C for 7 minutes. Products of PCR amplification were resolved
RESULTS

The panel of accessions exhibited a varied range of infection types at the seedling stage. Evaluation of the panel with six races of stem rust race Ug99 resulted in a wide range of infection types observed. Accessions 1012.B.1 (L), Bonza 63 and Tama displayed resistant infection types ranging from 0 to 2 to all six races used for the seedling tests. Accessions Kenya Paka, Beacon-Ken and Gabrino displayed resistant infection types to all races expect one each. Kenya Page and Trophy displayed susceptible infection types to all races tested. None of the accessions tested positive for the presences of Sr24 marker when screened with molecular marker Xbarc71.

Most if not all the accessions consistently exhibited resistant phenotypes over the years of field-testing. Infection responses remained relatively stable and consistent for each of the lines over the years of testing, except for the 2014 season where the disease responses were high. This was probably due to higher inoculum build up in the fields due to moist weather conditions that favor development and spread of the stem rust pathogen.

Accessions Trophy and Kenya Page displayed susceptible infection types to all the races used for the seedling tests. They as well displayed resistant to moderately resistant phenotypes through the years of field-testing with highs of up to 15M and 10MS respectively. These phenotypes suggest that ‘minor’ adult plant resistance genes could exist in them. Kenya Jay exhibited low percentage of moderately susceptible(5M;10MS) to susceptible (5S) diseases scores coupled with both resistant and susceptible infection types observed during seedling testing (Table 3) indicating that it could carry both major and minor stem rust resistance genes. Accession 1012.B.1(L) despite displaying resistant infection types to all the races used for seedling screening, also displayed resistant to moderately susceptible (Table 4) phenotypes during field testing. This could be a suggestion that it carries primarily major resistance genes or both minor and major genes conferring resistance to stem rust. All other accessions exhibited quite high levels of resistance during field testing, implying that major genes conferring resistance to stem rust could exist in them.

Molecular markers for Sr24 and Sr36 genes were used to screen the accessions used in this study (Table 4). Marker Xbarc71 was used to detect presence of gene Sr24. None of the accessions under study showed presence of this gene. Xwm477 marker was used to detect presence of gene Sr36. Five accessions namely Beacon-Ken, Gabrino, Kenya Sungura, Lenana and Primex showed presence of the genes where a 190 base pair band was observed depicting presence of the gene (http://maswheat.ucdavis.edu).

DISCUSSION/CONCLUSIONS

Initial Screening of a panel of 300 old East African accessions identified 19 accessions from Kenya with field resistance. These were screened with six stem rust races that occur in Kenyan wheat growing fields as shown in our study at the seedling stage to determine the mode of resistance exhibited by these accessions.

Four of the races namely TTKSK, TTKST, TTKTT and TTTSK are of the Ug99 lineage (http://rusttracker.cimmyt.org/?page_id=22). Races TKTTF and TRTTF are races of stem rust not found in the Ug99 lineage of races but were detected in Kenya in recent surveys as re-emerging races that occur predominantly in Ethiopia (Hailu et al., 2015). The race TKTTF caused epidemics in neighboring Ethiopia in 2013-2014 (Olivera et al., 2015) and was detected in Kenya in 2014 (http://rusttracker.cimmyt.org/?page_id=22). The race TKTTF possesses virulence to the gene SrTmp that was incorporated into Kenyan varieties to provide resistance to races of stem rust of the Ug99 lineage (Njau et al., 2011). Commercial varieties “Robin” and “Eagle 10” with the gene SrTmp were released in Kenya in 2010 to combat the threat posed by Ug99 to wheat production. Recent studies show that the current predominant races rende11th Egerton University International Conference and Innovation Week r most of the current commercially grown varieties in Kenya susceptible.

Our study revealed that old Kenyan accessions exhibit resistance to the stem rust races occurring in Kenya.
The resistance therein the accessions are both of major and minor effect as revealed from current studies. The accessions in our study were released/bred as varieties in Kenya between 1962 and 1975, implying that diversity for resistance genes to stem rust still exists in them. Three accessions were resistant to all the races used to screen them at the seedling stage, and they were still resistant during all seasons of field testing, implying major larger effect genes confer the resistance. Three lines also potentially carry minor small-intermediate effect genes, as they were susceptible at the seedling stage and resistant during field screening. This could be an indication that they carry adult plant resistant genes that have been proposed to be durable (Singh et al., 2008). Wheat genotypes known to possess this “durable” type of resistance are being utilized as parents for hybridization in breeding programmes globally (Njau et al., 2010). The present study identified three such accessions, and 13 accessions indicated that the resistance therein could be both major and minor. The type of resistance notwithstanding, this accessions characterization of resistance to stem rust deemed them invaluable as sources of resistance not only to race Ug99 but also to emerging races of stem rust.

Molecular marker Xwmc477 was used to assay for presence of the resistance gene Sr36. The race TKTTF possesses virulence to this gene and several accessions were resistant to it, three of which tested positive for the marker. Several other markers linked to genes for resistance are known (www.maswheat.ucdavis.edu) and further screening with molecular markers should be done on the accessions to determine which genes could be present in them and identify accessions with novel genes.

Studies involving genetics of resistance should be conducted on the accessions. Several mapping populations have been initiated from them to study what kind if resistance exists in them and how it is inherited. The accessions in the present study could be incorporated into programmes breeding for rust resistance to further augment efforts to combat the threat posed by wheat stem rust to wheat production and ultimately food security.

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REFERENCES


The use of inoculants offers an alternative to the use of chemical fertilizers that are expensive to small scale farmers. This study evaluated the response of soybean and common bean to three legume inoculants. Three common bean varieties and two soybean varieties seeds were inoculated at the recommended rate at planting. Plants were grown under greenhouse conditions using two different soils; a Nitisol and Andosol in a Completely Randomized Design. Non-inoculated seeds were also planted and grown under the same conditions. At mid-podding, nodule number and fresh weight above ground biomass and root dry biomass per plant were determined. Biologically fixed nitrogen was determined using the Nitrogen Difference. Data was subjected to ANOVA and means separated using Tukey’s LSD using SAS Software. Results indicate that nodule number and weight per plant were significantly higher with Biofix inoculant application (117 nodules) for common bean relative to the controls (75 nodules). In soybean, inoculation with Legumefix recorded significantly higher number of nodules (29 nodules) than the control (16 nodules). Inoculation of common bean with Biofix (11.94 g) significantly increased the shoot dry biomass compared to the uninoculated control (6.53 g). Biofix inoculation significantly fixed more nitrogen (29.3 kg ha\(^{-1}\)) compared to the uninoculated control (17.9 kg ha\(^{-1}\)) in the common bean while Legumefix inoculation fixed significantly higher nitrogen (51.9 kg ha\(^{-1}\)) than the control (31.1 kg ha\(^{-1}\)) in the soybean. High fertility soil resulted in higher nodulation and plant growth in both legumes compared to the low fertility soils. These results suggest that rhizobia inoculation of legumes enhances the nodulation, growth and biological nitrogen fixation. The response to inoculation also depends on the variety being grown and the soil fertility status. Further work under field conditions is recommended to confirm these findings.

Keywords: Inoculant, Biological nitrogen fixation, common bean, soybean, Rhizobia, Biofix, Legumefix

**INTRODUCTION**

A major problem facing Kenya’s smallholder farmers is declining soil fertility as a result of continuous cropping without sufficient replenishment of soil nutrients. This has led to decreasing food productivity against an increasing population. Nitrogen is the most commonly deficient crop nutrient. The demand for nitrogen in a deficient soil is normally achieved by the use of chemical fertilizers. However, the high cost of mineral nitrogen fertilizers and their unavailability at the required time are the two major constraints responsible for low fertilizer nitrogen inputs (Yakubu et al., 2010). Legume improves the soil fertility through its ability to fix atmospheric nitrogen in association with rhizobia. This emphasizes the importance of developing alternative means by use of beneficial bacteria that are sustainable, environment friendly and affordable. As such, biofertilizers containing rhizobia are an essential component of an integrated soil fertility management strategy (Uribe et al., 2012).

Biological nitrogen fixation and grain yields of legumes are normally increased when inoculated with effective and efficient strains of *Rhizobium* (Zarei et al., 2012). *Rhizobium* inoculation in legumes stimulates growth and increases yields and is an alternative source to the expensive commercial nitrogen fertilizers (Bambara and Ndakikemi, 2009; Moradet al., 2013). Lesueur et al., (2012) reported that the utilization of effective good quality rhizobial inoculants by farmers has a real potential to improve legume yields in unfertile soils requiring high applications of mineral fertilizers. They tested effective soybean commercial inoculants in different locations in Kenya and found out that application of the rhizobial inoculants significantly increased soybean yields in about 75% of the farms evaluated.

Maso et al. (2014) reported a lack of enough background information to substantiate the potential benefits of biofertilizers for resource-poor small scale farmers in sub-Saharan Africa and therefore the need
for continued evaluation (Jefwa et al., 2014). Also, most of the biofertilizers fail to meet the quality standards acclaimed by the manufacturers (Mathu et al., 2012; Compro-II, 2013a). Otieno et al. (2009) conducted a study to investigate the response of grain legume to inoculation. Their results indicated an increasing trend of number of nodules and nodule weight, seed yield and growth parameters with seed inoculation. Studies were conducted by Giri and Joshi (2010) through application of rhizobium as a biofertilizer on nodule formation and growth of chickpea and to evaluate the efficiency of seed inoculation for nitrogen fixation. They reported a 10.83% and 14.06% increase in total shoot and root length, respectively and 9.0% more germination as compared with control.

However, inoculation of legumes with rhizobial inoculants does not show positive response to nodulation and crop growth at all instances because of a variety of biotic or abiotic factors that affect nodulation of plants (Aung et al., 2013). For example, Mungai and Karubiu (2010) reported unresponsiveness of common bean to inoculation with commercial rhizobial inoculant (Biofix) in terms of shoot and root dry matter and biological nitrogen fixation. Legume inoculants can sometimes fail because of poor quality, poor survival during storage and death on the legume seed after inoculation. Some indigenous isolates have been found to be as good or superior in nitrogen fixation effectiveness to commercial inoculant strains under greenhouse conditions (Mungai and Karubiu, 2010). Mweetwa et al. (2014) also noted a lack of commercial rhizobia inoculation responses in cowpea, soybean and groundnuts.

The uncertain performance of Rhizobium inoculants may explain the limited farmer adoption despite their potential to reduce the mineral fertilizer requirement, and reduce cost of production. Smallholders may benefit from good quality products that are correctly applied to the appropriate crop under appropriate soil and crop management (Jefwa et al., 2014). There is therefore need to validate the quality and the efficacy of these products under different soil conditions to add knowledge on profitable technologies for adoption to the farmers. The objective of this study was to test the effectiveness of Biofix and Legumefix inoculants on common bean and soybean growth in two different soil types.

MATERIALS AND METHODS

Three commercial products were tested for their efficacy in greenhouse using two different soil types (Nitisol and Andosol) and three common bean and two soybean varieties.

Commercial Rhizobia Inoculants

Commercial inoculants Biofix-Soybean, Biofix-Common bean from MEA Limited and Legumefix-Soybean were purchased. Biofix is the most available and commonly used inoculant by farmers in Kenya and although legumefix is not produced locally, some early studies have shown Legumefix- soybean performing better than Biofix- soybean in other part of the country (Compro II, 2013).

Plant Material and Soil

The test crops used were two soybean varieties; Nyala and TGx1740-2F (SB19) and three common beans varieties; AFR 708 (Chelalang), Lyamungu-85(Tasha) and GLP 2 (Rosecoco). Nyala is an early maturing soybean variety with an average on-farm yield of 700 kg/ha with large grain size. It can be intercropped with other crops and nodulates with specific strains of rhizobia, while SB19 is a medium maturing variety with promiscuous nodulation and has high grain and biomass yield with an average yield of 900 kg/ha (ICRISAT, 2013). AFR 708 and Lyamungu-85 varieties are newly released common bean varieties by Egerton University with special attributes of being high yielding, pest and disease resistant. AFR 708 is reported to yield more than the local checks (Njoka et al., 2009), that is, GLP 2 and Mwezi Moja (GLP 1004). GLP 2 is a high yielding variety suitable for medium altitudes while Mwezi moja is a medium yielder and suitable in dry areas (KALRO, 2008). Maize (H614D) was included as a reference crop for biological nitrogen fixation (BNF) estimation. Nitisol (Chuka-0°20.472’ E037°41.691’) and Andosol (Njoro-0°23.723’ E037°35.043’) soil were collected from the 0-20 cm top layer, air-dried, sieved to pass 2 mm and thoroughly homogenized. Moisture content (MC) at field capacity (FC) was determined to standardize water addition in the pot trials as described by Somasegaran and Hoben, (1994). The Andosol FC water content was determined to be 483 ml while that of the Nitisol was found to be 520 ml.

Soil samples (20 cm depth) were collected at the beginning of the study from the two sites for characterization of initial soil chemical properties. The soils were air-dried, prepared and analysed using
standard procedures as described by Okalebo et al. (2002). Soil pH was determined using a glass electrode pH meter at 1:2.5 soil/water ratio. Available P was extracted using the Mehlich-3 and determined using the ammonium vanadate method and amount determined using a spectrophotometer. Organic carbon was determined by Walkley and Black sulfuric acid–dichromate digestion followed by back titration with ferrous ammonium sulfate whereas nitrogen was determined using the Kjeldahl method.

The common bean experiment consisted of three treatment; T1= Biofix, T2= Di-ammonium phosphate (DAP) and T3= Control (No fertilizer, no inoculation), while the soybean consisted of four treatments; Biofix, Legumefix, DAP and Control (No fertilizer, no inoculation). The experiment was laid out in a completely randomized design (CRD) with three replicates in the greenhouse and the pots were rotated regularly on the benches to minimize the effect of shading.

**Soil Preparation and Product Application**

Pot volume used was 5.3 L (15.0 cm inner diameter and 30 cm length), and contained different heights of soil for Njoro and Chuka soil respectively. Each pot was filled with 4kg of soil. The soils have different bulk densities and accounted for the different heights of soil-filled tubes and this was done by putting the same amount of soil (4 kg) of the two soils but packing them to different heights to ensure a similar bulk density. PVC tubes were closed at the bottom using a nylon mesh, and placed on plastic plates.

Biofix and Legumefix were applied based on manufacturer’s recommendations of 50 g of the inoculant to 15 kg of soybean and 10 kg for common bean with large sized seeds. For the greenhouse experiment, 100 g of soybean was coated with 0.3 g of the inoculant while 0.5 g of the inoculant was used to coat 100 g of the common bean. Immediately after coating, the seeds were spread on paper and allowed to dry in a shady place. For the positive control, common beans received 12.2 kg N ha⁻¹ (DAP at 67.5 kg ha⁻¹) to simulate farmers’ practices (Mungai and Karibiu, 2010) with each pot receiving 0.135 g while soybean received 22.5 kg N ha⁻¹ (DAP at 125 kg ha⁻¹) recommended rate (KALRO, 2006) at 0.25g per pot.

**Planting, Nutrient Addition, Thinning and Water Addition**

Seeds were surface-sterilized by soaking in 3.5% NaOCl solution for 5 minutes and then thoroughly washed with distilled water. Three healthy seeds of uniform size were then planted per pot, and thinned to one plant per pot of comparable height and vigour at 7 d after planting. Uninoculated pots were planted before those with inoculated soybeans to avoid contamination during planting. Basal nutrients were applied as minus-N solutions (750 mg K, 270 mg Ca, 165 mg Mg, 60 mg S, 36 mg Mn, 1.5 mg Zn, 0.6 mg Cu, 0.9 mg B, 0.15 mg Mo and 0.15 mg Co pot⁻¹) (Somasegaran and Hoben, 1994). Stock solutions were diluted in 20L of distilled water and 10 ml added to plants every two days. The pots were watered regularly to maintain the soil at field capacity. The watering was done by taking three representative pots from each of the two soils and weighing to determine the amount of water (average of the three) to bring the soil water content back to FC.

**DATA COLLECTION**

**Determination of Nodule Number and Nodule Weight**

At mid podding, plants were carefully uprooted from the pots and placed on sieves to avoid loss of nodules during cleaning. The soil was then gently washed off the roots under a stream of running tap water. The nodules were then carefully removed from the roots, counted and weighed.

**Determination of Biomass Yield, Biologically Fixed Nitrogen and Symbiotic Efficiency**

The above ground and root biomass were determined at mid-podding after drying to a constant weight at 65 °C. Total nitrogen fixed was determined using the Nitrogen Difference Method as described by Unkovich et al. (2008). In this method, legumes in all the treatments were grown under greenhouse conditions alongside the non N fixing reference crop, maize (Abdul-Latif, 2013). At mid podding, percent tissue N was determined in all plants using the Kjeldahl method (Bremner and Mulvaney, 1982). The percent nitrogen fixed was then determined by calculating the difference between the N in the inoculant and that in the reference crop. The symbiotic efficiency of the inoculation treatments was obtained by comparing the nitrogen concentration in the inoculant treatment with the nitrogen content in the mineral N application treatment.

**DATA ANALYSES**

Data were analysed using SAS Statistical Package Version 9.3 (SAS 2010). To determine the effects due to inoculation, analysis of variance at 95% confidence
limit was done and means separated using the least significance difference (LSD) test at p ≤ 0.05.

Symbiotic efficiency was calculated using the following formula (Beck et al., 1993);

\[
\text{S.E. (%) } = \frac{A}{B} \times 100
\]

Where, S.E. = symbiotic effectiveness, A = the amount of nitrogen in the plant inoculated, B = the amount of nitrogen in the nitrogen applied control (DAP).

RESULTS

Chemical Properties of the Study Soils
The study soils varied in terms of pH with the soils from Chuka having a pH of 5.01 (moderately acidic) and Njoro soil having a pH value of 6.32 (slightly acidic). The Chuka soil had low level of extractable P while the Njoro soils had sufficient amount of P. The total nitrogen and organic carbon were moderate for the two soils (Okalebo et al., 2002; Mungai et al., 2009) (Table 1). Chuka soil is characterized as a Vitric Andosol, while the Njoro soil is characterized as Rhodic Nitisol, (Jaetzold et al., 2005).

Effect of Rhizobial Inoculation on Number of Nodules
The nodule number per plant of common bean was significantly affected by the soil type and the inoculation. There was no significant effect due to the varieties. However there was significant interaction among the soil, treatment and the varieties. In terms of soil type, Andosol recorded a significantly higher nodule number (112) than the Nitisol (20) (Figure 1). Inoculation of the common bean varieties with Biofix also led to a significant increase in the number of nodules (117 nodules) compared to the uninoculated control (75 nodules) and the di-ammonium phosphate application (6 nodules).

In the soil by variety by inoculation interaction, Biofix had a significant effect on nodule production of common bean varieties in the Andosol with AFR 708 and GLP 2 variety having significantly higher nodule numbers than Lyamungu-85. Also, in Andosol inoculation of Lyamungu-85 variety with Biofix did not increase the nodule number compared to the control. However, in Nitisol, inoculation of Lyamungu-85 variety with Biofix led to significantly higher nodule numbers than the control (Figure 1).

The number of nodules of soybean was significantly affected by the variety, treatment and variety by inoculation interaction. The soil type had no significant effect on the nodulation of soybean. The SB19 variety recorded a significantly higher number of nodules per plant (20 nodules) than the Nyal variety. Legumefix recorded significantly higher nodules (29 nodules) than Biofix (22 nodules), the uninoculated control (16 nodules) and the DAP application. Biofix also recorded significantly higher nodules than the uninoculated control. In the variety by treatment interaction SB 19 variety recorded significantly higher nodule numbers than the Nyal variety when inoculated with Legumefix and Biofix (Figure 2).

Effect of Rhizobial Inoculation on Nodule Fresh Weight
The nodule weight of common beans was significantly affected by the soil, variety and inoculation. Also significant interactions effects of soil by inoculation, variety by inoculation and soil by variety by inoculation were observed. Andosols recorded a higher nodule weight (1.46g) than the Nitisol (0.54g per plant) in beans. Inoculation of common beans with Biofix led to significantly higher nodule weight (2.09g) than the uninoculated control (0.84g). Di-ammonium phosphate application recorded the least nodule weight. The varieties also responded differently with AFR 708 recording the highest nodule weight (1.29g) that was significantly different from the Lyamungu-85 variety (0.58g), but not from GLP 2 (1.14g). In the Andosol, GLP 2 variety recorded the highest nodule fresh weight and was significantly different from the Lyamungu-85 variety (Figure 3). In the Nitisol however, AFR 708 variety recorded the highest nodule fresh weight following inoculation compared to GLP 2 and Lyamungu-85 varieties (Figure 3).

In the three-way interaction, Biofix had a significant effect on the nodule weight of the common bean varieties in Andosols with AFR 708 and GLP 2 variety having significantly higher nodule weight compared to the Lyamungu-85 variety. Also, in Andosols inoculation of Lyamungu-85 variety with Biofix did not increase the nodule weight compared to the control. However, in the Nitisol, inoculation of Lyamungu-85 variety with Biofix led to significantly higher nodule weight over the control (Figure 3).

The nodule weight of soybean was significantly affected by the soil and inoculation but the variety did not have a significant effect on the nodule weight. Soybean recorded a significantly higher nodule weight (122.1 mg) in Andosols compared to Nitisols (62.4 mg). Legumefix inoculation recorded the highest nodule weight (189.1 mg) compared to the
uninoculated control (77.9 mg) and the DAP application (2.08 mg). There was significant difference in nodule weight for soybean inoculated with Legumefix and Biofix in both the soil types. Application of DAP suppressed the nodule fresh weight in both soils and varieties tested in both the Andosol and the Nitisol (Figure 4).

Effect of Rhizobial Inoculation on Shoot Dry Weights
For the common bean, there was significant effect due to the soil type, inoculation, soil by variety and soil by inoculation interaction. However, there was no significant difference among the varieties, variety by inoculation interaction and soil by variety by inoculation interactions. The Andosol recorded a significantly higher shoot dry weight (13.37g) than the Nitisol (8.33g). In terms of the treatment effect, DAP application recorded the highest shoot weight (14.08g) that was significantly higher than the Biofix inoculation and the uninoculated control. Additionally, inoculation with Biofix (11.94g) significantly increased the shoot dry biomass compared to the uninoculated control (6.53g).

In the soil by variety interaction, the three common bean varieties had a higher shoot dry weight in the Andosol compared to the Nitisol. In the Andosol, AFR 708 variety performed better than Lyamungu-85 variety but no significant difference was noted between AFR 708 and GLP 2 variety. However, in the Nitisol, GLP 2 and Lyamungu-85 varieties performed better than AFR 708 variety (Figure 5 A). In terms of the soil by treatment interaction, Biofix inoculation led to a significantly higher shoot dry weight in the Andosol compared to the Nitisol. The increase in shoot dry weight due to Biofix inoculation over the control was more pronounced in the Nitisol (330.1%) compared to the Andosol (19.6%). Di-Ammonium Phosphate application recorded the highest shoot dry weight in both soils types (Figure 5B).

In soybean, there was a significant difference in shoot dry weight between the soil type, variety and among the inoculation. There was also a significant soil by variety interaction on the shoot dry weight. In the Andosol, inoculation with Legumefix recorded a significantly higher shoot dry weight than the control. However, there was no significant difference between the Biofix application and the control (Figure 6A). In the Nitisol, inoculation of the soybean with Legumefix and Biofix led to significantly higher shoot dry weight than the control (Figure 6A). In terms of variety, SB19 recorded a significantly higher shoot dry weight (7.52 g) than the Nyala variety (4.34). In the soil by variety interaction, SB 19 variety recorded significantly higher shoot dry weight in both the Andosol and the Nitisol compared to the Nyala variety in both the soil types (Figure 6B).

Effect of Rhizobial Inoculation on Root Dry Weights
For the common bean, the root dry weight was significantly affected by the soil type and the treatment. However, there was no significant effect due to the variety and the interactions of the variety and the inoculation. In the Andosol, DAP application recorded a significantly higher root dry weight (7.6 g) than the Biofix inoculation and the control. However, the inoculation of the bean with Biofix led to a significantly higher root dry weight (5.6 g) than the control (4.0 g) (Figure 7). In the Nitisol Biofix inoculation of common bean with Biofix significantly increased the root dry weight compared to the uninoculated control. However there was no significant difference between the Biofix inoculation and the DAP application (Figure 7).

The root dry weight of soybean was significantly affected by the soil type, variety, treatment and soil by variety interaction. Similarly, in soybean; the Andosol recorded a significantly higher root dry weight (3.25 g) compared to the Nitisol (0.89 g). The SB19 variety recorded a significantly higher root dry weight than the Nyala variety. Inoculation of soybean with Legumefix and Biofix did not increase the root dry weight compared to the uninoculated control (Figure 8A). The highest root dry weight was recorded due to the addition of DAP across the varieties and soils. In the soil by variety interaction, SB 19 variety recorded significantly higher root dry weight in both the soils compared to the Nyala variety (Figure 8B).

The Effect of Inoculation on Plant Tissue Nitrogen, Biological Nitrogen Fixation and Symbiotic Effectiveness
The plant tissue N content and the BNF were significantly affected by inoculation. The variety, soil and the interactions were however not significant. Inoculation of common bean with Biofix significantly increased the tissue nitrogen compared to the control. DAP application recorded the highest plant tissue nitrogen. In terms of BNF, Biofix inoculation significantly fixed more nitrogen compared to the uninoculated control. However, the symbiotic
efficiency of Biofix inoculation was less than 100% (Table 2).

For the soybean, the plant tissue N and the BNF were significantly affected by the treatment. The variety, soil and the interactions were however not significant. Inoculation increased the tissue nitrogen compared to the control. Legumefix inoculation recorded a significantly higher nitrogen level compared to the uninoculated control. However, no significant difference was noted when compared to the Mineral N application and Biofix inoculation. Additionally, inoculation of soybean with Legumefix fixed a significantly higher nitrogen level compared to the uninoculated control and recorded a symbiotic efficiency of 105.6% that was higher than 100% compared to Biofix inoculation that recorded a symbiotic efficiency of 88.1% (Table 3).

DISCUSSION

In the present investigation rhizobium inoculation of common beans and soybean significantly increased the nodule number per plant compared to the uninoculated control. This may be due to the presence of adequate rhizobia strains in the root rhizosphere which initiated the formation of the nodules. The result of this study was in accordance with earlier finding by Tahir et al. (2009) who reported increase in soybean nodule numbers and nodule dry weight from 73 to 125 and 1.36 to 1.53 g, respectively, by inoculation alone. It has also been reported that nodule number, dry weight and soybean shoot yield increased when seeds inoculated with Rhizobium (Javaid and Mahmood, 2010; Musyoki et al., 2011). Otieno et al. (2007) also reported similar results that rhizobial inoculation significantly increases nodule number and dry weight in studied legume species compared to application of farmyard manure and N-fertilizer. Lamptey et al. (2014) reported that soybean seeds inoculated with commercial Rhizobium inoculants (Legumefix) established better, grew more vegetatively, produced higher shoot biomass and nodulated more vigorously.

There was a variation in nodulation of soybean following inoculation with Legume fix and Biofix with Legume fix recording higher nodulation than Biofix inoculation. Results of nodulation among the inoculants indicate that the strains in Legume fix could be of higher quality in terms of efficiency and effectiveness than in Biofix. A study by Aliyu et al. (2013) showed that some of the rhizobia strains used in the trials did not show significant difference from control while others recorded even lower nodulation. The Common bean and soybean had nodules even without inoculation in Andosol. This indicates that the soil contains native rhizobia that nodulated the legumes (Chemining’wa et al., 2004). Nodulation observed in control plots indicates that native common bean and soybean rhizobia in the soils are compatible with varieties tested.

This study found that N fertilizer application significantly reduced the number of nodules and nodule fresh weight per plant. This indicates the preference of host plant to utilize available N added to the soil which requires less energy than fixing N from the atmosphere. Muhammad (2010) and Van der Bom (2012) also reported that application of nitrogenous fertilizer resulted in reduction of nodules number and rate of nitrogen fixation in soybean. Inhibitory effect of added nitrogen fertilizer to nodulation had been reported by Otieno et al. (2009), Bekunda et al. (2010) and Thuita et al. (2012).

The results from this study also indicated that the rhizobial inoculants did not significantly increase the shoot and root dry weight compared to the control. This is explained by the fact that enhanced growth of the legumes is mainly due to nitrogen fixed by rhizobia (Mweetwa et al., 2014). Another factor that may have resulted in no inoculation response is the quality of inoculants used. Similarly, other authors have reported inability of inoculation with Biofix and other rhizobial inoculant to result in significant increase in shoot dry biomass in common bean, soybean, cowpea and green gram over the control (Mungai and Karubiu, 2010; Mathu et al., 2012 and Gitonga et al., 2010).

The present study also revealed different inoculation effect depending on the type of soil with the Nitisol being more responsive to inoculation than the Andosol. Success of rhizobia inoculation is highly site specific and depends on a number of interactions including environmental, soil and biological factors (Argaw, 2012). Soil factors that influence plant and rhizobial growth include acidity, temperature, moisture, fertility, influence infection and nodulation of legumes (Cooper and Schere, 2012). This may be as a result of high N level in the Andosol compared to the Nitisol and this may have hindered the legumes in responding to rhizobia inoculation as much as the Nitisol. When the soil N levels are high the legume will use the readily available N rather than fix nitrogen through the BNF process. Soil pH has been widely reported to influence nodulation because it can induce deficiency in some
introduced commercial inoculants (Evans, 2012 and Atieno, 2013 working on three inoculation of common bean seeds resulted in study nutrients such as t with SB19 responding to inoculation more than me., 2011). 2013) reported a difference in inoculation effect of et al. The inoculated had more nodules than et al. (2012) et al. performed egerton University International Conference and Innovation Week of different parts of the world has been shown to be especially efficient at fixing nitrogen. There are varying parts in the interaction between variety and strain in soybean (Solomon et al., 2012; Mhango, 2015). SB19 responded well to inoculation compared to Nyala variety and this may be due to the SB19 being a promiscuous variety and Nyala being a specific nodulating soybean variety and SB19 could have been nodulated by other rhizobium species in the soil. Thuita et al. (2012) and Atieno et al. (2012) working with the two varieties in soils from Central and Coast province of Kenya also reported similar results with SB19 responding to inoculation more than Nyala variety.

In the common beans varieties uninoculatedLyamungu-85 variety was able to form more nodules than those that had been inoculated with Biofix in the Andosol while in GLP 2 and AFR 708 variety the inoculated had more nodules than uninoculated in the same soil. These results suggested that different varieties of beans had preference for certain rhizobia and indigenous rhizobia strain were better than inoculant strains for the Lyamungu-85 variety in the Andosol. This is in line with what was reported by Gicharu et al. (2013) working on three climbing bean cultivars who showed variation in nodulation of the cultivars in response to inoculation with rhizobial strains.

Plant tissue analysis from this study revealed that inoculation of common bean and Soybean with Biofix did not significantly increase shoot nitrogen over the control. Previous studies assessing the response of several legumes to inoculation with Biofix revealed that there was generally no significant increase in the amount of total nitrogen accumulated with inoculation (Mungai and Karubiu, 2010; Khafa, 2013 and Mweetwa et al., 2014) on inoculation of bean genotypes. Others studies also found indigenous Rhizobium strains to be highly effective symbiotic N fixers than introduced commercial inoculants (Evans, 2005; Yadav et al., 2011).

In soybean, variation in tissue N and biologically fixed N was observed between the Legumefix (soybean) and Biofix (soybean) inoculation. The symbiotic efficiency of Legumefix inoculant was greater than that of Biofix inoculation. This indicates the presence of strains with a high potential in the Legumefix compared to the Biofix showing that some inoculant strains are of higher quality than others. Rhizobia strains of different origin vary in their symbiotic efficiency (Zaman-Allah, 2007). Additionally, the biologically fixed N was significantly higher than the control though the response depended on the legume (COMPRO II, 2013c). The approach of using effective or superior exotic rhizobia strains as inoculants has failed in various environments due to various reasons including the use of ineffective and non-competitive rhizobia strains as inoculants (Slattery et al., 2004). The total nitrogen accumulated by legumes has previously been shown to reduce with Biofix inoculation. For example, a 4.13% reduction was observed in groundnuts (COMPRO II, 2013c).

CONCLUSIONS

Rhizobia inoculation of common bean seeds resulted in enhanced nodule numbers and weight in genotypes tested across the soil types except for Lyamungu-85 variety in Andosols. This indicates importance of testing genotypes in various locations to improve selection of genotypes for the required trait they have been tested for. In this study, Legume fix performed better than Biofix in enhancing soybean nodulation.

For the greenhouse evaluation, the results of the study indicated that the products generally had positive influence on the measured parameters compared to control and thus inoculation would be beneficial in improving productivity of common bean and soybean as assessed using nodulation and shoot and root biomass. Additionally, field testing is required to determine whether improvement to growth would result in yield increase.

ACKNOWLEDGMENTS

This research was supported through a sub-grant by the International Institute of Tropical Agriculture (IITA) to Egerton University through the COMPRO-II Project funded by the Bill and Melinda Gates Foundation.
REFERENCES


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Table 1: Chemical properties of the study soils

<table>
<thead>
<tr>
<th>Soil</th>
<th>Depth (cm)</th>
<th>pH (H₂O)</th>
<th>Extractable P (mg kg⁻¹)</th>
<th>Organic Carbon (%)</th>
<th>Total Nitrogen (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitisol</td>
<td>0-20</td>
<td>5.01</td>
<td>14.0</td>
<td>2.46</td>
<td>0.16</td>
</tr>
<tr>
<td>Andosol</td>
<td>0-20</td>
<td>6.32</td>
<td>43.6</td>
<td>3.62</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Table 2: Effect of inoculation on plant nitrogen content, biological nitrogen fixation (BNF) and symbiotic efficiency (SE) of common bean

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant Nitrogen (mg/g)</th>
<th>S.D</th>
<th>BNF (kg/ha)</th>
<th>S.D</th>
<th>Symbiotic Efficiency (%)</th>
<th>S.D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biofix</td>
<td>36.9b ±5.3</td>
<td></td>
<td>29.3a ±4.4</td>
<td>79</td>
<td>±9</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>27.8c ±4.2</td>
<td></td>
<td>17.9b ±3.2</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>DAP</td>
<td>46.5a ±5.7</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>LSD α = 0.05</td>
<td>7.1</td>
<td></td>
<td>7.1</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Means followed by the same letter within a column are not significantly different at α = 0.05
S.D= Standard deviation

Table 3: Effect of inoculation on plant nitrogen content, Biological nitrogen fixation (BNF) and symbiotic efficiency (SE) of soybean

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant Nitrogen (mg/g)</th>
<th>S.D</th>
<th>BNF (kg/ha)</th>
<th>S.D</th>
<th>Symbiotic Efficiency (%)</th>
<th>S.D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biofix</td>
<td>46ab ±7.2</td>
<td></td>
<td>40.5ab ±9.2</td>
<td>88</td>
<td>9.0</td>
<td></td>
</tr>
<tr>
<td>Legumefix</td>
<td>55a ±9.1</td>
<td></td>
<td>51.9a ±8.7</td>
<td>105</td>
<td>8.3</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>38b ±6.7</td>
<td></td>
<td>31.1b ±7.4</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Mineral N</td>
<td>52ab ±6.9</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>LSD α = 0.05</td>
<td>14</td>
<td></td>
<td>14</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Means followed by the same letter within a column are not significantly different at α = 0.05
S.D= Standard deviation

Figure 1: Interactive effect of soil*variety* inoculation on the number of nodules per plant in common bean. Error bars represent standard error of the means; DAP- Di-Ammonium Phosphate
Figure 2: Interactive effect of variety*inoculation on the number of nodules plant of soybean. Error bars represent standard error of the means; DAP - Di-Ammonium Phosphate

Figure 3: Interactive effect of soil, variety and inoculation on nodule weight of common bean. Error bars represent standard error of the means; DAP - Di-Ammonium Phosphate

Figure 4: Effect of soil type and inoculation on the nodule fresh weight of soybean. Mean followed by the same letter for each section are not significantly different at α=0.05. DAP - Di-Ammonium Phosphate
Figure 5: Interactive effect of soil*variety (A) and soil*inoculation (B) on the shoot dry weight of common bean. Error bars represent standard error of the means; DAP - Di-Ammonium Phosphate.

Figure 6: Effect of soil*inoculation (A) and the soil*variety interaction (B) on the shoot dry weight of soybean. Mean followed by the same letter are not significantly different at α=0.05. Error bars represent standard error of the means.

Figure 7: Effect of soil type and inoculation on the root dry weight of common bean. Error bars represent standard error of the means.
Figure 8: Effect of inoculation (A) and the soil*variety interaction (B) on the root dry weight of soybean. Mean followed by the same letter are not significantly different at \( \alpha = 0.05 \). Error bars represent standard error of the means.
**EFFECT OF COLOURED AGRO-NET COVERS ON INSECT PEST INFESTATION AND TOMATO (Solanumlycopersicon MILL) IMPROVEMENT**

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**ABSTRACT**

Tomato (Solanumlycopersicon Mill) is one of the most important vegetable crops consumed throughout the world; and is rich in important vitamins, minerals and antioxidants. Production of the crop in open fields is however constrained by several biotic and abiotic stresses that lead to low tomato yields and quality. This study aimed at determining the effects of coloured agro-net covers on microclimate, pest infestation and yield of tomato cultivar ‘‘Rio Grande’’. The study consisted of two trials conducted using a randomized complete block design (RCBD) with five replications and six treatments. Tomato plants were grown under blue, yellow, grey, white or multi-coloured net covers with a no net cover as the control. Data were collected on microclimate (temperature, soil moisture, relative humidity and photosynthetically active radiation), pest counts and crop yield variables. Net covering modified the tomato crop microclimate with highest temperatures and soil moisture and, relative humidity levels recorded under white (21.03°C), blue (30.03%) and multi-coloured net covers (76.26%), respectively compared to the no net control treatment (16.32°C, 14.82% and 64.90%). Photosynthetically active radiation (PAR) was lowest under the blue agro-net cover (416.09µmolm⁻² s⁻¹) and highest under control treatment (985.00µmolm⁻² s⁻¹). Tomato plants grown under coloured-colour nets (yellow and blue) had lower population of silverleaf whitefly, thrips and aphids while mite population was lower under neutral-colour net covers (white, grey and multi-coloured). The neutral-colour net covers (24938.87, 19525.16 and 21541.93kg/ha) resulted in higher yields compared to coloured-colour net covers (16804.62 and 14551.05kg/ha). Results of the study indicate that use of agro-net covers especially the neutral-colour net cover can improve microclimate, protect tomato against insect pests and can be considered a viable strategy for tomato production by smallholder growers.

**Key words:** Solanumlycopersicon; protected production; microclimate modification; agro-net cover

**INTRODUCTION**

Tomato is one of the world’s most important vegetable crops consumed and ranks second after potato in the world. Present world production stands at 170750767 tonnes produced on 5023810 hectares of land (FAO, 2017). In Africa, total production area of tomato increased from 159593ha in 1961 to 1214227 ha in 2014 and production increased from 1968812 tonnes in 1961 to 19253066 tonnes in 2014 (FAO, 2017). In sub-Saharan Africa including Kenya, tomato is still among the most commonly grown and consumed vegetable crop as it greatly contributes to food security, nutritional balance and income for resource poor growers (FAO, 2017). It has high nutritional value with important vitamins, mineral and antioxidants (Velioglu et al., 1998) whose consumption has been shown to reduce the risks of cardiovascular diseases and certain types of cancer (Clinton, 1998). Tomato is consumed fresh or utilized in preparation of wide range of processed products such as tomato juice, soup, paste, puree, ketchup, and sauce (Ray et al., 2011).

Despite the potential of tomato in improving the livelihoods of rural population, low yields remain a common scenario. Tomato production is however, constrained by insect pests and diseases, and by abiotic factors (Fufa et al., 2011). Although pesticides are available for control of most insect pests of tomato, they are expensive and unaffordable to small scale farmers who are the majority of tomato growers. In addition, such chemicals are hazardous to humans as well as the environment (Weinberger and Lumpkin, 2005). Greenhouse tomato production has been advocated for as a way of solving some of these problems. However, its adoption in many of the developing countries has been extremely slow, due to high investment costs. As a result, majority of farmers still grow their tomato in the open fields, despite all the challenges (HCDA, 2006).

Simple technologies have been developed in different parts of the world and proved successful in protecting crops against adverse weather conditions and insect
pests. Netting technology has been used to protect agricultural crops from environmental hazards thus enhancing plant microclimate for improved crop yield and quality (Shahak et al., 2004). Coloured (photo-selective) shading nets are currently being developed with the aim of improving crop production by taking advantage of their optical properties. Coloured nets modify the spectral composition of the transmitted and reflected sunlight (Shahak et al., 2004) which tend to have differential effects on insect pests and crop performance (Shahak et al., 2008; Shahak, 2008). An understanding of the specific effects of the different colours of agro-net covers on tomato pest infestation and microclimate modification would be critical in ensuring better use of the technology. This study aimed at determining the effects of coloured agro-net covers on microclimate, pest infestation and yield of tomato cultivar “Rio Grande”.

MATERIALS AND METHODS

Experimental Site
Two trials (Nov. 2013 to Feb. 2014 and May to Sep. 2014) were conducted at the Horticulture Research and Demonstration Field, Egerton University, Njoro-Kenya. The field lies at a latitude of 0°23’S longitude 35°35’E and an altitude of 2238m. The area receives a mean annual rainfall of about 1000mm with average maximum and minimum temperatures ranging from 19°C to 22°C and 5°C to 8°C, respectively. The soils are well drained dark reddish clays classified as Mollic andosols (Jaetzold and Schmidt, 2006).

Planting Material, Experimental Design and Treatments
Seeds of tomato cultivar “Rio Grande” sourced from Kenya Seed Company – Eldoret were sowed in a nursery to obtain transplants used as the planting material in this study. This determinate tomato cultivar was chosen because it has good disease tolerance and is high yielding but sensitive to variations in environmental conditions (HCDA, 2006). The experiment was laid in a randomized complete block design (RCBD) with five replications and six treatments. The treatments were growing tomato under; blue, yellow, grey, white and multi-coloured (predominantly white in colour with blue and yellow stripes) net covers maintained permanently covered except during routine management and a no net cover treatment as the control. Agro-net covers used were of 0.4mm pore diameter sourced from A to Z Textile Mills Ltd., Arusha, Tanzania. Each block measured 32.5-m × 3-m separated by a 0.5-m path from the adjacent block. Within each block, each individual experimental unit measured 3-m × 5-m separated by a 0.5-m path. On covered treatments, seven posts 1.2-m long were installed before planting to provide support for the net covers. Three posts were mounted on each side of the experimental unit at 2.5-m apart along the 5-m bed and one at the middle of the plot to serve as support system for the cover. The posts were grounded to 20-cm depth to ensure that they were firm enough to provide the needed support leaving 1-m of the length of posts above the ground. Agro-nets were then mounted completely covering the plots and pegged at each corner to minimize wind interference. The plots were permanently covered and only opened during routine management and data collection periods.

Land Preparation, Planting and Maintenance Practices
The field was manually prepared using hoes and rakes. Transplanting holes were manually dug using hand hoe and diammonium phosphate fertilizer (18% N, 46% P₂O₅) incorporated in every planting hole at a rate of 10g and thoroughly mixed with soil prior to transplanting. Tomato seedlings at the four true leaf stage were transplanted in four rows at 50-cm spacing within the row and giving a total of 40 tomato plants per experimental unit. Thereafter, standard good agricultural practices including; gapping, top dressing, watering, weeding and disease control were done uniformly in all experimental units on need basis. Calcium Ammonium Nitrate (CAN) was applied in two splits as a top dress at the rate of 300kg ha⁻¹ when plants were three weeks old and the second split three weeks later.

DATA COLLECTION
Data for all variables studied were measured from 12 plants in the inner rows of each experimental unit.

Microclimate: WatchDog 2000 series Mini Station data loggers (2475; Spectrum Technologies, Inc.) were used to collect microclimate data. The data loggers were mounted on wooden posts 0.5-m high at the centre of each experimental unit and were set to collect data hourly which were averaged weekly. On weekly basis, the data were downloaded into a computer. Microclimate data collected included; air temperature (°C), relative humidity (%), PAR light (µmolm⁻²s⁻¹) and soil moisture as volumetric water content (%) using an external sensor (WaterScout™SM 100; Spectrum Technologies).
Insect pest counts: Data were collected on the number of adult silver leaf whitefly (Bemisiatabaci), spider mites (Tetranychusurticae) and onion thrips (Frankliniellaintonsa) and nymphs of aphid (Aphisgossypii). Hand lens were used to produce magnified images of small insects (mites and thrips). In the case of whitefly, yellow sticky traps from Koppert Biological Systems (K) Ltd., Nairobi, Kenya were also mounted on each plot to trap flying whiteflies and later counted.

Fruit yield: Fruit harvesting was done once every week beginning when the first fruits were at breaker stage and continued for a period of four weeks. At each harvest, tomato fruit from each tagged plant were separately counted and the number of fruits obtained recorded and later used to compute the average number of fruits per plant (no./plant). Thereafter, tomato fruits harvested from each experimental unit were then separately sorted as marketable and unmarketable. Unmarketable fruits included small size fruits (< 30mm in diameter), those damaged by insects or diseases and those with physical damage or physiological defects. The data obtained were used to compute marketable and unmarketable fruits per plant. The fruits for each category were then weighed and weight obtained recorded in grams and later used to compute the total fruit weight, marketable and unmarketable fruit weight in kilograms per hectare (kg ha⁻¹).

DATA ANALYSIS

Data collected were subjected to Analysis of Variance (ANOVA) using PROC GLM code of SAS (version 9.1; SAS Institute, Cary, NC, USA). Data were analyzed using the statistical RCBD model: \( Y_{ijk} = \mu + \beta_i + \tau_k + \epsilon_{ijkl} \) where; \( Y_{ijk} \) is the tomato yield response, \( \mu \) is the overall mean, \( \beta_i \) is the effect of the \( i \)th block (\( i = 1,2,3,4,5 \)), \( \tau_k \) is the effect of the \( k \)th treatment (\( 1,2,3,4,5 \)) and \( \epsilon_{ijkl} \) is the random error component. Means for significant treatments were separated using Tukey’s Honestly Significant Difference (Tukey’s HST) test at \( P < 0.05 \).

RESULTS

Effects of Different Colours of Agro-net Cover on Tomato Plant Microclimate

Covering tomato with agro-net covers of different colours influenced microclimate of the immediate crop environment. Air temperature, relative humidity and soil moisture (measured in volumetric water content) were higher while PAR was reduced under agro-net covered plots compared to under the control treatment (Figure 1). Throughout the study, temperatures were highest under the white cover. Mean temperature for this treatment for the two trials was \( 21.03^\circ \text{C} \). Among the other treatments, mean temperatures were \( 18.75^\circ \text{C}, 18.24^\circ \text{C}, 17.94^\circ \text{C}, 17.12^\circ \text{C} \) under yellow, grey, multi-coloured, and bluenet covers, respectively compared with \( 16.32^\circ \text{C} \) for the control treatment (Figure 1A). Averaged over the two trials, relative humidity was lowest under the control treatment at 64.90% and highest under the multi-coloured cover at 76.26% (Figure 1B). Among the other treatments, mean relative humidity was recorded as 73.91% under grey cover followed by 72.46% under blue cover, then 69.78% under yellow cover and 67.35% under white cover.

Averaged over the two trials, soil moisture content was lowest under the control treatment (14.82%) and highest under blue cover (30.03%) (Figure 1C). Among the other treatments, the highest soil moisture content was observed under yellow cover (26.75%) followed by multi-coloured (24.23%) then white cover (23.14%) with moisture content being lowest under grey net cover (23.03%). To the contrary, the use of different colours of agro-net cover reduced PAR (Figure 1D) reaching the crop throughout the study period. The mean PAR received by plants was highest under the control treatment (985.00μmolm⁻² s⁻¹)and lowest under blue cover(416.09μmolm⁻² s⁻¹). Among the other treatments, PAR values were 679.48μmolm⁻² s⁻¹ under white cover, 624.64μmolm⁻² s⁻¹ under multi-coloured cover, 539.17μmolm⁻² s⁻¹ under grey cover and 447.05μmolm⁻² s⁻¹ under yellow cover.

Effects of Different Colours of Agro-net Cover on the Population of Tomato Insect Pest

The number of silverleaf whitefly, aphids, onion thrips, and mites on the tomato crop were significantly reduced following the use of the different coloured agro-net covers (Table 1). During all data collection periods, the lowest population of silverleaf whitefly was observed under the yellow net followed by grey cover, then white then multi-coloured cover while the highest population was obtained under the control treatment with no net cover. Among the net covered treatments, whitefly population was highest under the blue cover in all sampling dates. Silverleaf whitefly data collected from the sticky traps mounted at the centre of each plot showed a trend similar to that of the populations obtained on individual plants with the lowest and highest whitefly population observed under the yellow cover and control, respectively.
Aphid numbers was lowest under the yellow and white net covers with intermediate aphid numbers recorded under the grey, blue and multi-coloured covers in most sampling dates while the highest population was obtained under the control treatment in all sampling dates. Thrips population was on the other hand lowest under the blue net cover in all sampling dates and highest under the control treatment. Among the other treatments, the numbers of thrips recorded on individual plants was lower under the yellow net cover than under multi-coloured, grey and white covers with no statistical differences noted in the mean number of thrips recorded for these treatments in all sampling dates. The lowest mite population was recorded under the grey cover throughout the study period except at 56 DAT when mite population was lowest under the white cover. Among the other treatments, mite numbers tended to be lower under the white cover followed by yellow cover but slightly higher under the multi-coloured cover in most sampling dates. Throughout the study period, mite population on plants was highest under the control treatment.
Table 1: Effect of different colours of agro-net cover on pest population of tomato plants

<table>
<thead>
<tr>
<th>Treatment</th>
<th>28</th>
<th>56</th>
<th>70</th>
<th>84</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Days after Transplanting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Silverleaf whitefly/plant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grey</td>
<td>1.49b*</td>
<td>1.39bc</td>
<td>1.38cd</td>
<td>1.38b</td>
</tr>
<tr>
<td>Yellow</td>
<td>1.21b</td>
<td>1.19c</td>
<td>0.94d</td>
<td>0.94c</td>
</tr>
<tr>
<td>Blue</td>
<td>2.00a</td>
<td>2.02a</td>
<td>1.91ab</td>
<td>2.50a</td>
</tr>
<tr>
<td>White</td>
<td>1.62ab</td>
<td>1.80ab</td>
<td>1.60bc</td>
<td>1.41b</td>
</tr>
<tr>
<td>Multi-coloured</td>
<td>1.70ab</td>
<td>1.83ab</td>
<td>1.26cd</td>
<td>1.40b</td>
</tr>
<tr>
<td>Control</td>
<td>2.07a</td>
<td>2.18a</td>
<td>2.09a</td>
<td>2.76a</td>
</tr>
<tr>
<td></td>
<td>Silverleaf whitefly on yellow traps/plot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grey</td>
<td>1.95b</td>
<td>2.05bc</td>
<td>2.23bc</td>
<td>1.71bc</td>
</tr>
<tr>
<td>Yellow</td>
<td>1.49c</td>
<td>1.73c</td>
<td>1.93c</td>
<td>1.45c</td>
</tr>
<tr>
<td>Blue</td>
<td>2.27b</td>
<td>2.39b</td>
<td>2.52b</td>
<td>2.05b</td>
</tr>
<tr>
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<td>2.15b</td>
<td>2.25b</td>
<td>2.40b</td>
<td>1.88b</td>
</tr>
<tr>
<td>Multi-coloured</td>
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<td>2.15b</td>
<td>2.35b</td>
<td>1.97b</td>
</tr>
<tr>
<td>Control</td>
<td>2.97a</td>
<td>3.05a</td>
<td>3.14a</td>
<td>2.59a</td>
</tr>
<tr>
<td></td>
<td>Aphids/plant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grey</td>
<td>0.64ab</td>
<td>1.24b</td>
<td>1.15b</td>
<td>1.31b</td>
</tr>
<tr>
<td>Yellow</td>
<td>0.40c</td>
<td>1.16b</td>
<td>1.26b</td>
<td>1.22b</td>
</tr>
<tr>
<td>Blue</td>
<td>0.62ab</td>
<td>1.28ab</td>
<td>1.35b</td>
<td>1.29b</td>
</tr>
<tr>
<td>White</td>
<td>0.44c</td>
<td>1.11b</td>
<td>1.17b</td>
<td>1.21b</td>
</tr>
<tr>
<td>Multi-coloured</td>
<td>0.52bc</td>
<td>1.22b</td>
<td>1.32b</td>
<td>1.27b</td>
</tr>
<tr>
<td>Control</td>
<td>0.71a</td>
<td>1.46a</td>
<td>1.61a</td>
<td>1.70a</td>
</tr>
<tr>
<td></td>
<td>Mites/plant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grey</td>
<td>0.85</td>
<td>0.91bc</td>
<td>0.67c</td>
<td>1.15b</td>
</tr>
<tr>
<td>Yellow</td>
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<td>0.82bc</td>
<td>0.76bc</td>
<td>1.27ab</td>
</tr>
<tr>
<td>Blue</td>
<td>1.21</td>
<td>1.07ab</td>
<td>1.04b</td>
<td>1.52ab</td>
</tr>
<tr>
<td>White</td>
<td>0.93</td>
<td>0.69c</td>
<td>0.82bc</td>
<td>1.19b</td>
</tr>
<tr>
<td>Multi-coloured</td>
<td>1.00</td>
<td>0.70c</td>
<td>0.87bc</td>
<td>1.31ab</td>
</tr>
<tr>
<td>Control</td>
<td>1.22</td>
<td>1.28</td>
<td>1.41a</td>
<td>1.62a</td>
</tr>
<tr>
<td></td>
<td>Thrips/plant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grey</td>
<td>0.65ab</td>
<td>1.00ab</td>
<td>0.97</td>
<td>0.62b</td>
</tr>
<tr>
<td>Yellow</td>
<td>0.47b</td>
<td>0.96ab</td>
<td>0.79</td>
<td>0.63b</td>
</tr>
<tr>
<td>Blue</td>
<td>0.41b</td>
<td>0.67b</td>
<td>0.71</td>
<td>0.51b</td>
</tr>
<tr>
<td>White</td>
<td>0.70ab</td>
<td>1.05a</td>
<td>0.94</td>
<td>0.73b</td>
</tr>
<tr>
<td>Multi-coloured</td>
<td>0.65ab</td>
<td>1.17a</td>
<td>0.93</td>
<td>0.89ab</td>
</tr>
<tr>
<td>Control</td>
<td>0.97a</td>
<td>1.12a</td>
<td>0.98</td>
<td>1.32a</td>
</tr>
</tbody>
</table>

*Means followed by the same letter within a column and a variable are not significantly different according to Tukey’s honest significant difference (HSDT) test at P ≤ 0.05

Effects of Different Colours of Agro-net Covers on the Yield of Tomato
Growing tomato under the different coloured net covers significantly influenced tomato fruit yield both in terms of fruit numbers and fruit weight (Table 2). The use of white net cover resulted in the highest fruit number per plant with the lowest fruit number per plant obtained under the blue net cover. Among the other treatments, more fruits were harvested from plants under multi-coloured net cover followed by the control, grey net cover and yellow net cover in descending order. Upon separation of fruits into marketable and unmarketable fruits, the highest number of marketable fruits was also obtained under the white net cover while the lowest number was under the blue net cover. Among the other treatments, the number of marketable fruits obtained was in descending order from multi-coloured, grey, yellow and control treatment.
Table 2: Effect of different colours of agro-net cover on yield of tomato

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number of fruits</th>
<th>Marketable fruits</th>
<th>% relative increase</th>
<th>Unmarketable fruits</th>
<th>% relative decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grey</td>
<td>42.00bc*</td>
<td>26.60bc</td>
<td>40.74</td>
<td>15.40bc</td>
<td>39.37</td>
</tr>
<tr>
<td>Yellow</td>
<td>34.80cd</td>
<td>23.00bc</td>
<td>21.69</td>
<td>11.80c</td>
<td>53.54</td>
</tr>
<tr>
<td>Blue</td>
<td>29.00d</td>
<td>17.90c</td>
<td>-5.29</td>
<td>11.10c</td>
<td>56.30</td>
</tr>
<tr>
<td>White</td>
<td>53.00a</td>
<td>36.80a</td>
<td>94.71</td>
<td>16.20bc</td>
<td>36.22</td>
</tr>
<tr>
<td>Multi-coloured</td>
<td>47.70ab</td>
<td>28.70ab</td>
<td>62.43</td>
<td>19.00b</td>
<td>33.07</td>
</tr>
<tr>
<td>Control</td>
<td>44.30abc</td>
<td>18.90c</td>
<td>5.29</td>
<td>11.10c</td>
<td>56.30</td>
</tr>
</tbody>
</table>

Contrary to marketable fruit numbers, the lowest number of unmarketable fruits per plant was realized under the blue net cover while the highest number was obtained under the control treatment. Among the other treatments, the number of unmarketable fruits obtained was in ascending order from yellow, to grey, to white covers and highest under the multi-coloured cover.

Fruit weight per plant followed a trend similar to that of fruit numbers with the highest and lowest total fruit weight obtained under the white and blue net covers, respectively (Table 2). Among the other treatments, higher total fruit weight was obtained under the multi-coloured net, followed by under the grey net, then yellow net and lowest under the control treatment with no net cover. On the other hand, the highest marketable fruit weight was obtained under the white net and the lowest under the control treatment. Among the other treatments, marketable fruit was higher under the multi-coloured net, followed by the grey net then the yellow net and the lowest under the blue net. Marketable fruit yield was 103.04% higher under the white net cover, 72.03% higher under the multi-coloured net, 41.36% higher under the grey net, 32.67% under the yellow net and 24.88% under the blue net compared to control plants. Unmarketable fruit weight recorded a trend almost opposite to that of marketable fruit weight, with the highest unmarketable fruit weight obtained under the control treatment and the lowest under the blue net cover. Among the other treatments, unmarketable fruit weight was highest under the grey net followed by the white net then under the multi-coloured and lowest under the yellow net cover.

**DISCUSSION**

Growing tomato under the different coloured agro-net cover proved to be of potential benefit in the production of tomato. Regardless of the colour of agro-net cover, net covers modified the microclimate around the growing tomato plants marked by higher air temperature, soil moisture and relative humidity compared with the control treatment. On the other hand, photosynthetically active radiation was reduced by the use of coloured agro-net covers. The existence of net covers has been shown to alter the exchange of radiation, momentum and mass between the crop and the atmosphere hence modifying plant micro-environment. Netting also offers a partial barrier (Bextine & Wayandande, 2001) that reduce the mixing of outside air with inside air thus reducing heat loss to the surrounding atmosphere, which leads to temperature build up (Tanny et al., 2003). In the current study, temperatures generally tended to be higher under neutral-colour net covers (white, multi-coloured and grey) than under coloured-colour net covers (blue, and yellow). Similarly, (Tinyane et al., 2013) recorded higher temperatures under neutral-colour net covers compared to coloured-colour net covers while working on tomato cultivars which was attributed to transparent and less densely knitted pattern of the threads under neutral-colour net covers.
that transmitted high amounts of light. Higher air temperature recorded under neutral-colour net covers (white, multi-coloured and grey) in the current study could also probably have been as a result of higher light transmission in these treatments compared to coloured-colour net covers.

Relative humidity was also higher under the coloured agro-net covers than in the uncovered plots in the current study. According to Elad et al. (2007), relative humidity is often higher under nets than outside, as a result of water vapour being transpired by the crop and reduced mixing of drier air outside with that of the netted area, even when the temperatures under netting are higher than outside. Reduction in radiation resulting from netting also contributes to increased relative humidity (Stamps, 1994). Besides reducing radiation, nettings also reduce wind speed and wind run which in turn decreases evaporation due to reduced air mixing which result in an increase in relative humidity (Elad et al., 2007). These arguments lend support to the observations made in the current study where a higher relative humidity was observed under agro-net covered plots than in the uncovered plots. Among the agro-net covered plots, relative humidity tended to be higher under coloured-colour net covers than under neutral-colour net covers possibly due to the relatively higher soil moisture, and lower air temperature and light intensities recorded under coloured-colour net covers compared to under neutral-colour net covers.

Similar to relative humidity and temperature, volumetric water content also tended to be higher under agro-net covers than the control plots in the current study. Use of shade netting, regardless of colour reduces solar radiation levels reaching crops underneath resulting to a decrease in evaporation, thus maintaining higher soil moisture content (Elad et al., 2007). Air movement is also restricted under net covers (Nair & Ngouajio, 2010) which results in reduced wind damage to the crop allowing air beneath the nets to remain humid (Ilic et al., 2012). Iglesias and Alegre (2006) also demonstrated that reduction of transpiration under net covers led to increased moisture retention in the soil due to minimized water uptake by plants. Besides reduced transpiration rates, existence of a net cover may also have reduced soil evaporation rate under netted areas due to restricted air movement, resulting in higher soil water retention. Findings of the current study corroborate those of earlier studies on spinach (Meena et al., 2014), and cabbage under net covers (Muleke et al., 2014). Among the agro-net covers, soil moisture tended to be higher under coloured-colour net covers than under neutral-colour net covers possibly due to the higher relative humidity levels and lower air temperature recorded under coloured-colour net covers than under neutral-colour net covers that may have contributed to reduced evapotranspiration rate and higher soil moisture levels.

Contrary to temperature, soil moisture and relative humidity, photosynthetically active radiation that reached the tomato crop were lowered by the use of the different coloured agro-net covers compared to no net control. Netting is frequently used to offer physical protection against excessive solar radiation (Shahak et al., 2004) and exhibits special optical properties that allow control of light that reaches the plants (Oren-Shamir et al., 2001). Covers have also been shown to block light from entering into the canopy of plants (Arthurs et al., 2013). The reduction in PAR under covers in the current study could therefore be attributed to the light blocking properties of the materials. Both, the direct and diffuse transmission factor of the net determines the light inside the net covered structure (Hemming et al., 2012). Since neutral-colour nets scatter higher amount of light resulting into availability of more diffused radiation capable of reaching a larger volume of the plant, in a more homogenous way (Nissim-Levi et al., 2008). Coloured-colour net covers essentially act as opaque material giving less reflection of all light spectra (Shahak, 2008). A net having a high transmission factor for diffuse light and a high transmission gives more light intensity (Hemming et al., 2012). According to Castellano et al. (2008), neutral-colour net covers have a higher transmissivity values compared to coloured-colour net covers due to higher values of reflectivity. This could explain the higher PAR recorded under the neutral-colour net covers compared to under coloured-colour net covers in the current study.

The population of silverleaf whitefly, aphids, thrips and mites remained lower under different coloured agro-net covers compared to open field production in the current study. Net covers have been reported to be effective physical barrier excluding a wide range of lepidopteron pests from growing plants (Gogo et al., 2014). Besides, nets have properties to filter the UV radiation (280-400nm) interfering with the vision of insect pests and hence their ability to see and discern the host plants (Shahak et al., 2004). The elimination of the UV portion of the light spectrum interferes with UV vision of insects and as a consequence, their behaviour related with movement, host location ability
and their population parameters (Diaz & Fereres, 2007) hence lowering their population under agro-net covers. These arguments support the observations made in the current study where a reduced number of pests was observed under agro-net covered plots than in the uncovered plots.

In the current study, pest population variables were differently influenced by the different coloured net covers. A greater reduction in silverleaf whitefly and aphid population was realized when tomato was grown under the yellow net cover. Reduced number of silverleaf whitefly and aphids observed under the yellow net cover can be attributed to the pigments contained under this net cover that attracts whiteflies and aphids. Therefore, crops grown under these nets could potentially be at a lower risk of pest infestation (Antignus & Ben-Yakir, 2004). According to (Ben-Yakir et al., 2012), the optical property and light reflection of yellow net cover makes whiteflies and aphids land and stay arrested on it for an extended period of time without penetrating through the net. These arguments lend support for the reduced number of silverleaf whitefly and aphid population registered under the yellow net cover compared to other different colours of agro-net covers observed in the current study. Blue net cover also contain pigments known to attract thrips (Shahak, 2008). Growing tomato under blue net cover could potentially be at lower risk of thrips infestation. The lower number of thrips recorded under blue net cover compared to other coloured agro-net covers could be attributed to pigments contained in the net that attracted thrips and stayed arrested on it for an extended period of time without penetrating through the net number in the current study.

Higher number and total fruit weight of tomato was obtained under neutral-colour net covers (white, grey and multi-coloured) compared to coloured-colour net covers (yellow and blue). The higher yield under these nets in the current study can be associated to more light scattering that result into availability of more diffused radiation in a more homogenous way causing higher absorption of PAR resulting to more light use efficiency (LUE), photosynthetic rate and dry matter accumulation (Shahak, 2008). According to Lloyd (1995), enhancement of light has been reported to increase radiation absorbed by the crop, stomatal conductance and net carbon dioxide assimilation leading to increased crop productivity under shading. Spectral modification of composition of light by neutral-colour net covers could have also promoted fruit set and fruitlet survival that led to higher yields. Beside, the increase in yields under neutral-colour net covers could be attributed to the higher number of branches registered under this net covers in the current study compared to under the coloured-colour net covers. The higher yield recorded under neutral-colour net covers could also be attributed to higher light intensity recorded under these net covers compared to coloured-colour net covers. This may have increased number of stomata per mm² and on the other hand increased overall dry matter content (Salas et al., 2015). Less yield in coloured-colour net covers was observed under the current study. The yellow and blue net covers essentially acts as opaque material which gives less reflection of all light spectra, thereby reducing the photosynthetic activity and fruit yield (Shahak, 2008). The higher yield recorded under neutral-colour net covers over coloured-colour net covers can also be explained by greater exposure to red and far red radiation during growth and development. According to (Kasperbauer & Hamilton, 1984), the relationship of red and far red solar radiation influences the development of chloroplasts to ensure efficient plant survival, which possibly influenced the photosynthetic capacity promoting a higher productivity. The higher fruit yield from neutral-colour net covers resulted mostly from enhanced fruit production rates, namely the number of fruits produced per plant. Opaque materials reflect radiation out of the structure, decreasing temperature but increasing shading. Excess shading induces etiolation of the plants and redistribution of carbohydrates due to competition for light between plants, likely decreasing fruit yield and quality. Coloured-colour net covers reduced yield of tomato. The low yield under these net covers could be attributed to low number of fruits per plant recorded in the current study. Lower yields recorded under coloured-colour net covers can also be attributed to higher relative humidity recorded under these nets that reduced the crop yield. Meena et al. (2014) observed that higher humidity recorded under the net covers due to sufficient rain, reduced crop yield. According to Nissim-Levi et al. (2008), increased scattered light recorded under pearl net (neutral-colour net) led to plants with a larger number of branches. Lower penetration capacity of blue and red range radiation under coloured-colour net covers reduces photosynthetic activity (Ombodi et al., 2015) possibly explaining the lower yields recorded for coloured-colour net covers in the current study. According to Atkinson et al. (2006), lower productivity under coloured-colour net covers is attributable to the redirection of photo-assimilates for leaf area production in order to increase the solar radiation.
gathering leaving less energy for the formation of fruit. Growing tomato under net covers also substantially improved marketable yields of the crop. Better marketable yields obtained under net covers could probably have been as a result of the reduced number of pests from injuring fruits in these treatments in the current study. Net covers also protect crops against direct solar radiation thus avoiding damage to the fruit epidermis and promote better solar radiation distribution within the plant canopy improving quality of fruits (Stamp, 2009). In addition, plant leaf area tends to increase under low light conditions following the use of nets that result in better coverage of the fruit reducing heating of the fruit surface (Gent, 2007). Besides, the modified microclimate (increased air temperature and soil moisture) under covered treatments may also have contributed to the improved crop performance and reduced physiological disorders favouring the production of more fruit that met the market standards. Similarly, Nair & Ngouajio (2010) reported higher marketable yields of cucumber under nets compared with control. The increase in marketable yields recorded in neutral-colour net covers compared to coloured-colour net covers could be attributed to higher production of fruit number and total fruit weight in the current study.

CONCLUSION

The use of coloured agro-net covers appears to be a promising technology that can be used for improving tomato yields through modification of microclimate and reduction of insect pest population. For a grower to obtain higher yields and better quality, the use of white net covers in tomato production in regions with similar climatic conditions to those of the site of the current study is recommended. In order to further validate the results, additional studies on the subject using different cultivars of tomato, mesh sizes of the net covers and in different agroecological zones is recommendable. An analysis of the effects of coloured agro-net covers on plant hydric status and water needs; and beneficial insects and insect vector transmitted diseases would also be beneficial to growers.

ACKNOWLEDGMENTS

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Salas, R.A., Gonzaga, Z.C., Wu, D., Luther, G.,


CULTURE AND SOCIO-ECONOMICS
ABSTRACT

Kenya has demonstrated a firm commitment to the fulfillment of children’s rights, as evidenced in the legal instruments that have been enacted. These include domestic instruments like the constitution of Kenya, the penal code, and the Children’s Act (2001); and international instruments like the United Nations Convention on the Rights of a Child (UNCRC), and the African Charter on the Rights and Welfare of the Child (ACRWC). The responsibility of ensuring that children enjoy their rights is shared between the government on the one hand, and parents and caregivers on the other. However, for parents and caregivers to meaningfully fulfill and protect children’s rights, it is important for them to understand those rights. This study, which was conducted in Rongo Sub-County, in Migori County, sought to assess the level of knowledge about children’s rights among parents and caregivers in rural Kenya. The study employed the survey method, complemented by document analysis, with parents and caregivers as the target population. Data were collected from a sample of 357 parents and caregivers, who were selected through stratified and random sampling. Data was also collected from key informants. Information was collected through questionnaires, in-depth interviews and focus group discussions. The findings were analyzed using the Statistical Package for Social Sciences (SPSS). The study revealed that most parents and caregivers do not have adequate knowledge of children’s rights, as outlined in the legal instruments applied in Kenya. The study shows that most parents and caregivers apply cultural and religious beliefs and practices as their major points of reference in determining what constitutes children’s rights. The findings of this study are very important, since they reveal one of the major challenges in the achievement of universal rights for children. The study recommends that greater efforts should be made to disseminate the contents of the legal instruments that guide the enforcement of children’s rights in Kenya. These include translation of the instruments into local languages, simplification of the contents and intensified campaigns in the media and public gatherings.

Key Words: Children’s Rights; Children’s Act, Caregivers, Level of Knowledge, Cultural Practices,
In 1924, the League of Nations adopted the Declaration of the Rights of the Child, which granted specific rights to children and responsibilities to adults (Fitzpatrick, 2016).

The atrocities that were witnessed in the Second World War (1939-1945), including torture and extermination of entire populations, galvanized the international community into taking decisive steps to actualize universal human rights. These efforts culminated into the International Declaration of Human Rights in 1949 (United Nations, 2010), which recognized that children’s rights are a fundamental part of human rights, and that children especially need protection due to their vulnerability. In acknowledgement of the need for the protection of children’s rights, the United Nations adopted the International Declaration on the Rights of the Child in 1959 (United Nations, 2010). Later in 1959, the United Nations adopted the Declaration of the Rights of the Child, which outlined the rights of children (United Nations, 1959). The overriding principle in the declaration was that all decisions and actions that are taken for, or on behalf of, a child, must be in the best interests of the child. Later in 1989, the UN General Assembly adopted the Convention on the Rights of the Child (UNCRC), which describes the rights of children in greater detail. In addition the UN also adopted instruments that targeted specific child rights, including prohibition of child labour (Convention 182 on the Worst forms of Child Labour in 1999) and involvement of children in armed conflict (the Optional Protocol Regarding the Participation of Children in Armed Conflicts in 2000).

The UNCRC has been signed and ratified by all countries except the USA and Somalia, which have signed but not ratified it.

Kenya, being one of the countries that have signed and ratified the international instruments, including the UNCRC, has demonstrated a firm commitment to the fulfillment of children’s rights. Kenya has also signed and ratified the African Charter on the Rights and Welfare of the Child (ACRWC), which was adopted by African countries to address the challenges that are unique to the African child. In addition to the international instruments, Kenya has put in place a legal framework that ensures that the rights of the child are protected. These include the constitution of Kenya, and legislation. The constitution of Kenya specifically guarantees the rights of children and entrenches the “best interests of the child” principle (Republic of Kenya, 2010). In addition, Kenya has enacted legislation to provide the legal framework for children's rights. These include the Persons with Disabilities Act, the Sexual Offenses Act, and the Refugees Act (Odera, 2014). However, the piece of legislation that dedicates itself to children’s rights is the Children’s Act (2001) (Republic of Kenya, 2001). The Children’s Act domesticates the UNCRC, and the hitherto fragmented pieces of legislation that addressed themselves to the rights of a child (Iskander, 2015).

The rights of a child, as envisaged in the UNCRC, and the Children’s Act, may be classified into four categories: survival rights, development rights, protection rights, and participation rights. Survival rights include the rights to life, basic needs such as food, shelter, healthcare, and an adequate living standard. Development rights include the rights to play, leisure, and cultural activities. The freedoms of thought, conscience and religion are also categorized under development rights. Protection rights are aimed at ensuring that a child is safeguarded against all forms of abuse, neglect and exploitation. Protection rights include safeguards for children who may be refugees, in employment, or those who may be in the criminal justice system. Children who may have suffered exploitation or abuse of any kind are also protected. Finally, participation rights include a child’s freedom the express their opinions, to have a say in matters affecting their own lives, to join associations and to freely assemble. Children are entitled to opportunities to participate in the activities of their societies as they prepare for adulthood.

Kenya has also implemented several policies that touch on child welfare, including the waiving of maternity fees in all government health facilities; provision of free treatment for malaria (and provision of free mosquito nets) to children under the age of five years; provision of universal and free primary education; implementation of a direct cash transfer program to families to care for orphans and vulnerable children (OVCs); and the implementation of a social protection policy, among other initiatives. Regarding institutions, Kenya has established various institutions that are aimed at safeguarding children’s rights. These include the children’s courts, the National Council for Children’s Services (NCCS), the Department of Children’s Services (DCS), the Kenya National Commission on Human Rights (KNCHR), among others.

Nevertheless, despite the legal, policy and institutional framework, children in Kenya continue to suffer violations of their rights. For example, children...
In view of the aforementioned, this study, which was conducted in Rongo Sub-County, in Migori County, sought to assess the level of knowledge about children’s rights among parents and caregivers in rural Kenya.

STATEMENT OF THE PROBLEM

Kenya has put in place several legislative, policy and institutional measures to ensure that the children enjoy their rights as envisaged in the UNCRC. However, despite the implementation of these measures, children in Kenya continue to suffer violations of their rights, sometimes at the hands, or with the knowledge of their caregivers. There is need therefore to determine the extent to which parents and caregivers are aware of children’s rights.

OBJECTIVES OF THE STUDY

The general objective of the study was to assess the level of knowledge of children’s rights in the study area. Specifically, the study sought to:

1. Identify the children’s rights that are known to the parents and caregivers in the study area;
2. Determine the socio-demographic factors that influence the level of knowledge of children’s rights in the study area;
3. Establish the sources of information about children’s rights

MATERIALS AND METHODS

This study was conducted in Rongo town, located in Rongo sub-county, which is one of the eight sub-counties in Migori County. The rapid expansion of Rongo University since its establishment in 2011 has resulted in exponential growth in the population of the town. In 2016, the town was estimated to have a population of 50,000 people (INFOTRACK, 2016). The mainstay of the economy of the town is the education sector (the nearby Rongo University, primary and secondary schools); and the agriculture sector (SONY Sugar Company, situated approximately 20 kilometers to the West of the town, Sukari Industries, and sugarcane farming). A section of the population is self-employed in their small scale business enterprises. The study area was selected because it is situated in a region where there have been many reports of children suffering social and economic violations. It is also peri-urban, and has a diverse population with diverse characteristics. Rongo town has 13 estates, namely Central, Ogeng’o, Makutano.
Population and Sampling
The study employed the survey method, in which data were collected using questionnaires, key informant interviews and Focus Group Discussions (FGDs). The survey was complemented by document analysis. The target population for this study were parents and caregivers, who, at the time of the study, had children aged 18 years and below. Data were collected from a sample of 357 parents and caregivers, and 30 key informants. The sample size was arrived at using a formula which is used in calculating the minimum sample size when the universe contains more than 10,000 objects (Babalola, 1998):

\[ n = \frac{Z^2pq}{d^2} \]

Where: \( n \) - minimum sample size; \( Z \) - The normal deviate corresponding to the desired; confidence level = 1.96; \( p \) - The proportion of people in the study population thought to have the key characteristic(s) being measured; \( q \) - The opposite of \( p \) (1-\( p \)); \( d \) – The degree of accuracy desired =0.05.

The first stage of the sampling process involved clustering the study area into the 13 estates that constitute Rongo town. In the second stage, enumeration areas were randomly selected from each of the villages. Systematic random sampling was then used to select specific housing units from a listing of all households in each of the selected enumerated areas. Finally, a questionnaire was administered to one adult, either male or female, who was selected from each of the selected housing units. Whenever the researcher came across a household where the adults did not fulfill the inclusion criteria, the next household was chosen for replacement. Also, any household where there was more than one eligible adult for selection, only one was randomly selected using the simple random method. This strategy ensured that the selected sample was fairly representative of the study area.

Data Collection
The reliability of the questionnaire was ascertained by employing the test-retest reliability method, which was carried out by administering the questionnaire to a group of 20 adults in Homabay. After an interval of 2 weeks, it was re-administered to the same set of people. The two sets of scores were correlated. The questionnaire was complimented by 30 key informant interviews, with key informants being purposively selected from among teachers, administrative officers, and Community Own Resource Persons (CORPs) in the study area. This sample size of 30 is based on Bartlett et al. (Bartlett, Kotlik, & and Higgins, 2001), who argue that a sample size of 30 is adequate for key informant interviews in surveys where the target population is less than 1,000 objects. Secondary sources of data included books, journals, magazines, reports from libraries, and the internet, among others. The findings were then analyzed using the Statistical Package for Social Sciences (SPSS).

RESULTS
Data was collected from 357 respondents, most of whom were parents. Only 18.2% were caregivers, most of whom were grandparents. The mean age of the respondents was 31 to 35 years. The study found that some of the caregivers were more than 65 years old, an indication that there are several grandparent headed households in the study area. Approximately half (49.6%) of the subjects were married. A majority (73.9%) of the subjects had completed secondary level of education, with 30.8% having some post-secondary school education. More than three quarters (78.4%) were Christians, which is consistent with the findings of previous studies in the study area. The largest segment (32.8%) of the respondents was in formal employment, while 16.5% were unemployed (Table 1). The socio-demographic characteristics of the subjects indicate that the population is largely middle class.
Table 1: Socio-demographic characteristics of respondents

<table>
<thead>
<tr>
<th>Socio-Demographic Characteristics</th>
<th>Male n (%)</th>
<th>Female n (%)</th>
<th>Total n (%)</th>
</tr>
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<tr>
<td>Status</td>
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<tr>
<td>Parent</td>
<td>115 (32.2)</td>
<td>177 (49.6)</td>
<td>292 (81.8)</td>
</tr>
<tr>
<td>Caregiver</td>
<td>49 (13.7)</td>
<td>16 (4.5)</td>
<td>65 (18.2)</td>
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<tr>
<td>Total</td>
<td>164 (45.9)</td>
<td>193 (54.1)</td>
<td>357 (100)</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 – 25 years</td>
<td>7 (2.0)</td>
<td>19 (5.3)</td>
<td>26 (7.3)</td>
</tr>
<tr>
<td>26 – 30 years</td>
<td>23 (6.4)</td>
<td>22 (6.2)</td>
<td>45 (12.6)</td>
</tr>
<tr>
<td>31 – 35 years</td>
<td>39 (10.9)</td>
<td>41 (11.5)</td>
<td>80 (22.4)</td>
</tr>
<tr>
<td>36 – 40 years</td>
<td>33 (9.2)</td>
<td>38 (10.6)</td>
<td>71 (19.9)</td>
</tr>
<tr>
<td>41 – 45 years</td>
<td>26 (7.3)</td>
<td>24 (6.7)</td>
<td>50 (14.0)</td>
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<tr>
<td>46 – 50 years</td>
<td>19 (5.3)</td>
<td>21 (5.9)</td>
<td>40 (11.2)</td>
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<tr>
<td>51 years and above</td>
<td>17 (4.8)</td>
<td>28 (7.9)</td>
<td>45 (12.6)</td>
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<tr>
<td>Total</td>
<td>164 (45.9)</td>
<td>193 (54.1)</td>
<td>357 (100)</td>
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<td>Marital Status</td>
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<tr>
<td>Never married</td>
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<td>13 (3.6)</td>
<td>13 (3.6)</td>
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<tr>
<td>Married</td>
<td>102 (28.6)</td>
<td>75 (21.0)</td>
<td>177 (49.6)</td>
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<tr>
<td>Separated/divorced</td>
<td>38 (10.6)</td>
<td>68 (19.0)</td>
<td>106 (29.7)</td>
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<td>Widowed</td>
<td>24 (6.7)</td>
<td>37 (10.4)</td>
<td>61 (17.1)</td>
</tr>
<tr>
<td>Total</td>
<td>164 (45.9)</td>
<td>193 (54.1)</td>
<td>357 (100)</td>
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<td>Level of Education</td>
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<td>17 (4.8)</td>
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<tr>
<td>Finished Primary School</td>
<td>35 (9.8)</td>
<td>41 (11.5)</td>
<td>76 (21.3)</td>
</tr>
<tr>
<td>Finished Secondary School</td>
<td>68 (19.0)</td>
<td>86 (24.1)</td>
<td>154 (43.1)</td>
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<td>Post- Secondary Education</td>
<td>54 (15.1)</td>
<td>56 (15.7)</td>
<td>110 (30.8)</td>
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<tr>
<td>Total</td>
<td>164 (45.9)</td>
<td>193 (54.1)</td>
<td>357 (100)</td>
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<tr>
<td>Religious Affiliation</td>
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<td>Christian</td>
<td>114 (31.9)</td>
<td>166 (46.5)</td>
<td>280 (78.4)</td>
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<td>Muslim</td>
<td>31 (8.7)</td>
<td>15 (4.2)</td>
<td>46 (12.9)</td>
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<tr>
<td>Other</td>
<td>19 (5.3)</td>
<td>12 (3.4)</td>
<td>31 (8.7)</td>
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<td>Total</td>
<td>164 (45.9)</td>
<td>193 (54.1)</td>
<td>357 (100)</td>
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<tr>
<td>Occupation</td>
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</tr>
<tr>
<td>Permanent Employment</td>
<td>51 (14.3)</td>
<td>66 (18.5)</td>
<td>117 (32.8)</td>
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<tr>
<td>Casual Employment</td>
<td>44 (12.3)</td>
<td>55 (15.4)</td>
<td>99 (27.7)</td>
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<tr>
<td>Self- Employment</td>
<td>48 (13.4)</td>
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<td>81 (22.7)</td>
</tr>
<tr>
<td>Not Employed</td>
<td>21 (5.9)</td>
<td>39 (10.9)</td>
<td>59 (16.5)</td>
</tr>
<tr>
<td>Total</td>
<td>164 (45.9)</td>
<td>193 (54.1)</td>
<td>357 (100)</td>
</tr>
</tbody>
</table>

Awareness of Children’s Rights
Respondents were asked about their awareness of specific children’s rights. They were required to freely list the fundamental children’s rights that they were aware of. In the free listing, the right to food emerged as the most commonly known among the respondents. More than half (66.9%) of the subjects also identified the right to shelter as a fundamental right. However, less than half (42.6%) included the right to life in their list, as indicated in Figure 1.
The researcher then asked the subjects whether they were aware of the rights of children as per Kenyan law. More than half (mean of 62.5%) of the subjects were aware of the survival rights of the child, as opposed to less than one fifth (15.7%) who were not aware of them (Panel 1, Table 2). The study revealed that of all rights, the right to food, shelter and clothes was the most widely known. Fewer than half of the respondents were aware of development and protection rights (Panels 3 and 4, Table 2). Of the development rights, the right to education and a name were known to more than half the respondents (55.2% and 52.4% respectively). The study discovered that less than one fifth (17.6%) of the subjects were aware of the right of a child to play. Almost a half of them (48.5) were not sure if a child has such a right. Interestingly, slightly more than half of the subjects (51%) were not sure if a child has a right to parental love. Most of those who were not sure about the right to love felt that a parent has a duty to provide basic needs, and they did not see love as a child’s right. Nevertheless, it is instructive to note that for development and protection rights, most of the respondents were unsure of their existence. A mean of 42.3% and 43.1% were not sure about development and protection rights respectively. Only 18.5% (for development rights) and 16.2% (for protection rights) were not aware of these rights.

The study revealed that the least known of children’s rights are those that touch on participation. Less than one fifth (mean of 15.4%) of the subjects are aware of participation rights. More than half of the subjects (54.6) were not aware of any of the participation rights, with only 30% being unsure. Qualitative data revealed that most of the respondents, including those who were aware of participation rights, were of the opinion that children should not be entitled to these rights.
Table 2: Level of knowledge of rights (prompted responses)

<table>
<thead>
<tr>
<th>Category of Rights</th>
<th>Specific Rights</th>
<th>Level of Awareness of Rights</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Aware</td>
</tr>
<tr>
<td>Survival Rights</td>
<td>Right to life</td>
<td>180 (50.4)</td>
</tr>
<tr>
<td></td>
<td>Right to food, shelter and clothes</td>
<td>291 (81.5)</td>
</tr>
<tr>
<td></td>
<td>Right to healthcare</td>
<td>198 (55.5)</td>
</tr>
<tr>
<td></td>
<td><strong>Mean</strong></td>
<td><strong>223 (62.5)</strong></td>
</tr>
<tr>
<td>Development Rights</td>
<td>Right to Play and leisure</td>
<td>63 (17.6)</td>
</tr>
<tr>
<td></td>
<td>Right to education</td>
<td>197 (55.2)</td>
</tr>
<tr>
<td></td>
<td>Right to a name</td>
<td>187 (52.4)</td>
</tr>
<tr>
<td></td>
<td>Right to parental love</td>
<td>117 (32.8)</td>
</tr>
<tr>
<td></td>
<td><strong>Mean</strong></td>
<td><strong>141 (39.5)</strong></td>
</tr>
<tr>
<td>Protection Rights</td>
<td>Right to protection from child labour</td>
<td>193 (54.1)</td>
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<td></td>
<td>Right to protection from sexual</td>
<td>120 (33.6)</td>
</tr>
<tr>
<td></td>
<td>exploitation</td>
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<tr>
<td></td>
<td>Right to protection from abuse and</td>
<td>107 (30.0)</td>
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<tr>
<td></td>
<td>neglect</td>
<td></td>
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<tr>
<td></td>
<td>Right to protection for children with</td>
<td>160 (44.8)</td>
</tr>
<tr>
<td></td>
<td>disabilities</td>
<td></td>
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<tr>
<td></td>
<td><strong>Mean</strong></td>
<td><strong>145 (40.6)</strong></td>
</tr>
<tr>
<td>Participation Rights</td>
<td>Right to access information</td>
<td>81 (22.7)</td>
</tr>
<tr>
<td></td>
<td>Right of association</td>
<td>58 (16.2)</td>
</tr>
<tr>
<td></td>
<td>Right to freedom of thought</td>
<td>43 (12.0)</td>
</tr>
<tr>
<td></td>
<td>Right to express opinions</td>
<td>39 (10.9)</td>
</tr>
<tr>
<td></td>
<td>Right to have a say in own life</td>
<td>63 (17.6)</td>
</tr>
<tr>
<td></td>
<td>Right to the freedom to assemble</td>
<td>48 (13.4)</td>
</tr>
<tr>
<td></td>
<td>Right to participate in activities</td>
<td>52 (14.6)</td>
</tr>
<tr>
<td></td>
<td><strong>Mean</strong></td>
<td><strong>55 (15.4)</strong></td>
</tr>
<tr>
<td>Total Mean</td>
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<td><strong>125 (35.0)</strong></td>
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</table>

Cross Tabulation of Socio-Demographic Characteristics and Level of Awareness of Children’s Rights

The study sought to establish the relationship, if any, between socio-demographic characteristics and awareness of children’s rights. The chi square test was applied to determine whether there was any significant association between specific socio-demographic categorical variables (sex, marital status, religious affiliation and occupation) and the level of knowledge of children’s rights. The test was selected because it does not require equality of variances among the groups under study. In addition, it permits evaluation of both groups and multiple group variables, and its calculations provide data on how each of the groups under study performed (McHugh, 2013). However, the chi square is a test of significance, which does not give the strength of the association. In case the Chi Square test yields a result that indicates a significant association, it is recommended to apply the Cramer’s V...
test, which is a correlation measure (McHugh, 2013). However, the Cramer’s V Test value of 0.1815 suggests that while there is a significant relationship, the association between marital status and healthcare seeking behaviour is not very strong. The gamma statistical tool was also applied to determine the association between specific continuous variables (age and level of education) and level of knowledge. The gamma was selected because it can also be tested for significance.

The chi square test revealed that there was no significant relationship between sex, age, religious affiliation and occupation on the one hand, and the level of knowledge of children’s right (panels 1, 5 and 6, Table 3). The test however showed a significant relationship between marital status and the level of knowledge ($X^2=18.8467, \ df =6, \ P = 0.05$). Nevertheless, the Cramer’s V Test shows that the association, though positive and significant, is weak (panel 3, Table 3). The gamma test found that age, and the level of educational attainment, had a strong and positive influence on the level of knowledge of children’s rights (panels 2 and 4, Table 3).

### Table 3: Cross tabulation of socio-demographic characteristics and level of knowledge

<table>
<thead>
<tr>
<th>Socio-Demographic Characteristics</th>
<th>Level of Awareness</th>
<th>Not Aware</th>
<th>Not Sure</th>
<th>Aware</th>
<th>11th Egerton University International Conference and Innovation Week</th>
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</thead>
<tbody>
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<td></td>
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<td>61</td>
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<tr>
<td><strong>Sex</strong></td>
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<td>Male</td>
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<td>Female</td>
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<td>Female</td>
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<td>Total</td>
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<td><strong>Age</strong></td>
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<td>18 – 25 years</td>
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<td>Separated/divorced</td>
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<td>Widowed</td>
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<td>Total</td>
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<td><strong>Level of Education</strong></td>
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<tr>
<td>Post -Secondary Education</td>
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<td>Total</td>
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</table>

Table: Cross tabulation of socio-demographic characteristics and level of knowledge

<table>
<thead>
<tr>
<th>Socio-Demographic Characteristics</th>
<th>Level of Awareness</th>
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Table: Cross tabulation of socio-demographic characteristics and level of knowledge

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Source of Knowledge about Children’s Rights
Study participants were asked how they came to learn about children’s rights. It was established that most of them relied on religious books (bible and Quran) as the source of information regarding how to treat children. Slightly more than half also cited cultural beliefs and traditions as there guide in understanding children’s rights. Less than half of the respondents had known about children’s rights through mass media. It is instructive that most of the information obtained from the media was from news items about the violations committed against children. Only approximately one third cited attendance of workshops, seminars and reading of literature as there sources of knowledge on children’s rights. An even smaller number got to know about children’s rights in school.

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<td>Cultural Beliefs and Practices</td>
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<td>Pamphlets, Billboards, Flyers</td>
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![Figure 2: Respondents sources of knowledge about children's rights](image)

DISCUSSION
This study revealed that overall, less than half of the respondents are aware of children’s rights. This is an indication that the level of knowledge on children’s rights is very low in the study area. It is instructive that in the free listing, where respondents were required to mention off-head the rights known to them, some fundamental rights did not feature prominently. These include the right to life and to parental love. In the free list, while the right to basic needs was well known to most of the respondents, none of them mentioned the participation rights. This could be explained by the fact that most of them rely on religious books and cultural beliefs and practices as the source of information about children’s rights. This is an indication that information regarding children’s rights has not been adequately disseminated in the study area.

The study also found that age, and the level of educational attainment, influenced the level of awareness of children’s rights. The influence of age could be due to changes in the education curriculum, which nowadays incorporates some studies on human rights in general. The older generation, who went through earlier curricular, might not have had an opportunity to study children’s rights. Further, the younger generation might be benefiting from alternative media, which has a lot of information about children’s rights, and violations of the same. The influence of the level of educational attainment is due to the fact that education empowers one to read, and thus gain access to information. In addition, topics covering human rights in general, and children’s rights in particular, are usually covered in greater detail in the advanced stages of the Kenyan educational system. Thus, people who reach higher levels of study are more likely to have a better understanding of human rights than those who don’t.

CONCLUSIONS AND RECOMMENDATIONS
Based on the findings of this study, the following conclusions were made:
1. The level of knowledge of children’s rights in the study area is low.
2. Age and the level of educational attainment influence the level of knowledge on children’s rights.
3. The main sources of knowledge about children’s rights are religious and cultural beliefs.

RECOMMENDATIONS

The study makes the following recommendations:

1. Relevant government agencies, including the children’s department and the judiciary, should make greater efforts to disseminate the contents of the Children’s Act and other legal instruments that have been enacted to protect children’s rights. These contents should be simplified for easier understanding.

2. The ministry of education, and universities, ought to review the curriculum, with a view to integrating children’s rights as a learning subject.

REFERENCES


ABSTRACT

Alternative family care for children counters significant gaps in realizing the best interests of children with a range of suitable alternative care options. It necessitates the desire to support children to remain with, and be cared for in a family environment whenever exposed to circumstances of vulnerabilities. During such situations, significant others and relatives to the child’s initiatives provide home and family through alternative family care arrangements to children. This study demonstrates the importance of formalized alternative family care in the best interests of children for improved social development. The scope of the study focused on children’s alternative family care literature analysis, providing an overview of the current situation and illustrating promising practices, opportunities and challenges of alternative family care in Kenya. The methodology involved desk review of available literature on alternative family care for children and consulting experts in the child protection sector while making an overview of the existing situation. Interpretative techniques of coding and recursive abstraction were used to analyze data. The results indicates that formalized alternative family care for children binds care givers and provides a sense of care control and ownership for quality care provision to children. Further, the results indicate that formalized alternative family care arrangements for children provide security both to the child and the care giver thereby minimising chances of abuse and exploitation. The study concludes by appreciating the initiative and recommends formalizing all alternative care practices to care givers for improved social development.

Keywords: Alternative family care; Children in need of care and protection; Best interest of the child

INTRODUCTION AND BACKGROUND INFORMATION

Globally, alternative care for children is a reaction to significant gaps in realizing the best interests of the child. The heart of this care exists, necessity and the desire to support children to remain with, and be cared for within the family structures whereas its appropriateness comprises a range of suitable alternative care options with specific requirements for circumstances surrounding the child’s family environment (Long, 2007). African children continue to bear brunt situations due to poverty, HIV/AIDS epidemic, and livelihood insecurities.

The chronic poverty, emergencies, community violence, HIV/AIDS, discrimination and the lack of sufficient investment in and access to social protection and basic services all place multiple stresses on families and, in particular, on poor and marginalized families in Kenya. This results to strain on traditional community values and structures culminating to breakup of family care thereby exposing gaps in the nuclear family arrangements.

Consequently, families become incapacitated to provide the required urgent quality care and protection to the ever increasing number of children through appropriate alternatives for vulnerable children and those without parental care.

In Kenya, the number of children who are vulnerable to separation or who are in alternative care arrangements is difficult to quantify; estimations indicate that 2.4 million children are orphaned, however, orphanhood is not the only factor that makes children vulnerable in Kenya. The Kenya Demographic Health Survey (2014) estimates that only 55% of children aged 0-17 years live with both their biological parents, however, orphanhood is not the only factor that makes children vulnerable in Kenya. The Kenya Demographic Health Survey (2014) estimates that only 55% of children aged 0-17 years live with both their biological parents while a significant number of children live in alternative care arrangements. Notably, a common trend in Kenyan rural communities is that many children are sent to live with extended family members to better their access to basic services (such as education and health care), to alleviate pressure on families experiencing economic hardships or to increase their opportunities in life which is often in reasoning to serve the best interests of those children though casually carried out.
In its traditional sense, family is a nurturing and caring environment and is the ideal place in which to raise a child. Growing up in a family helps children to develop a sense of self-esteem, belonging, family values, and religious and cultural identity (Browne 2009). Due to the nature of family care, children learn to interact better with the community and are better equipped to face life challenges. Alternative family care for children thus is often a community phenomenon that is reluctantly practiced by families in circumstances when keeping children in their own families is not possible. Its appropriateness requires formalized arrangements for children without parental care for realization of the best interests of children which objectively secures effective realization of all child rights and the child’s overall development through expanding opportunities to reach their full potential. This study sought to demonstrate the prominence of formalized alternative family care in the best interests of children for improved social development in Kenya.

METHODOLOGY

A mixed methods approach informed the content of this paper which entailed a desk review methodology, where in information was collected through a systematic review of the available documents relevant to alternative family care arrangements in Kenya. The information gleaned from literature review was complimented by focus group discussions with the senior management staff at the DCS (what does DCS stand for?) headquarters and officers overseeing alternative care responsibilities.

The study procedure in the first stage involved developing a desk review methodology framework to address the desk review questions generated from the study objective. In the second stage, guiding questions aided the focus group discussions with the senior management staff and officers overseeing alternative care responsibilities at DCS on formalized alternative family care arrangements. Interpretative technique of recursive abstraction was used to analyse the reviewed literature while the focus group discussions were recorded, transcribed and emerging themes generated and aligned to the reviewed literature review to inform the best practices.

Constraints and Limitations

The process necessary to achieve this paper was considered challenging but a worthwhile undertaking, especially in terms of the need for child protection. The bulk of the information used for this paper was based on the secondary sources, namely reports and documents provided for the literature review – although it was not possible to verify the quality and accuracy of the information provided in them. The majority of the material had either a global or regional perspective, which means that country-specific examples were limited. Despite these limitations, this paper is seen as an important contribution to the body of literature on family support services and alternative care for children.

RESULTS AND DISCUSSIONS

This paper presents a snapshot of the nature and levels of interventions for alternative family care in Kenya. The results identified five key thematic areas for alternative family care arrangement for children in Kenya. Results include both legislative arrangements and service oriented practices presenting an overview of the current situation and illustrates promising practices, opportunities and challenges of alternative family care in Kenya. The results are in the key thematic areas which were derived from the themes and patterns which emerged from both literature review and focus groups. Virtually, results reveal that all elements across identified indicators for child protection indicated some arrangements for alternative family care for children.

Legal and Policy Framework

The results reveal that the the legal and institutional framework for child care and support system for all children including children in the alternative family care in Kenya is relatively strong. This is because Kenya has domesticated the UNCRC, the African Charter on the Rights and Welfare of the Child and implements the United Nations Guidelines for alternative care of children 2010. The Constitution also provides a strong basis for children’s rights through a progressive bill of rights. Various legislation and policies including the Children Act 2001 are being reviewed to to be harmonised with the Constitution to ensure that their provisions are in line with the Constitutional provisions. The results reveal that harmonization of policies has been an ongoing activity and the Government has been able to document the guidelines for alternative family care for children in Kenya. The document is a milestone in the alternative family for children since it spells out the basic requirements in alternative care for children. Notably, the paper recognizes the key role National council for
children services play, however it points to the need to strengthen its role in coordinating children issues.

Nature of Alternative Family Care

The study reveals that informal alternative family care for children is commonly practiced in Kenya. Guidelines for the alternative family care in Kenya (2014) stipulates that all alternative family care arrangements need to be formalised even at the local administration offices for control and best interest of children. However, this paper reveals dismal effort in ensuring this. This demands a concerted effort for informal alternative care givers listing to ascertain the number of children in such settings. This is because lack of records may lead to discrimination of children in terms of government support and monitoring of their welfare. The decision to place children in informal care arrangements is made by the care giver and the community, and without proper awareness, there is the risk that the placement of children into this care may not be in the best interests of the child. Formal alternative family care on the other hand has been advocated in Kenya for a long period of time and awareness campaigns by both state actors and non-state actors emphasized adoption, guardianship and foster care. The results reveal that registered guardianship is on the rise in the Kenya and awareness creation on registration will go a long way towards realizing the best interests of children. Further, the study points that limited information is available on foster care in the country which needs to be addressed to enhance child protection. The reviewed literature had scanty information on adoption of children, a point which was noted in the focus discussions that pointed at the high cost and long procedures involved. The study also reveals low monitoring of fostered and adopted children to ensure quality service provision to children in such arrangements.

Preventative Services

The Government of Kenya has undertaken substantial initiatives towards family strengthening programmes. The social assistance unit coordinates implementation of all the four cash transfer programmes aimed at strengthening household’s economic capacity. Cash transfer programmes for orphans and vulnerable children and that for older persons are enjoined with a complimentary service of hospital insurance scheme where beneficiaries in these programmes benefit. The study reveals that strengthened households are capable of managing the socio-economic shocks. This will allow them retain children at family levels. However, there is the risk that the support package may lead to continuing dependency on this support for livelihood (Rutter & Evans 2011). The reviewed complaints on the cash transfers implementation revealed the public urge to be registered in the program notwithstanding the prevalent complaints on missuse of funds from the program. The study also reveals reports of wrong motives of caregivers in the alternative family care arrangement. Discussions from the focus groups indicated that care givers may register in the social assistance program so as to get money which never benefit children hence the question- why money? Such motives were noted in the focus groups to be non-beneficial to the child and may bring conflict which may deter social development in the community.

Placement and Review Procedures

The State has set a national policy on the admission, placement and review of children placements in the alternative family arrangements. Notably monitoring such arrangements requires a committed effort for effective monitoring and supervision. The study noted however lack of effective supervision of children in alternative family care arrangements. It further points to lack of up to date data on placements of children in the charitable children institutions which pose risks to abuse. The study however reveals that the Department of children services is rolling out child protection information management system which if properly utilized will enhance child protection. The reviewed literature missed out guaranteed assessment processes that identify and seek to address root causes for the unnecessary separation of children, such as discrimination, poverty, or disability; hence, children may be unnecessarily separated without these considerations.

The results revealed availability of a range of care options in Kenya. It notes that a number of state and non-state actors play a crucial role in the care and protection of children during difficult circumstances. The children officers, volunteer children officers, NGOs and CBOs provide care and facilitate both reintegration and re-unification of children during such situations. However, the care of children with special needs category are often less attended to due to lack of specialised care. The Children Act does not oblige care providers to ensure individualised care solutions that promote stability and permanence in planning care, through reunification with the family, or the continued provision of alternative care, implying that care plans may not be adequately tailored to the need of the child.
Leaving Alternative Family Care Arrangement
The results reveal that some care givers provide quality care to children while others expose children to abuse. Quite often some children are unable to survive the harsh environments in such alternative care arrangements and they run away from such care. The focus groups also revealed that some families who had bad motives in alternative care arrangements dump or rather chase away children after misusing the property they ought to benefit from. Conflicts arising from such practices may not only demoralise the child but completely interfere with the child’s wellbeing (Rees & Selwyn 2009). This is reported to be rare in the formalised alternative care arrangements since it is considered binding. The results indicate that in some care centres, during the period of exit from care centres, they provide comprehensive covers like vocational training, life skills and start up kits and psycho-social support. In some alternative care centres the living care arrangements are not planned early enough and children living care are faced with the challenge of being self-reliant from one day to another. The study revealed that limited data was available on the situation of children after care exposing a gap in follow-up and inspections of children in alternative family care and even after care in the alternative family arrangement.

CONCLUSION
The paper concludes by noting that the legal framework for child protection in Kenya embraces both global and regional requirements and at the same time the Country has put in place policies and standards to uphold their implementation. The study however revealed inconsistencies in implementation but recognized the relevance and importance of formalized alternative family care for best interests of children.

RECOMMENDATIONS
The paper recommends the following for realization of the best interests of children in the formalized alternative family care practice;

- Record keeping for children in alternative care should be mandatory. Alternative care providers should be required to submit updated records to the Director of Children’s Services on a periodic basis.
- Community sensitisation on formalized alternative family care for children need to be increased in order to increase levels of community participation in the process.
- Analysis is required on informal care givers who are not biological parents of the children. This would identify grandmothers or other care givers to enable the State to understand their needs and include them in the social protection and safety net programmes.
- Disaggregated data on this informal care arrangement should be compiled on a regular basis and a report should be submitted to the national office for a central data base on children in this form of care.
- There is the need to develop initiatives towards promoting, fostering, training and providing social support to foster parents and developing a data base of accredited foster care centres that can be reached if required.

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SOCIAL PROTECTION TARGETING APPROACH FOR CUSHIONING STREET CHILDREN IN KENYA

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ABSTRACT

Risk and quest for opportunity among households feature heavily in socio-economic life in the 21st century. Globally, the importance of having a well-functioning social protection scheme has proven to reduce poverty and inequality through programs that help cushion the impact of crises on children’s wellbeing. Just like in many third world countries, Kenya embraced the household targeting approach proposing that state provided benefits depending on individuals’ circumstances. The approach consequently targets households with a focus to orphans and vulnerable children. Nevertheless, the critical group of children in the streets does not fit into the countries’ targeting criteria for social protection’s intervention. This is despite the fact that most street children in Kenya are from poverty stricken families and are exposed to such circumstances due to breakdown of traditional family and community structures. Poverty and its associated pressures explicitly expose children to risks, making them become less able to access opportunities that social protection schemes are being built, refined and reformed to address. This paper examined social protection targeting approach to the street children’s risk in Kenya. Specifically, the study looked at the design of cash transfer to OVCs (define OVCs) to find out possible approaches for incorporating the street children. The study adopted desk research combined with interpretive descriptive approach. The available documents on targeted social protection schemes in Kenya were reviewed and the interpretive descriptive approach helped probe deeper into interpretations, seeking to discover associations, relationships and patterns. The experts in social protection were consulted and relational content methodology used to analyze gathered information. The study revealed that targeted social protection programs led to reduction in the likelihood of sexual activities among young people, improved psychosocial status, increased school enrolment, reduced depression, facilitated labour force participation and increased social capital thereby contributing significantly to improved child wellbeing in Kenya. The paper recommends tailoring the social protection targeted approaches for mitigating the street children renaissance in Kenyan towns.

Keywords: Social protection; Targeting; Street children

INTRODUCTION

Children worldwide are exposed to risks resulting from vulnerabilities affecting realization of their full potential in life. In recent years, countries have resorted to embracing social protection schemes for improved wellbeing of children. The social protection schemes are aimed at supplementing household livelihoods, thereby reducing poverty and inequality for enhanced child wellbeing through cash transfer to households and its complimentary services. Kenya’s social assistance scheme, just like social security schemes in many third world countries is based on household targeting approach, proposing that state provided benefits differ depending on individuals’ circumstances and livelihood status. The social protection targeting approach for cash transfers in Kenya is premised on certain outlined eligibility criteria. It focuses on households as the entry point, targeting the ultra-poor, labour-constrained, and or caring for orphans and vulnerable children. It seeks to improve food security and health, and nutritional and educational status, particularly of children with aim of improving the overall wellbeing of children in the household.

Indeed, the undesirable wellbeing of street children in Kenya is associated with the effects of macro-level causes that push children onto the streets which includes, poverty and economic need, the societal dysfunctions, rural -urban migration, and loss of parents. On the other hand, micro-level causes, which are predominantly concerned with internal family dynamics (Taylor et al. 2013) and other pull factors drawing from social networks, sense of freedom and
excitement, exceedingly contributes to vulnerability among this fragile group of children in the streets.

Nevertheless, this vulnerable group of children in the Kenyan streets barely fit into the countries’ targeting eligibility criteria for cash transfer for orphans and vulnerable children and its complimentary programs. This is notwithstanding the fact that most street children in Kenya are from poverty stricken families and are exposed to such circumstances due to breakdown of traditional family and community structures for support. Poverty and its associated pressures to children explicitly expose children to risks, making them become less able to access opportunities which social protection schemes are being built, refined and reformed to address. This paper aims at examining social protection household targeting approach to the street children’s menace in Kenya. Specifically, the paper looked at the design of social protection Programme in Kenya to find out possible integrated approaches for incorporating the street children in the cash transfer programmes for improved wellbeing of children.

METHODOLOGY

The study adopted desk research combined with interpretive descriptive approach. The available literature documents on targeted social protection schemes approach and its complimentary programs in Kenya were reviewed. The interpretive descriptive approach helped probe deeper into interpretations, seeking to discover associations, relationships and patterns rather than simply describing the phenomena. The experts in social protection programs were also consulted and relational content methodology was used to analyze the gathered information.

RESULTS AND DISCUSSION

Household Targeting Approach in Kenya

The paper reveals that targeting is often used as a process of identifying the poor households for social assistance programmes in Kenya. In the context of national social protection policy and the operational frameworks of cash transfer for orphans and vulnerable children in Kenya, targeting comprises stages as the country builds a comprehensive social protection system. The stages include: government’s decision on the social issue to tackle; allocation of sufficient resources to address the issue effectively; design the actual mechanism for identifying recipients; and the actual process of implementing the selection mechanism, through registration. Poor quality implementation can result in a range of errors. However, the more complex the selection mechanism, the more likely that errors will happen during implementation. Therefore, the decision of considering street children in the eligibility criteria in the social assistance programme would still follow the stages outlined. It would only require designing an approach of implementation that would best contribute towards improving the wellbeing of children in the streets.

Social Cash Transfer Programmes on Community Dynamics

The results revealed that CT-OVC has had a broad range of positive impacts on beneficiary households, including poverty reduction, increase in food consumption and dietary diversity, improvement in schooling and health care utilization, and strengthening of the local economy. The literature indicates that the CT-OVC programme had positive impacts on the livelihoods of beneficiaries and their communities in rural Kenya, particularly for female headed and smaller households. The literature presented evidence of a positive impact of the programme on the quality of food consumption. The programme had a significant impact on the accumulation of some productive assets, especially among some subgroups within beneficiaries. The programme influenced the flexibility of beneficiary households and individuals in terms of the type of income generating activities in which they participate, most of which involve casual labour. For those individuals (particularly women) that lived far from markets, the receipt of the transfer helped facilitate engagement in casual wage labour activities. The CT-OVC programme increased social capital and strengthened informal safety nets and risk sharing arrangements. In addition, for even the poorest households, transfers contributed to increased self-esteem and increased ability to engage in community and religious activities. These positive effects on trust-based reciprocity within communities may be undermined due to jealousy of similarly poor non-beneficiary households and perceived targeting errors. When beneficiaries spend the cash transfer they transmit the impact to others inside and outside the local economy, more often to households not eligible for the cash transfer, who tend to own most of the local businesses.

The results therefore indicate that the CT-OVC programme impacts the livelihoods of beneficiary and non-beneficiary households alike, leading to a number of policy implications. Cash transfers can be more than
just social assistance – not only can they help vulnerable households avoid the worst effects of severe deprivation, they can also contribute to economic and social development. Since cash transfer programmes impact the livelihoods of beneficiary households, alignment with other sectoral development programmes in a coordinated rural development strategy could lead to synergies and greater overall impact. The programme’s impact is credible and if tailored in consideration of street children meeting its eligibility criteria would result to improved wellbeing of children.

**Impact on Labour Supply**

The literature on labour supply is modelled as an individual decision through a series of household and context variables as this decision takes place within the decision making process of the household and within a given economic context. The two main types of labour supply: wage labour, and labour on own farm were taken into consideration pointing to the influences on livelihood of children wellbeing in these programs. This indicated that: the programme has a significant impact on the accumulation of productive assets which reflects hard work; there is a positive effect on hired labour for crop weeding, and the programme is associated with an increase in female headed household participation in nonfarm enterprises; there is robust evidence of an indirect impact of the programme on agricultural production; and the programme has a variety of impacts on labour supply, varying by gender and by type of labour. Overall, grouping all types of labour and for all adults, indicates no significant impact of the programme on participation in wage or own farm labour. The programme facilitates labour force participation for those living farther from markets. In addition, the programme is associated with a generally positive impact on participation in non-agricultural wage labour (particularly for males), compared to generally negative impact on participation in agricultural wage and own farm labour.

**Schooling and Health**

The data revealed that the programme has positive impact on school enrolment for older children. Children residing in beneficiary households were more likely to be enrolled in school. Moreover, most children had half year more of grade completion and were less likely to drop out of school. The CT-OVC has significant impact on young children and it led to improved health of young children since the parents participated in most programmes since they were easily coordinated to participate in programmes.

The literature and discussions also indicated that the social welfare program reduces the relative odds of sexual activities among young people ages 15–25, with larger impacts among females (42%) relative to males (26%). This implies a reduction in the likelihood of sexual activities among the females and males. These results are particularly promising for HIV prevention because of their potential generalizability to other large-scale national programs and because they demonstrate that a poverty-focused social protection program can have positive spillover effects on one important HIV related outcome.

Understanding the mechanisms through which cash transfer programs work to reduce HIV risk is important to ensuring programs can be tailored to achieve maximum impacts. Potential mechanisms for cash transfer program to reduce risk include reducing financial barriers to schooling, thus increasing school attendance and thereby reducing HIV risk. It has also been hypothesized that alleviating poverty may reduce the need for young people to engage in transactional sex which may reduce the risk of HIV. For young women in particular, cash transfer programs may reduce their dependence on male partners, potentially reducing unwanted sexual relationships or unprotected sex acts. The results reveal that it is also possible that lifting homes out of severe poverty improves mental health and increases hope for the future, which may also have protective effects on HIV risk behaviors.

The findings suggest that during the programme’s implementation period, the programme boosted the life chances of OVC by facilitating their safe and healthy transition into adulthood. The programme also had an impact on improving the mental health of young people. The literature reveals that youths, particularly 15 to 24 year old from beneficiary households, in comparison with those from non beneficiary households were less likely to suffer from depression and more likely to score above the median on the hope of scale, an indicator of agency and self-efficacy. In addition, the programme led to a more positive view of the future for young people living in beneficiary households.

The literature and consultations revealed that young women aged 12 to 24 in beneficiary households were less likely to have ever been pregnant relative to their counterparts in non Programme households. This occurred because young women in beneficiary
households had higher school attainment. This effect was much stronger among young women who had been living in programme households for longer periods. Therefore, the findings indicate that cash transfer programmes have impacts beyond their immediate objectives in Kenya. The delayed sexual activities, reduced risky sexual behaviour and vulnerability, delayed first pregnancy and improved psychosocial status among young people were additional to the primary objectives of the Programme. This amounts to social development spillovers which could benefit critical categories of children in Kenya.

CONCLUSION

The results indicate that targeted social protection approach in Kenya enjoys massive government and stakeholders support. The decisions surrounding its inception, implementation design and operations are aimed at improving the welfare of children through households as the entry points. The cash transfer programs in Kenya are intended to strengthen the households thereby alleviating poverty but has exhibited spillover effects towards improving the wellbeing of children. Its achievements over the implementation period has resulted to reduction in the likelihood of sexual debut among young people age 15–25; improved psychosocial status among young people; increased school enrolment; reduced depression among children; facilitates labour force participation; and increased social capital and strengthened informal safety nets and risk sharing arrangements. Such significant contributions of the programme with better implementation strategies can greatly address the welfare of children in the streets in Kenya.

RECOMMENDATIONS

The paper recommends the following for realization of the best interests of children through targeted social protection approach to street children in Kenya;

- The state Department of Social Protection and stakeholders should tailor the social protection targeted programmes to mitigating the street children menace in Kenyan towns.
- Indicators for street children should be considered in the social protection programme with emphasis on the programmes eligibility criteria.
- The entry point for the Social protection programme implementation for the street children should target households for easy reintegration of children from the streets.

REFERENCES


THE INFLUENCE OF SOCIAL-CULTURAL FACTORS ON CROP FARMING AMONG PASTORALIST COMMUNITIES WITH A FOCUS ON SWEET POTATO PRODUCTION IN SAMBURU COUNTY, KENYA

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ABSTRACT

Despite the benefits associated with crop production, access to communal land for production purposes among the pastoralists community is based on complex social-cultural, historical norms and conditions that historically have maintained flexible access to resources across space and time. The prevailing socio-cultural practices have the power to influence adoption of agricultural technology. Sweet potato is one of the world’s highest yielding crops in terms of production per unit area, exceeding that of major cereals like rice. The roots and leaves of sweet potatoes are consumed while its vines are used as animal feed in many parts of the world, yet it remains a survival crop which people eat only when they are on the verge of starvation. In Kenya production and utilization has increased with the acreage under sweet potato rapidly rising in recent years. Samburu County has a population growth rate of 4.45 percent per annum, poverty level of 73 percent and population density of 12 persons per square kilometers. In the County traditional beliefs, negative attitudes towards crop production, strong cultural systems, harsh climatic conditions and insecurity have contributed to low levels of community development, especially sweet potato production in agriculturally potential areas. This is evidenced by the fact that the World Vision, Kenya introduced 7,800 sweet potato vines in Porro and Maralal wards, Samburu Central Sub-County in 2010 and 2011 to six women and youth groups of agro-pastoralists to bulk and distribute so as to enhance food security at household level. Despite sweet potato’s ability to tolerate marginal growing conditions such as dry spells and requiring less labour than other staples, its production among the agro-pastoralists has been low at an average of 0.025 acres. This paper provides a theoretical perspective on the influence of social cultural factors on integration of crop farming in pastoral communities.

Kewords: Socio-Culture, Factors, Sweet Potato Production, Agro-pastoralists, Samburu Central Sub-County.

INTRODUCTION

Sweet potato is one of the world’s most important food crops and the amount produced is similar to or slightly higher than that of cassava. Sweet potato is cultivated in farms in the tropical and sub-tropical to temperate zones of the Far East and United State of America (U.S.A), making it world’s number one tuber crop (Dergas, 2007). It provides more edible energy per hectare than wheat, rice or cassava. The crop requires fewer inputs and less labour than other staple crops. It tolerates marginal growing conditions such as dry spells and poor soils. Sweet potato is ranked seventh as world food crop and is likely to increase in importance in future due to its cultivation by farmers who are facing chronic food shortage due to unreliable weather and falling purchasing power (Ngoda, 2006). The crop has an annual production of more than 100 million metric tons ranking thirteenth globally in production value among agricultural commodities (Collins, 1995; Ngoda, 2006).

Value of Sweet Potato in Food Security and Health
Sweet potato is cultivated primarily for the enlarged edible storage roots which provide high amounts of starch to staple diets which can be eaten either boiled or roasted alone or with other foods such as milk, porridge, soups or meat and blended with wheat flour to make wheat products (Department of Agriculture, Samburu County, 2014). Sweet potato, especially the Orange-fleshed varieties, is rich in vitamin A (Scott, Rosegrant & Ringler, 2000). A comparison with other food crops shows that sweet potato variety SPK 004, yields more calories per unit area than maize and cassava. Its protein yield is much higher than that of cassava.

Sweet potato is an important food crop in Sub-Saharan Africa, outranking cassava and maize. It is widely grown throughout East Africa on a small scale, mainly for subsistence purposes. It is currently gaining
popularity along with other High Value Traditional Crops (HVTC). However, despite of its potential, sweet potato has remained largely untapped in Sub-Saharan Africa, where the average yield has remained 10 times lower among small scale farmers than that seen among commercial growers. This is because commercial growers have access to irrigation, fertilizers, and credit (Bill & Melinda, 1999). In Rwanda, the nutritional values of the orange-fleshed sweet potato have attracted non-governmental organizations working with people living with Acquired Immunodeficiency Syndrome (AIDS) that urge their clients to grow and consume them (Kimenye, 2008). According to National Food and Nutrition Security Policy (2012) improvement of nutrition will reduce occurrences and severity of infectious disease with specific action on HIV and AIDS affected families. Uganda, which is the second largest producer of sweet potato in the world after China, continues to feed her children on sweet potatoes for breakfast as school snack and chips (Kimenye, 2008).

According to Hagenimana, Low, Anyango, Kurz, Gichuki & Kabira (2001), sweet potato is an important staple crop in Kenya. Its production and utilization in Kenya has been on the rise, with the acreage under sweet potato rapidly increasing in recent years. Sweet potato provides essential nutrients, including carbohydrates, proteins, minerals, and vitamins (Stathers, Namanda, Mwanga, Khisa & Kapina, 2005). Its edible root tubers are chipped, dried and milled into flour. It is then used to prepare snacks and special recipe for weaning young babies. Orange fleshed /yellow varieties not only contain high calorific value but are also rich in proteins and minerals (calcium and iron) and vitamins (riboflavin and thiamine). They also contain high levels of β-carotene, which is a precursor for Vitamin A (Nxumalo, 1998; Kamau, 2004). Research shows that sweet potatoes contain more starch than the Irish potatoes. Its starch has properties that are useful in many food products and manufacturing processes (Huntrods, 2009). For this reason, it is used to produce industrial starch, natural colorants, fermented products, ethanol, lactic acid, acetone and butanol (Duvernaya, Chinna, & Yencho, 2013). However there is a different perception about sweet potatoes among the communities in Kenya. Sweet potato is considered as a poor man’s food mainly used by resource limited households (Scott et al., 2000).

Social-Cultural Factors in Relation to Production of Sweet Potatoes among Pastoralist Communities

According to Vanclay (2004), adoption of practices that take place in a social context such as farming is not a technical activity, but a social-cultural practice, which becomes a way of life. Traditional beliefs, negative attitudes towards production, strong cultural systems, harsh climatic conditions and the worsening insecurity have largely contributed to low levels of community development, especially sweet potato production in insecure zones, which are agriculturally potential areas (World Vision Report, 2014). Despite the benefits associated with crop production, access to communal land for production purposes among the pastoralists community is based on complex social, cultural, and historical norms and conditions that historically have maintained flexible access to resources across space and time (Burn silver, Boone & Galvin 2003).

Empirical studies that have attempted to test the relationship of key variables to adoption behavior among farmers from different socio-economic backgrounds have yielded mixed results. Vernooij, Shrestha, Ceccarelli, Labrada, Song & Humphries (2009) identified and categorized factors influencing adoption of new agricultural technologies into farm and farmer associated attributes, technology associated attributes and the farming objective. Studies have shown that the prevailing socio-cultural practices have the power to influence adoption of agricultural technology. Bebe & Magembe, (2012) reported that influence from the neighborhood significantly and negatively affected the extent of shift from pastoral to agro-pastoral farming systems. The study revealed that as farmers interacted more with their neighbours, the probability of allocating more land for crop production declined by 12.7 percent. So, depending on who forms the neighborhood, farmers could decide to allocate more or less land towards sweet production. Langyintuo & Mulugetta (2005) argued that as farmers interact more with their neighbours and outside world, they become more able to assess the relevance of new technologies and ideas thus they exercise a choice.

Munshi &Myaux (2006) revealed that social norms are relevant for technologies where individual adoption decisions generate costs and benefits from both the profitability of the technology and the possibility of social sanction. Diale (2011) and Mazuze (2004) also agree that cultural influences are factors that affect adoption of technology. Nkurumwa (2009) found that social and cultural factors are a major concern to
adoption of agro-pastoralism among the Maasai people. Livestock is tightly intertwined in the Maasai economy and social structure, religion and relationships; which is almost similar with the Samburu pastoralists. The young Samburu men cannot tolerate being seen by young women and girls tilling land for crop production, instead of looking after livestock, despite the prolonged drought and frequent cattle rustling.

Bandiera & Rasul (2006) used a random sample of household heads from several villages in Mozambique and found that kinship is very significant to adoption of new technology. They also revealed that herding effects may be more complex than once thought. These results support the strength of ties position, which argues that more socially significant ties will be more influential in behavioral choice. When many people have adopted an innovation, the remaining farmers strategically delay to reduce uncertainty. Magembe, Bebe, Laga & Chelang’a (2013) in a study that compared the socio-economic factors associated with shift from pastoral to agro-pastoral farming systems in Trans-Mara West Sub-County found that some households shifted to agro-pastoralism out of necessity, whereas others shifted by choice. For some of the households, the shift was a means to reduce risk, while for others it was a reflection of changing cultural, dietary habits and social norms. But for Samburu community members they commonly produce and utilize maize and beans compared to sweet potatoes as observed in 4000 hectares and 3200 hectares under food crops (maize, beans) and cash crops (wheat, barley) respectively (DoASC, 2014).

**Production Potential for Sweet Potatoes in Samburu County**

Samburu County agricultural department is planning to promote drought resistant food crops e.g. sorghum, sweet potatoes, cow peas, green grams and local vegetables through capacity building of community members on adoption of crop production, especially sweet potato as alternative livelihood to pastoralism(Samburu County Intergraded Development Plan (SCIDP, 2013). The ability of sweet potato to establish ground cover very fast enables suppression of weeds such as striga, control of soil erosion and maintenance of soil fertility; hence it is an attractive crop for farming system (Kimenye, 2008). Sweet potato production will benefit the agro-pastoralists, fight persistent hunger and improve the source of income if its promotion is enhanced, as drought tolerant crop SCIDP (2013). The crop’s ability to yield under adverse climatic and poor soil conditions as well as under low or non-use of external inputs and adaptability to a wide ecological range makes it a suitable crop for resource limited households (Walker, 2000). Due to rampant animal diseases, persistent drought, frequent cattle rustling, harsh climatic conditions, poor soils, inadequate and unreliable rainfall, sweet potato production is considered as an alternative solution to food security for pastoralists in Samburu County (Department of Agriculture, Samburu County (DoASC), (2014); (SCIDP, 2013).

Sweet potato farming in Samburu Central Sub-County is supported by World Vision. The organization was established in the area following an appeal by Samburu community to its head office through local leaders to explore possibility of facilitating community development in the area in an attempt to reduce poverty thus enhance food security. The organization is vibrant in the area and has been supporting agro-pastoralist groups. In 2010, World Vision supported the agro-pastoralist groups with 3000 certified sweet potato vines variety SPK 004 from Katumani Research station in Machakos County. In the year 2011 an additional supply of 4,800 vines were given to groups in the two wards of Samburu Central Sub-County. Figure 1 and Figure 2 are pictures of sweet potato farming in Samburu and a sweet potato establishment field respectively. According to Samburu Pastoralist Livelihood Improvement Project (SAPLIP), (2015) the households growing beans, sweet potatoes, cassava and cowpeas were 28.6 percent during baseline findings, however the specific acreage of cassava and sweet potatoes were negligible.
Agricultural potential land is about 140,000 hectares in the Samburu County. However only 4000 hectares and 3200 hectares are under food crops and cash crops respectively (DoASC, 2014). Although sweet potato production has been promoted through demonstrations of proper agronomic practices and utilization, the crop acreage is less than 0.025 acre as compared to maize, which is 2 acres per farmer. The expectation is that sweet potato, as a drought tolerant crop will ensure food security and poverty reduction in Poro and Maralal wards, thus reducing dependency on food relief especially during years of prolonged drought (DoASC, 2014). The County is planning to reduce the dependency on relief food through capacity building of the community members on production of drought resistant food crops like sweet potato (SCIDP, 2013).

Despite the benefits associated with crop production, access to communal land for production purposes among the pastoralists community is based on complex social, cultural, and historical norms and conditions that historically have maintained flexible access to resources across space and time. Communal land is communally owned and controlled by the elders who prefer livestock farming as compared to crop production. There is also the traditional belief that tilling of land is associated with certain communities. These factors contribute to negative attitude towards crop production and in particular cultivation of sweet potatoes.

CONCLUSION

Pastoralists are bound by strong social values that influence decisions on adoption of crop farming. Food preferences, strong value for animals as compared to food cropping may act as obstacles to acceptance of sweet potato production. Sweet potato in particular is viewed as food for certain community members. Traditional beliefs, negative attitudes towards production, strong cultural systems, harsh climatic conditions and the worsening insecurity have largely contributed to low levels of community development, especially sweet potato production in insecure zones, which are agriculturally potential areas. Samburu County is no exception and faces similar challenges towards adoption of sweet potatoes.

RECOMMENDATIONS

Crop farming especially sweet potato which has been introduced in Samburu County has the potential for improving food security and reducing dependency on relief food. It is important for the county government of Samburu to continuously support the promotion of the crop among the pastoralists to enhance integration with livestock farming. Educational activities should be implemented to sensitize the farmers on the benefits of sweet potato production and to overcome the social and cultural barriers that hinder production and consumption. Adoption of sweet potato as an alternative livelihood to pastoralism should be enhanced, while discouraging traditional beliefs, negative attitudes towards the crop. There is thus the need for an empirical study on the sweet potato production to establish the socio-cultural factors influencing the growing of sweet potatoes in Samburu County.

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ABSTRACT

The study was carried out to determine the factors driving households’ participation in agricultural land rental markets in Kwale County, Kenya. The bivariate probit results obtained from a cross-sectional survey of 386 small scale farmers show that, Land poor households were more likely to rent in land and vice versa. High transaction costs and rental prices impeded the access to land by small scale farmers through land rental markets. This raises a policy concern on the importance of reducing transaction costs through improvement of transport and communication infrastructure which in turn reduces search, monitoring and enforcement costs. Furthermore, there is need to strengthening the land ownership rights and societal ties. These aspects will increase land tenure security and trust between the landlord and tenant hence reducing the screening and negotiation costs.

Key words: Bivariate Probit, Renting in, Renting out, Small scale farmers, Transaction costs.

INTRODUCTION

While large parts of Sub-Saharan Africa (SSA) can be characterized as land abundant, scarcity of farmland is becoming a major concern to policy makers as the continent’s populations grow (Headey and Jayne, 2014). Access to farmland in sub-Saharan Africa (SSA) is a key factor that determines whether or not rural households are poor, food insecure, and vulnerable to shocks (Potts, 2006; Woodhouse, 2006). Although land rental and sales markets have typically not been regarded as features of traditional tenure systems, recent evidence (Holden and Bezabih, 2009; Hertel, 2011) suggests that, agricultural land markets are far more widespread than commonly perceived, and the role of such markets in facilitating access to land is of considerable interest to both researchers and policy makers.

Historically, the Coast region of Kenya has had land injustices which have led to the increase in squatters. Generally, there has been limited land redistribution in the study area due the fact that most of the land is either under group ranch or it is communal land with few households having private land ownership. It is the unbalanced landholding pattern and increased population that might have resulted into landlessness (Njuguna and Baya, 2000). thus the emergence of agricultural land rental market. As a result of increasing population of young farmers who are often landless, there is unbalanced resource endowment (Nyangena, 2010).

According to Deininger and Jin (2005) the emergence of agricultural land rental market can be beneficial to less land endowed farmers provided they are more labour endowed. Participation in agricultural land rental market could also help in reducing land fragmentation (Tan et al., 2006). It could also help in increasing agricultural output and consequently increase in agricultural incomes by allowing more effective use of unused agricultural land (Jin and Deininger, 2009).

Despite the potential positive effects posed by participation in agricultural land rental markets, it has not been embraced by many households in the coastal region of Kenya. In addition to that, there is still inadequate literature in developing countries especially coastal Kenya which has over the year experienced land injustices that could provide empirical evidence on the drivers to farm households to participate in agricultural land rental markets. The objective of this paper was therefore, to find out the determinants of participation in agricultural land rental markets in Lunga Lunga Constituency, Kenya. An improved understanding on the drivers for participation in this market is therefore important in improving the access to land and hence improvement in livelihood of the small scale farmers. The paper adds to the existing body of literature, the factors influencing participation in the agricultural land rental market in areas that are
experiencing challenges of historical land injustices. The choice of the study area also provides the uniqueness of this study. Kwale County and the coast region of Kenya have been fought with historical land injustices which informs the high level of squatters with relatively high poverty and food insecurity levels of 74.9% and 30% of the population in Kwale County respectively (KCIDP, 2013). This is due to the low levels of production in the primary productive sectors of agriculture, livestock and fisheries.

Further, it establishes the relationship between transaction costs (search, screening and negotiation costs and monitoring and enforcement costs) and participation in the agricultural land rental market. Araujo et al. (2007) viewed transaction costs as the sum of costs which result from the contractual relationship in the land market, and can either prevent or enable the acquisition of land depending on its level. Previous literature (Bezimana, 2011; Holden and Ghebru, 2013) used possession of a title deed as a proxy for transaction costs. Such a proposition is inappropriate in this study because majority of the transactions in the study area are informal and the households are squatters thus possession of a title deed is inconsequential. The knowledge generated is important to the debate in enhancing the participation in land rental market, particularly in areas that are experiencing historical land injustices and the land transactions are mostly informal markets. This paper also analyses the determinants of renting in and renting out agricultural land jointly. This is critical in this study because it acknowledges the influence of the decision to rent in land on the decision to rent out land, hence the use of a bivariate probit model. Previous studies (Jin and Jyne, 2011; Amare, 2013; Ricker-Gilbert and Chamberlin, 2016) studied this decisions independently thus ignoring the fact of their interdependence.

**ANALYTICAL FRAMEWORK**

To determine the socioeconomic and institutional factors influencing small scale farmer’s participation in agricultural land renting in and renting out, a bivariate probit model was used. The model can capture the interrelation between the two decisions (renting in and renting out). This is as opposed to estimation of the two separate probit (or logit) models which would provide biased estimates of the parameters of participation in land renting in and land renting out, since it ignores the potential correlation between the unobservable (captured by the error terms) of the two decisions. The decision to rent in is contingent on the decision to rent out (Neill and Lee, 2001; Wooldridge, 2004). Bivariate model is also used in testing the simultaneity between renting out land and renting in land (Tu and Bulte, 2010).

The structural form of the bivariate Probit model can be expressed as follows.

$$Y_{i1}^* = \alpha_1 Y_{i2}^* + x_{i1} \beta_1 + \epsilon_{i1}; y_{i1} = 1 \text{ if } Y_{i1}^* > 0; = 0, \text{ otherwise}$$

$$Y_{i2}^* = \alpha_2 Y_{i1}^* + x_{i2} \beta_2 + \epsilon_{i2}; y_{i2} = 1 \text{ if } Y_{i2}^* > 0; = 0, \text{ otherwise}$$

$$E(\epsilon_{i1}) = E(\epsilon_{i2}) = 0 ; Var(\epsilon_{i1}) = Var(\epsilon_{i2}) = 1$$

$$Cov(\epsilon_{i1}, \epsilon_{i2}) = \rho \text{ and } i = 1,2,3,...,n$$

(1)

(2)

(3)

The unobservable, perceived utility $Y_{i1}^*$ from participation in the land renting in market depends on a vector of explanatory variables $x$ so that the binary outcome $y_{i1} = 1$ arises when the latent variable $Y_{i1}^* > 0$. While on the other hand, we observe $y_{i2}$ (renting out) if and only if $y_{i2}$ (renting out) = 1.

The empirical model was expressed as follows

Rentin$^*_{i1} = \alpha_1 \text{ Rentout}^*_{i1} + x_{i1} \beta_1 + \epsilon_{i1};$

Rentin$^*_{i1} = 1 \text{ if Rentin}^*_{i1} > 0; = 0, \text{otherwise}$

(4)

Rentout$^*_{i1} = \alpha_2 \text{ Rentin}^*_{i1} + x_{i2} \beta_2 + \epsilon_{i2};$

Rentout$^*_{i1} = 1 \text{ if Rentout}^*_{i1} > 0; = 0, \text{otherwise}$

(5)

$$E(\epsilon_{i1}) = E(\epsilon_{i2}) = 0 ; Var(\epsilon_{i1}) = Var(\epsilon_{i2}) = 1$$

$$Cov(\epsilon_{i1}, \epsilon_{i2}) = \rho \text{ and } i = 1,2,3,...,n$$

(6)

Where Rentin$^*_{i1}$ and Rentout$^*_{i1}$ are latent dependent variables referring to the household’s decisions to participate in agricultural land renting in and out respectively, $x_{i1}$ and $x_{i2}$ is the vector of explanatory variables as presented in Table 1. The explanatory variables were derived from review of previous studies on land rental markets (Hoang, 2003; Jin and Jyne, 2011; Jin and Jayne, 2013; Amare, 2013; Amare and Beyene, 2015). The random errors $\epsilon_{i1}$ and $\epsilon_{i2}$ are distributed as standard bivariate normal variables (σ) with correlation coefficient $\rho$. The bivariate model has the following characteristics:
RESULTS AND DISCUSSION

Descriptive Statistics

The descriptive statistics of the variables used in the bivariate probit are presented in Table 1 in Appendix 1. Household heads who engaged in agricultural land renting in were relatively younger and more educated as compared to those who rented out land. Younger and educated farmers are more open to new ideas and opportunities and may have adequate capital to purchase land. They are also flexible in adapting to new market requirements, less risk averse, and more innovative than older farmers. Household who rented in land had a mean household size of 3 members while those who rented out land had a mean household size of 2 members. Household participation in agricultural land renting in market could possibly be because of the high demand for food and other services as a result of the larger household size, thus they would seek innovative ways such as land renting in land in order to increase food production.

Econometric Results

The results of the bivariate probit model in table 2 in Appendix 2, show that better educated household heads were more likely to participate in agricultural land renting in but were less likely to participate in renting out. Education level of the household head was statistically significant at 10% and 5% significance levels for renting in and renting out, respectively. Higher education levels gives household heads the ability to perceive, interpret and respond to new information faster than the less educated household heads (Teklu and Lemi, 2004). On the other hand, higher education levels of the household head exposed them to new ideas, farming skills and technologies which helped them to identify the potential benefits that can be derived through farming on land instead of renting it out.

Households with smaller farm sizes had higher probability of participating in land rent in market while at the same time it reduced their probability of renting out land at 1% significance level. Due to increased demand for land for the agricultural purposes, households with small land holdings tend to rent in land so as to meet the growing demand for food. This finding is consistent with previous studies (Nyangena, 2010; Jin and Jayne, 2011; Amare and Beyene, 2015) argued that, agricultural land rental markets increase access to land for households with relatively little owned land. In terms of renting out, households with relatively large landholding do not tend to specialize in agricultural production and therefore they rent out land to get an extra income to invest in other activities.

High agricultural land rental price lowered the probability of a household to participate in land renting in; however, it increased the probability of participating in land rent out. The influence of agricultural land rental market on participation was statistically significant at 1% level. High land rental price implies that farmers pay more to acquire one acre of land and this reduces the resources which can be used for renting more land and make investments. Higher rental price means that farmers sacrifice the little financial resources they have to acquire agricultural land and this discourages them from renting in agricultural land (Jin and Jayne, 2011). In terms of land renting out market, land rental price acts as income for household engaged in land rent out. An increase in agricultural land rental price translates to better earnings which can be invested in other off farm income generating activities hence motivating farmers to rent out land.

Higher transaction costs reduced the likelihood of a household to participate in agricultural land renting in and renting out market at 5% and 10% significance level, respectively. Transaction costs include search costs, screening and negotiation costs and monitoring (and enforcement). They depend on factors such as trust and tenancy security. According to Holden and Gheburi (2006), in a high-trust community costs related to search, screening, negotiation, monitoring and enforcement should be low. On the other hand, land fragmentation and a dispersed population and farm plots will tend to increase these costs as well as transportation costs related to land use. The results imply that, as the transaction costs increases, the cost of renting in land also increase hence making it expensive for the already poor farmers. An increase in transaction costs is a deterrent to renting in of land because it increases the cost of renting in (Hoang, 2003; Vranken and Swinnen, 2006). On the other hand, high transaction costs reduce the profit from the transaction therefore households are less likely to rent out agricultural land when the cost is high. Hoang (2003) noted that, transaction costs needs to be reduced in order to stimulate the rent out market in Vietnam.

firstly, the dependent variables are binary; secondly, the binary dependent variable of first equation is entered as covariate in the second equation and vice versa and finally, the unobserved heterogeneities of the two decisions are assumed to be correlated.
because it reduces the income acquired by the land owners.

Ownership of oxen positively influenced the probability of participation in land renting in market at 10% significance level but negatively influenced the probability of renting out land at 5% significance level. Oxen provide cheap labour to the rural areas and are sources of income when hired by other farmers. The extra income may be used to rent in agricultural land and other investment in new agricultural technologies. Amare and Beyene (2015) argued that, ownership of oxen offers an opportunity for resource constraint farmers to get access to land by transferring it from those who cannot use it efficiently (say, due to lack of traction power) to those who are capable of using it efficiently. On the other hand, oxen provide cheap labour to the farms. Households who owned oxen were less likely to rent out land because of the availability of labour to work on their farms as well the alternative source of income to finance farming activities thus able to put their available land into effective use. Households who owned oxen were wealthier and therefore they were less likely to rent out their land. Furthermore, Holden and Ghebru (2013) noted that, households with oxen needed to keep land so as to provide fodder for their livestock.

Access to extension services increased the household’s probability of participating in agricultural land renting in market land but decreased the probability of renting out land and this was significant at 1% and 10%, respectively. Farmers who have access to extension services are more empowered on farming skills, information of new technologies and market information, which they use in understanding the dynamics in the agricultural land rental market in terms of prices and land fertility differences. However, Hoang (2003) found that, access to extension services had a negative impact on renting in of land. This was attributed to the fact that extension services may be targeted at areas where the marginal productivity of land is relatively low and perhaps the quality of information given is low or even outdated. On the other hand, farmers may be provided with a good understanding on how to put their available land into productive use instead of renting it out.

CONCLUSIONS AND POLICY IMPLICATIONS

The objective of the study was to determine the drivers of small scale farmers’ participation in agricultural land rental market in Kwale County, Kenya. In achieving the objective, participation was measured as to whether a household rented in or rented out agricultural land. Findings were that households with highly educated chief decision makers as well small farm size were more likely to participate in renting in of agricultural land. Ownership of an oxen and access to extension services increased the likelihood of a household participation in renting in of land. These findings underpin the importance of encouraging reinvestment in agricultural productive assets such as oxen while engineering information and knowledge transfer which is important for land rental market development through provision of up to date, quality and demand driven extension services. However, unique drivers in renting in were observed. High transaction costs and rental price reduced the likelihood of participation in land renting in especially for the already poor households because of the increase in the cost of land attributed to high transaction cost ad rental prices. This raises a policy concern on the importance of reducing the transaction costs through improvement of transport and communication infrastructure which reduces the search, monitoring and enforcement costs. Furthermore, there is need to strengthening the land ownership rights and societal ties. These aspects will increase land tenure security and trust among the market participants hence reducing the screening and negotiation costs.

ACKNOWLEDGMENTS

The authors would like to acknowledge the financial support from African Economic Research Consortium (AERC) who funded this study. Our gratitude also goes to the staff of the Department of Agricultural Economics and Agribusiness Management of Egerton University, enumerators for their valuable contributions. Special thanks go to all households who responded to our questions.

REFERENCES


### APPENDIX 1

#### Table I: Descriptive statistics for continuous and categorical variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Renting in</th>
<th>Renting out</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>HHAge</td>
<td>Age of the household head in years</td>
<td>49.29</td>
<td>53.04</td>
<td>1.49**</td>
</tr>
<tr>
<td>HHSize</td>
<td>Number of people in the household</td>
<td>3.83</td>
<td>2.84</td>
<td>1.28**</td>
</tr>
<tr>
<td>Farmsize</td>
<td>Amount of land owned in acres</td>
<td>2.05</td>
<td>8.08</td>
<td>3.62**</td>
</tr>
<tr>
<td>Rentprice</td>
<td>Amount of rental price charged per acre in Kenya Shillings</td>
<td>2999.77</td>
<td>3153.85</td>
<td>13.43***</td>
</tr>
<tr>
<td>Transactioncost</td>
<td>Cost of communication, transport and negotiation incurred in land rental transaction Kenya Shillings</td>
<td>768</td>
<td>567</td>
<td>-1.66*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Renting in</th>
<th>Renting out</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educlev</td>
<td>% of those who had college level of education</td>
<td>12.68</td>
<td>11.34</td>
<td>56.54***</td>
</tr>
<tr>
<td>Genderhed</td>
<td>% of male household head</td>
<td>77</td>
<td>88.46</td>
<td>2.10***</td>
</tr>
<tr>
<td>Groupmembership</td>
<td>% of those who were members of a group</td>
<td>40.85</td>
<td>30.77</td>
<td>10.41***</td>
</tr>
<tr>
<td>Creditaccess</td>
<td>% of those who had access to credit</td>
<td>31.62</td>
<td>26.92</td>
<td>13.32***</td>
</tr>
<tr>
<td>Oxenownership</td>
<td>% of those who owned an ox</td>
<td>62.44</td>
<td>23.04</td>
<td>50.677***</td>
</tr>
</tbody>
</table>

Note: ***, **, * indicate significant at 1%, 5%, 10% level, respectively

### APPENDIX 2

#### Table II: Bivariate Probit on the determinants of agricultural land rental market participation

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupation</td>
<td>0.252</td>
<td>0.583</td>
<td>-0.413</td>
<td>0.376</td>
</tr>
<tr>
<td>Agehead</td>
<td>-0.031</td>
<td>0.030</td>
<td>-0.004</td>
<td>0.014</td>
</tr>
<tr>
<td>Genderhead</td>
<td>0.800</td>
<td>0.753</td>
<td>0.186</td>
<td>0.449</td>
</tr>
<tr>
<td>Educlev</td>
<td>0.492*</td>
<td>0.293</td>
<td>-0.458**</td>
<td>0.195</td>
</tr>
<tr>
<td>HHsize</td>
<td>0.194</td>
<td>0.145</td>
<td>-0.122</td>
<td>0.083</td>
</tr>
<tr>
<td>Ownedfarmsize</td>
<td>-0.544***</td>
<td>0.154</td>
<td>0.128***</td>
<td>0.034</td>
</tr>
<tr>
<td>Rentprice</td>
<td>-0.002***</td>
<td>0.000</td>
<td>0.001***</td>
<td>0.000</td>
</tr>
<tr>
<td>Transactioncost</td>
<td>-0.004**</td>
<td>0.002</td>
<td>-0.005*</td>
<td>0.003</td>
</tr>
<tr>
<td>Oxenownership</td>
<td>1.069*</td>
<td>0.580</td>
<td>-0.769**</td>
<td>0.385</td>
</tr>
<tr>
<td>Marketaccess</td>
<td>-1.281</td>
<td>0.939</td>
<td>0.548</td>
<td>0.535</td>
</tr>
<tr>
<td>Extensionaccess</td>
<td>0.076***</td>
<td>0.570</td>
<td>-0.765*</td>
<td>0.420</td>
</tr>
<tr>
<td>Groupmembership</td>
<td>0.991</td>
<td>0.703</td>
<td>0.601</td>
<td>0.414</td>
</tr>
<tr>
<td>Creditaccess</td>
<td>0.496</td>
<td>0.655</td>
<td>-0.429</td>
<td>0.454</td>
</tr>
<tr>
<td>Landfertility</td>
<td>-0.961</td>
<td>0.660</td>
<td>0.256</td>
<td>0.346</td>
</tr>
<tr>
<td>Constant</td>
<td>-3.493</td>
<td>2.031</td>
<td>-1.513</td>
<td>1.191</td>
</tr>
</tbody>
</table>

Number of observations = 381, Wald chi2 (28) = 76.84...rho = 0.02
Log likelihood = -55.211171, Prob. > chi2 = 0.0000

Note: ***, **, * indicate significant at 1%, 5%, 10% level, respectively
RELATIONSHIP BETWEEN ENTREPRENEUR INNOVATIVENESS AND PERFORMANCE OF AGRO-BASED SMALL AND MEDIUM MANUFACTURING ENTERPRISES IN KIAMBU COUNTY-KENYA

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ABSTRACT

The Small and medium Enterprise (SME) sector in Kenya is important both for the development of the economy and as a source of income and employment. It expanded from employing 3.7 million people in 1999 to 5.1 million in 2002 (GOK, 2005). The role of SMEs in Kenya’s development process is significant, particularly in the context of generating employment, wealth creation and income opportunities to thousands of people across the country. (Maragia 2008). The agro-based manufacturing sector plays a vital role in boosting growth in agriculture by stimulating agro-processing activities. This is in line with the aspirations of Vision 2030 and in supporting the country’s social development agenda through the creation of jobs, the generation of foreign exchange, and by attracting foreign direct investment (GOK, 2007). The study sought to establish the relationship between the entrepreneur’s innovativeness, and performance of SMEs in the agro-based manufacturing sector in Kiambu County of Kenya. To achieve the objectives, the study used descriptive survey research design. The target of the study included the 250 registered agro-based manufacturing SMEs in the food subsector in Kiambu County. Stratified random sampling techniques were used to draw a sample size of 69 enterprises. To collect the data a questionnaire with both closed ended and open ended questions were administered. The data collected was analyzed using Statistical Package for Social Science version 21 to generate descriptive statistics including percentages, frequency tables and mean scores. Correlation coefficient was used to determine the magnitude and direction of relationship between innovativeness, risk taking and the performance of the SMEs. Regression procedure was used to determine the nature of the relationship of both innovativeness and risk taking with the performance of the SMEs. The correlation analysis revealed that there is a significant linear relationship between innovativeness and performance of the SMEs. The correlation Coefficient index is 0.833 at P value less than 0.001 (r = 0.833, P < 0.001). The regression model of the study indicated that innovativeness explains 69.4% of the variation in performance of the agro-based SMEs. For one unit increase in innovativeness, performance increases by 1.053 units. Based on the findings of the study, the entrepreneurs should strive to be innovative within their financial ability and in consideration of whether the business environment is hostile or not.

Key words: Innovativeness, Entrepreneur, Small and medium Enterprises, Performance Agro-based.

INTRODUCTION

The small and medium sector is a source of income and employment in Kenya. It expanded from employing 3.7 million people in 1999 to 5.1 million in 2002 (GOK, 2005). The role of SMEs in Kenya’s development process is significant, particularly in the context of generating employment, wealth creation and income opportunities to thousands of people across the country (Maragia, 2008). Entrepreneurship is a major source of employment, economic growth, and innovation, promoting product and service quality, competition, and economic flexibility. It is also a mechanism by which many people enter the society’s economic and social mainstream, aiding culture formation, population integration, and social mobility (Hisrich, Langan-Fox and Grant, 2007).

The agro-based manufacturing sector in Kenya contribution to GDP is 10 per cent and has recorded a growth of 6.9 per cent in value addition (Kenya Institute of Policy and Research, 2010). The sector plays a vital role in boosting growth in agriculture by stimulating agro-processing activities. This is in line with the aspirations of Vision 2030 and in supporting the country’s social development agenda through the creation of jobs, the generation of foreign exchange, and by attracting foreign direct investment (GOK, 2007). To meet those goals, the sector has to become more efficiently driven to be able to compete effectively both in the local and international market. Specifically the entrepreneurs in this sector have to...
continuously embrace innovation, be proactive and bold enough to venture into new frontiers.

According to Ariss, Raghunathan, and Kunnather (2000) there have been observed technological advances both generally (most notably information and communication technologies) and, specific to the agro-industrial sector, in primary production (the application of biotechnology) and manufacturing sectors (new processing methods). These technological advances are serving to create new and unprecedented opportunities for agro-industrial enterprises in terms of product and process innovations. However they also raise the concern of agro-industrial enterprises being left behind if they are unable to gain access to these technologies in a timely and cost-effective manner (Elimitu & Kathawala, 1999).

Innovativeness of entrepreneurs is measured by the propensity by which they innovate their business (Milter and Friesen, 2002); their willingness to try new ways which are different from the existing; the enthusiasm to adopt new ideas or new methods to their business operation; and the eagerness to implement the innovation strategy in their business (Khandwalla, 2007).

Innovativeness is generally defined as conceptualization of new commodities (or greatly improved commodities) but also the successful bringing of new commodities to the market (Cakar and Erturk2010, Schumpeter 1934). Innovativeness also connotes the process of production which is implementation of a new or significantly improved production (Trott 2010). Innovation capability is one of the most important dynamics which enables firms to achieve high level of competitiveness both in the national and international market. In his book, The Theory of Economic Development, Schumpeter (1912), identified the entrepreneur as an individual who introduces new combinations i.e. innovations to the economy. He explains that innovations come in swarms i.e. the initial innovator is followed by a bunch of imitations which results in economic boom and that, periods of innovation and lack of innovation are the main causes of the business cycle.

Risk-taking refers to the tendency to take bold actions such as venturing into unknown new markets and committing a large portion of resources to ventures with uncertain outcomes. (Wiklua & Shepherd, 2003). Risk handling is the process in which potential risks to a business are identified, analyzed, mitigated and prevented, along with the process of balancing the cost of protecting the company against a risk versus the cost of exposure to that risk. The ideal way to cope with risk is to perceive risk at its inception, and taking risk under control right from its inception. Entrepreneurs, in actuality, tend to proactively deal with the risks. Risk-taking has strong relationship with performance of entrepreneurial firms.

A study by Naldi et al., (2009) in Sweden looked into the influence of risk taking and performance of family and nonfamily firm. The study found out that though family business (largely SMEs) do take risks as part of their entrepreneurial activities, they do it to a lesser extent than do nonfamily firms. The result of the study also indicated that the reason why family firms are less likely to take lower risk than other firms was because of contextual reasons such as governance structure likelihood of loosing ownership of the business. In fact the finding of the study suggests that risk taking have a negative effect on family business.

**METHODOLOGY**

**Research Design**

The study used a descriptive survey design. According to Elahi and Dehdashti (2011), a descriptive survey research is ideal when the research objectives include the following: Portraying the characteristics of a social or physical phenomenon and determining the frequency of occurrence; determining the degree to which the variables are associated and Making predictions regarding the occurrence of social or physical phenomena. The study intended to establish the relationship between the entrepreneur’s innovativeness in the agro-based manufacturing sector and performance, thus the design was ideal.

Both qualitative and quantitative research approaches were used. According to McMillan and Schumacher (1993) qualitative research is concerned with understanding the social phenomenon from the participants’ perspective while quantitative research is an inquiry into an identified problem, based on testing a theory, measured with numbers, and analyzed using statistical techniques. Combining the two approaches provides a richer presentation of the reality, (Silverman, 2005). The study combined the two approaches to understand the relationship between entrepreneurial orientation and performance of businesses in the agro-based manufacturing sector.
The study sought to find the relationship between the entrepreneur’s innovativeness, and the performance of the agro-based manufacturing SME’s. As shown in table I, 64% of the entrepreneurs agree that they always look for new markets to target, while 52% of the entrepreneurs agree that they create new products that provide value for their customers. While 56% of the entrepreneurs agree that they create value for their customers through partnerships, 74% agree that they regularly improve their existing products. From the findings, 66% of the entrepreneurs improve customer service through mobile money payment. Of all the entrepreneurs, 98% do not remain in the same business and they do not target only the existing markets. They are innovative in getting into different businesses as well as targeting new markets.

**DISCUSSION**

The hypothesis of the study was that there is no significant relationship between innovativeness, and performance of agro-based manufacturing SMEs in Kiambu County. The analysis reveals that there is a significant linear relationship between innovativeness and performance of the SMEs. The correlation Coefficient index is 0.833 at P value less than 0.001 ($r = 0.833, P < 0.001$). This is shown in table ii. The study concludes that there is a strong positive relationship between autonomy and the performance of the agro-based manufacturing SMEs. As the level of innovativeness increases, so does the performance of the SMEs.

The correlation between innovativeness and performance of the agro-based SMEs, was found to be significantly different from zero ($r =0.833, P< 0.001$). This is shown in table ii. This study concludes that there is a significant linear relationship between the entrepreneur’s innovativeness and the performance of the SMEs. As the level of innovativeness increases, the performance of the SMEs also increases.

The regression analysis results for innovativeness and performance of SMEs is shown in tables iii, iv and v. A simple regression model was fitted to the data and it was found to be significant ($F (1, 48) =109.04, p <0.001$). This is shown in table iv. The value $R^2 = 0.694$, as shown in table iii implies that innovativeness explains 69.4% of the variation in performance of the SMEs. The hypothesis $H_0$: $\beta_2 = 0$ (There is no significant relationship between innovativeness and performance of agro-based manufacturing SMEs in Kiambu County), is therefore rejected. This is because $\beta_2 =0.833$, and it is positive. Innovativeness has a positive influence on Performance. For one unit increase in innovativeness, performance increases by 1.053 units. The model equation generated for

**EMPIRICAL RESULTS**

**Instrumentation and Data Collection**

The data collection involved both primary and secondary data collection. The primary data was collected through a questionnaire and an interview. Interview guide was used to guide interviews conducted with the entrepreneurs. The interviews sought to have an in-depth probing on how entrepreneurs achieve innovativeness. Further, the interview sought to understand the relationship between innovativeness and the performance of the business based on the view of the respondents. During data collection questionnaires were administered by the researcher at the enterprise premises to avoid inconveniencing the entrepreneurs. This enabled collection of primary data on innovativeness. However, the business earnings data was obtained from secondary data based on the business financial records. The questionnaire had five scale likert questions which sought information on the innovativeness of the proprietor. The respondents rated each item by stating the level of agreement of each statement ranging from strongly agrees to strongly disagree. The questionnaire was administered by the researcher with the help of research assistants.

**DATA ANALYSIS**

Data analysis included both descriptive and inferential statistics. The data collected on innovativeness, and risk taking was scored to determine the level of innovation and risk taking. Similarly performance of the business was measured at the same time. Data was analyzed using statistical package for social science version 21. The variable relationship in the regression analysis was tested using inferential statistics. The ordinary least square regression analysis was used to determine the relationship that the independent variable had with the dependent variable. To test the linear relationship between the independent and the dependent variable of performance of the SMEs, Spearman’s rho correlation was used. The designation $r$ symbolizes the correlation coefficient which varies over a range of -1 to +1. The sign signifies the direction of the relationship. The coefficient is significant in situations where the significant level is between $P < 0.05$.

The regression analysis results for innovativeness and performance of the SMEs is shown in tables iii, iv and v. A simple regression model was fitted to the data and it was found to be significant ($F (1, 48) =109.04, p <0.001$). This is shown in table iv. The value $R^2 = 0.694$, as shown in table iii implies that innovativeness explains 69.4% of the variation in performance of the SMEs. The hypothesis $H_0$: $\beta_2 = 0$ (There is no significant relationship between innovativeness and performance of agro-based manufacturing SMEs in Kiambu County), is therefore rejected. This is because $\beta_2 =0.833$, and it is positive. Innovativeness has a positive influence on Performance. For one unit increase in innovativeness, performance increases by 1.053 units. The model equation generated for

The study sought to find the relationship between the entrepreneur’s innovativeness, and the performance of the agro-based manufacturing SME’s. As shown in table I, 64% of the entrepreneurs agree that they always look for new markets to target, while 52% of the entrepreneurs agree that they create new products that provide value for their customers. While 56% of the entrepreneurs agree that they create value for their customers through partnerships, 74% agree that they regularly improve their existing products. From the findings, 66% of the entrepreneurs improve customer service through mobile money payment. Of all the entrepreneurs, 98% do not remain in the same business and they do not target only the existing markets. They are innovative in getting into different businesses as well as targeting new markets.
innovativeness and performance, \( Y = \beta_0 + \beta_2X_2 \), which implies that, \( Y = 3.578 + 0.833X_2 \). Since \( Y \) is performance of the SMEs and \( X_2 \) is innovativeness, this means that \( \text{Performance} = 3.578 + 0.833 \times \text{innovativeness} \). This implies that there is a positive significant relationship between innovativeness and performance of SMEs in the agro-based food manufacturing sector in Kiambu County in Kenya.

CONCLUSION

The study concludes that innovativeness is a statistically significant factor in determining performance of agro-based manufacturing SMEs in Kiambu County. SMEs aiming to have a good performance should be innovative. The SMEs should regularly introduce improvements on existing products, improve the production process, and improve on customer services such as through online communication as well as use of mobile money payments. In addition the SMEs should strive to look for new business opportunities and new markets to target.

Based on the findings of the study, the entrepreneurs should strive to be innovative within their financial ability and in consideration of whether the business environment is hostile or not. Innovation within an organization is negatively impacted by pressure of hostile environment, where competition is high and resources are scarce. In the absence of a hostile environment, the entrepreneur should strive to regularly introduce improvements on existing products, as well as improve on the production process.

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### TABLES

**TABLE I DESCRIPTIVE STATISTICS ON RELATIONSHIP BETWEEN INNOVATIVENESS AND PERFORMANCE OF SMES**

<table>
<thead>
<tr>
<th>Opinion statements</th>
<th>SD%</th>
<th>D%</th>
<th>N%</th>
<th>A%</th>
<th>SA%</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Entrepreneur always looks out for new business opportunities.</td>
<td>14</td>
<td>28</td>
<td>22</td>
<td>28</td>
<td>8</td>
<td>4.2</td>
<td>0.57</td>
</tr>
<tr>
<td>(b) Entrepreneur always looks out for new markets to target</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>64</td>
<td>28</td>
<td>4.3</td>
<td>0.54</td>
</tr>
<tr>
<td>(c) Entrepreneur creates new products that provide value for all customers</td>
<td>0</td>
<td>0</td>
<td>22</td>
<td>52</td>
<td>26</td>
<td>4.0</td>
<td>0.70</td>
</tr>
<tr>
<td>(d) Entrepreneur reaches out to customers through social media</td>
<td>0</td>
<td>6</td>
<td>28</td>
<td>46</td>
<td>20</td>
<td>3.8</td>
<td>0.83</td>
</tr>
<tr>
<td>(e) Entrepreneur creates value for customers through partnerships.</td>
<td>0</td>
<td>14</td>
<td>16</td>
<td>56</td>
<td>14</td>
<td>3.7</td>
<td>0.89</td>
</tr>
<tr>
<td>(f) Entrepreneur regularly improves the existing products.</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>74</td>
<td>24</td>
<td>4.2</td>
<td>0.46</td>
</tr>
<tr>
<td>(g) Entrepreneur regularly improves production process</td>
<td>0</td>
<td>4</td>
<td>22</td>
<td>58</td>
<td>16</td>
<td>3.9</td>
<td>0.73</td>
</tr>
<tr>
<td>(h) Entrepreneur improves customer service through mobile money payment</td>
<td>2</td>
<td>6</td>
<td>6</td>
<td>66</td>
<td>20</td>
<td>4.0</td>
<td>0.83</td>
</tr>
<tr>
<td>(i) Entrepreneur remains in the same business and targets only existing markets</td>
<td>36</td>
<td>52</td>
<td>8</td>
<td>4</td>
<td>0</td>
<td>1.8</td>
<td>0.76</td>
</tr>
<tr>
<td>(j) Encourage development of employees ideas for the purposes of business improvement</td>
<td>0</td>
<td>3</td>
<td>18</td>
<td>7</td>
<td>0</td>
<td>3.7</td>
<td>0.80</td>
</tr>
</tbody>
</table>

N=50, Cronbach alpha =0.811 with 9 item. (Item i dropped.)
SD= Strongly Disagree, D= Disagree, N= Neutral, A= Agree SA= Strongly Agree
SD= Standard Deviation

**Table II. Correlation Between Innovativeness and SMEs Performance.**

<table>
<thead>
<tr>
<th></th>
<th>Perfomance</th>
<th>innovativeness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pearson Correlation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Innovativeness</td>
<td>Pearson Correlation</td>
<td>.833**</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>50</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).**
Table III Model Summary for Regression of innovativeness against Performance of the SMEs.

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.833a</td>
<td>.694</td>
<td>.688</td>
<td>.38408</td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), Innovativeness

Table IV Anova table for regression of Innovativeness against performance of SMEs

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>16.085</td>
<td>1</td>
<td>16.085</td>
<td>109.041</td>
<td>.000a</td>
</tr>
<tr>
<td>Residual</td>
<td>7.081</td>
<td>48</td>
<td>.148</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>23.166</td>
<td>49</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), innovativeness
b. Dependent Variable: Performance

d. Dependent Variable: Performance

Table V Coefficients for regression of Innovativeness against performance of SMEs

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
</tr>
<tr>
<td>1 (Constant)</td>
<td>3.578</td>
<td>.054</td>
<td></td>
<td>65.873</td>
</tr>
<tr>
<td>Innovativeness</td>
<td>1.053</td>
<td>.101</td>
<td>.833</td>
<td>10.442</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Performance
Extension in Kenya, the situation with regard to relaying of information and pathways used among farmers seems unsatisfactory. This is specifically the case in the production of 3rd ranked cereal crop “sorghum” (sorghum bicolor (L.)) by farmers in Western Kenya. Sorghum farming in Ndihiwa Sub-County in the Western Kenya region is an important agricultural activity in the economy. Sorghum is not only drought resistant, but can also withstand long periods of water logging. Several technologies have been developed by research institutions with the aim of increasing its production. However, despite joint efforts by the research agencies and partners, its production has stagnated resulting in low crop yields. This study sought to assess determinants of agricultural information sources and pathways among sorghum farmers in Ndihiwa Sub-County. A quantitative research design was used to obtain information on the study. A multi-stage sampling technique was employed to collect cross sectional data from 379 sorghum farmers in Ndihiwa sub-county, Western Kenya. Data collected was analysed using Statistical Package for Social Sciences (SPSS) version 17 and adopted the multinomial logit model to find the determinants of choice of agricultural information sources/pathways. The most important sources of information were fellow farmers, Agricultural Extension Officers, researchers and Community-based Organizations (CBOs) and the pathways were farmer-to-farmer, radios, Barazas (local meetings), and trainings. Gender, age, farming experience and education of household head, farm size, land ownership, employment/off-farm activities, access to credit facility and group membership significantly influenced access to agricultural information sources while age and education of household head, farm size, farming experience of household head, membership and access to credit facilities had a significant influence on the choice of pathways. These findings raise important insights as to whether agricultural information is being disseminated and communicated to sorghum farmers through the most appropriate, affordable sources and pathways. The study recommended that, a focal farmer be selected using a set of criteria or a center be established as the focal point whereby other farmers can send or visit. After which the questions or issues raised be channelled to the appropriate source.

Keywords: Sorghum, agricultural information, communication, sources, pathways, dissemination.

INTRODUCTION

The access to and use of agricultural information is an important factor in improving agricultural production in any country (Nxumalo & Oladele, 2013). Its application plays an important role in increasing farmers’ knowledge, crop production and yield. The research efforts in Kenya have been directed towards increasing economic growth, improving livelihoods and sorghum productivity. However, due to limited supply and limited use of quality seeds of improved varieties, fertilizers, inaccessibility to agricultural information, yields remain low. This has called for the intensification of information sharing, collection and dissemination through the available agricultural sources and pathways on sorghum production. Sorghum is the world’s most versatile crop as it can successfully be grown in a wide range of regions and climatic conditions (Bateman et al., 2009). O’Neill & Kamau (1990) point out that 52% of sorghum in Kenya is grown in Nyanza and 23% in Western of the country. Sorghum is an important food crop in an area where maize does relatively poor or fails due to erratic rainfall, pests and diseases. It has been recognized as a drought resistant/tolerant crop indicating that sorghum will continue to do well in areas that are drought prone, under high temperatures and water logged. Sorghum consumption in Kenya is approximately 3.0kg per year per capita (FAO, 2004). Sorghum is utilized for food, feeds, and industrial uses. There are good prospects for the expansion of industrial market for sorghum since the East Africa Breweries Limited (EABL) is looking for farmers to produce sorghum in large quantities in Nyanza region. Despite having research done to
improve the yield of sorghum, and with even more data being stored in various repositories, the production at the farmer level has remained low.

The decline in sorghum production in Ndhiwa sub-county of Western Kenya has contributed to food insufficiency, food insecurity and poor income for the population. Nevertheless, its production could arguably be improved by strengthening access to and use of relevant, reliable and useful information and knowledge. For agricultural information to reach the intended target there ought to be appropriate information sources and pathways. The information sources are institutions or individuals which provide content or expertise of interest to the recipients, for example fellow farmers, extension services, neighbours, family friends, markets, researchers and Community Based Organizations (CBOs), and agricultural companies. Pathways (channels) are methods or vehicles through which information is transferred or received. According to Murage et al. (2012), information pathways include agricultural extensionists, farmer teachers (FT), farmer-to-farmer (FF) approaches; farmer field schools (FFS), Training and Visit (T&V) approaches, radio, television, mobile and newspaper and magazines. Other channels include journal papers, posters, books, banners, pamphlets, reports, brochures, billboards and ICT-based (internet, mobile phones, documentary on DVD/CD players) applications, (Amudavi et al., 2009).

The findings from the study showed that farmer-to-farmer is a more popular method despite inadequate reliability of information and experience shared among farmers. Sharing of information is made easy through meetings/barazas, market places, and communication is enhanced by information delivery through the fellow farmers and radios. The use of other sources and pathways like researcher/CBOs and radios, televisions and mobile phones have not been fully utilized as a result of high cost, low literacy level, low income and limited service providers. Even though there are agricultural information in different forms and repositories, by different sources, the target farmers have not managed to access agricultural information to enable proper decision making. This study, therefore, sought to determine the choice of agricultural information sources and pathways on sorghum production in order to increase sorghum productivity. It is against the background that the yields of sorghum under farmers’ conditions have, however, remained low in spite of the research innovations.

MATERIALS AND METHODS

Description of the Study Area
The study was conducted in seven wards of Ndhiwa Sub-County in Homa Bay County, Western Kenya (Figure 1). Ndhiwa is located between 34o12’ and 34o40’ east and latitudes 0o28’ and 0o40’ south in the southwestern part of Kenya along Lake Victoria. There is a bimodal rainfall pattern: March – June for the long rains and August – November for the short rains. The Sub-County lies in lower midland agro-ecological zone, at an altitude of 1200 – 1400m above sea level. It is the third largest Sub-County with 7 County Assembly Wards. Ndhiwa’s population is 172,212, while the density is 244 persons per square kilometer (Kenya National Bureau of Statistics, 2013). It was selected because of its fertile land and good annual rainfall which could make it the food granary for most parts of Western Kenya.

Sample Size and Sampling Procedure
During the survey to identify the sources and pathways of agricultural information on sorghum production, a total of 379 farmers were interviewed from the entire population of 396. The reasons for not covering the entire sample were lack of financial resources, non-responsiveness by some farmers and poor road conditions. The sample size of 399 was determined according to Yamane (1973) formula used:

\[ n = \frac{N}{1+N(e^2)} \]

Where \( n \) is the sample size, \( N \) is the population size, and \( e \) is the level of precision. Using a population of 172,212 farmers and with 0.05 level of precision, the sample size was;

\[ n = \frac{172212}{1+172212(0.05^2)} \]

\[ n = 399 \text{ farmers} \]

The proportional sub-sample for each ward was calculated as below:

\[ n = \frac{400}{172212} \]

\[ n = 0.0023 \]

The respondents were selected by using proportionate stratified random sampling technique because the population sample is divided into wards. Stratified sampling ensures unbiased representation and inclusion of all the farmers as well as the cost per observation may be reduced by stratification.
Table 1: Farmers Proportionate Distribution in Ndhiwa Constituency

<table>
<thead>
<tr>
<th>Wards</th>
<th>Farmers Pop.</th>
<th>Proportion</th>
<th>Subsamples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kwabwai</td>
<td>31,596</td>
<td>31,596 × .0023</td>
<td>73</td>
</tr>
<tr>
<td>Kanyadoto</td>
<td>16,331</td>
<td>16,331 × .0023</td>
<td>38</td>
</tr>
<tr>
<td>Kanyikela</td>
<td>6,283</td>
<td>6,283 × .0023</td>
<td>14</td>
</tr>
<tr>
<td>N. Kabuoch</td>
<td>35,270</td>
<td>35,270 × .0023</td>
<td>81</td>
</tr>
<tr>
<td>S. Kabuoch</td>
<td>26,332</td>
<td>26,332 × .0023</td>
<td>61</td>
</tr>
<tr>
<td>KanyamwaKologi</td>
<td>23,442</td>
<td>23,442 × .0023</td>
<td>54</td>
</tr>
<tr>
<td>KanyamwaKosewe</td>
<td>32,958</td>
<td>32,958 × .0023</td>
<td>76</td>
</tr>
<tr>
<td>Total</td>
<td>172212</td>
<td></td>
<td>396</td>
</tr>
</tbody>
</table>

DATA COLLECTION

Questionnaires, observations and interviews were used to collect information from the farmers involved in the descriptive study. The tool was pre-tested to check its validity and reliability with a sample of 20 respondents similar to the study area. This was done in Koibatek which has similar characteristics to the study area. Some adjustments were done after the pilot-test results to improve on the reliability. The questionnaires were then administered to the farmers by the researcher with the help of 7 enumerators to collect the required data accordingly. It focused on household heads (male, female) for interview.

DATA ANALYSIS

After data collection, the questionnaires were cleaned for errors, coded, and then entered into the computer after which analysis of quantitative data was done using Statistical Package for Social Sciences (SPSS). Descriptive statistics namely percentages, frequency, means, standard deviations and Multinomial Logit (MNL) were used to determine the factors that influence the choice of agricultural information sources and pathways (Table 2). The choices made from the alternatives depended on a number of factors such as socio-economic factors and institutional factors. A typical MNL model uses this form:

\[ P_{ij} = \beta_0 + \beta_i X_i + \epsilon \]

where \( P_{ij} \) is the probability of choice of a given AIC pathway/source; \( X_i \) factors affecting the choice of AIC pathway/source; \( \beta_i \) is set of parameters to be estimated, \( j \) is alternative choices of AIC pathways/source; \( \epsilon \) represent randomized errors; \( i \) is individual respondent.

The Multinomial Logit (MNL) model was used to analyse the factors influencing choice of agriculture information source and pathways. MNL is a multi-equation model used because it predicts a nominal dependent variable given one or more independent variables. It is also simple to compute than its counterpart, the multinomial probit model.

RESULTS AND DISCUSSION

Socio-Economic Characteristics of the Respondents

Data depicted in Table 2 indicated that greater than one fourth (28.5%) of respondents were more than 50 years old followed by almost one fifth (20.8%) young aged respondents. Furthermore, half of the respondents appeared with age bracket of 31-50 years. Furthermore, half of the respondents appeared with age bracket of 31-50 years. Age is an important factor that influences the adoption of new technologies because it is said to be a primary latent characteristic in adoption decisions (Akudugu et al., 2012). Relatively few youths were involved in farming activities probably because they did not want to soil themselves. In addition, many young farmers do not have adequate resources. A lot of studies have found that age had a positive influence on adoption of agricultural technologies (Deressa et al., 2008; Akudugu et al., 2012). Age is correlated with farming experience and it is possible that as one advances in age, experience with farming technology also increases, hence decrease in choice of sources used, given that information has already been acquired through experience. Female headed-households (52.0%) were more than male headed households (48.0%). This can be attributed to the fact that the women remain at home to farm while the men migrate from rural to urban areas in search for employment and income generation.

Approximately 87% respondents appeared literate to varied level of education followed by almost 13% illiterate respondents. Among literates proportion of primary passed respondents (62.5%) appeared prominent. High literacy level suggests that adoption of new technology will be high as knowledge about available opportunities may influence the choice of sources and pathways to use. The level of education plays a critical role in the transformation process to transfer technology, assist farmers in problem-solving and enables them to be more embedded in the agricultural knowledge sharing (Balangaliza, 2014). The results corroborate with the findings of Rehman et al. (2011) that more educated farmers had more access to agricultural information. The household size is
often linked to supply of farm labour and its largeness exerts a positive effect on adoption of technologies. The results indicate that family size ranged from one to fifteen persons with an average of about 6 – 10 members (55.7%). Large families are sometimes presumed to assist in farms’ labour requirements (Ayuya, 2010). Higher number of family members leads to decision to take risk for participation in technology packages thus leading to accessing information. Conversely, large households imply that a lot of resources and technologies are needed to manage their farms.

Table 2: Socio-economic characteristics of the respondents (n = 379)

<table>
<thead>
<tr>
<th>Demographic characteristics</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age distribution</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below 30 years</td>
<td>79</td>
<td>20.8</td>
</tr>
<tr>
<td>31 - 40</td>
<td>92</td>
<td>24.3</td>
</tr>
<tr>
<td>41 - 50</td>
<td>100</td>
<td>26.4</td>
</tr>
<tr>
<td>Above 50 years</td>
<td>108</td>
<td>28.5</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>182</td>
<td>48.0</td>
</tr>
<tr>
<td>Female</td>
<td>197</td>
<td>52.0</td>
</tr>
<tr>
<td><strong>Marital Status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>293</td>
<td>77.3</td>
</tr>
<tr>
<td>Unmarried</td>
<td>86</td>
<td>22.7</td>
</tr>
<tr>
<td><strong>Education Level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No formal Education</td>
<td>49</td>
<td>12.9</td>
</tr>
<tr>
<td>Primary</td>
<td>237</td>
<td>62.5</td>
</tr>
<tr>
<td>Secondary</td>
<td>69</td>
<td>18.2</td>
</tr>
<tr>
<td>Tertiary</td>
<td>14</td>
<td>3.7</td>
</tr>
<tr>
<td>Adult Literacy</td>
<td>8</td>
<td>2.1</td>
</tr>
<tr>
<td>University</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Household size</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - 5</td>
<td>130</td>
<td>34.3</td>
</tr>
<tr>
<td>6 - 10</td>
<td>211</td>
<td>55.7</td>
</tr>
<tr>
<td>11 - 15</td>
<td>35</td>
<td>9.2</td>
</tr>
<tr>
<td>16 - 20</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>Farm Size (Ha)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.00</td>
<td>241</td>
<td>63.6</td>
</tr>
<tr>
<td>2.00</td>
<td>115</td>
<td>30.3</td>
</tr>
<tr>
<td>3.00</td>
<td>20</td>
<td>5.3</td>
</tr>
<tr>
<td>4.00</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>5.00</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>6.00</td>
<td>1</td>
<td>0.3</td>
</tr>
</tbody>
</table>

About 62.5% of farmers did not own title deeds. Land ownership with title deeds enables a farmer to have the right of usage which allows them to access new technologies and invest into the farm. Title deeds allow farmers to use land as collateral for loans. Ownership of land influences adoption of technology and hence agricultural productivity. About 64% of the farmers owned 1.0 hectare while the rest owned more than 2.0 hectares. The size of land determines the ability to acquire credit and act as collateral (Achieng’, 2014). Farmers with small farms place less interest on new and advanced technologies compared to commercialized farms (Akudugu et al., 2012; Abdullah & Samah, 2013).

Farming is the most important source of livelihood for majority (90.5%) of the farmers in Ndhiwa. Thus a meagre 9.5% obtained income from off-farm activities. The influence of off-farm income in the adoption of new technologies is derived from the fact that income earned can be used to finance the accessing agricultural information from other sources. Household with off-farm income might be motivated to invest in the uptake of new innovation (Ayuya, 2010).

Agricultural Information Sources

According to the findings documented in Table 3 revealed that 40.88% of the respondents indicated that fellow farmers were perceived most preferred agricultural information source by 40.88% respondents while Agricultural Extension Officers, researchers and CBOs were perceived information sources by 25.1 and 18.52% respondents respectively. Fellow farmers are popular sources of information because they foster solidarity, similar background and build morale by relying on each other (Kipkurgat, 2015). Farmers meet their peers and exchange ideas, information and knowledge among themselves. Opara (2008) also noted that fellow farmers were a very useful source of information in their findings. Agricultural extension services were rated second probably because the farmers could not reach the staff and the training activities such as field days, seminars, workshops were rare. While farmers consider agricultural information disseminated by extensionists to be accurate and reliable, farmer’s accessibility to new technologies is lacking due to problems associated with the extension system in Kenya (Kipkurgat, 2015). The change in extension models to demand driven coupled with devolution of agricultural activities from the central government may have served to weaken it. Previously, farmers would contact agricultural extension service providers for clarification on technical issues before making decisions (Etwire et al., 2013).

Researchers and Community Based Organizations (CBOs) were the least ranked by 18.52% of the respondents, probably because information disseminated is too technical for farmers. Researchers also often pass information to extension staff who disseminate to farmers albeit inaccurately at times. Jaetzold et al. (2006) in their study found that
information flow from research to the farmer and vice versa is hampered by the lack of a common source of reference.

Table 3: Sources of agricultural information used

<table>
<thead>
<tr>
<th>Sources</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fellow farmers</td>
<td>40.88</td>
</tr>
<tr>
<td>Agriculture Extension Officers</td>
<td>25.31</td>
</tr>
<tr>
<td>Researchers/CBOs</td>
<td>18.52</td>
</tr>
<tr>
<td>Agrovets, markets</td>
<td>15.29</td>
</tr>
</tbody>
</table>

Agricultural Information Pathways
The main agricultural information pathways mentioned by the respondents were personal media (67.6%), electronic media (17.2%), print media (8.0%) and those who did not access (6.3%) of the respondents (Table 4).

Farmer-to-farmer contact enables farmers to exchange news and adopt new technology, especially from experienced fellow farmers. Farmers get information from fellow farmers because of the proximity and perceived less risk. Agricultural information available to farmers is abundant but the main problem is getting what is relevant and quickly (Kipkurgat, 2015).

Extension workers, fellow farmers, consultants/specialists disseminate agricultural information through seminars, workshops, trainings, meetings and demonstrations. Some farmers hinted that they were too old to attend the barazas so they relied on fellow farmers (neighbours) for advice whenever they countered problems. Farmers attended barazas because the knowledge providers had more accurate and reliable information on sorghum production (Kitetu & Chai, 2009).

Radio as mentioned by 17.2% of the respondents was the most popular mass medium of communication in the study area. Agricultural information can be transmitted to large numbers of rural poor farmers through radio. Communicating on vital subjects, educating people on new practices in their local language could enhance sorghum production. The coverage by radio is wide and has the ability to pass information that can reach all farmers (Irfan et al., 2006). Rural radio is an excellent communication tool and pathway that enhances and improves sharing of agricultural information in Ndhiwa though the time of delivery is not appropriate.

Trainings, seminars and demonstrations were pathways used mainly by researchers, CBOs and extension staff to disseminate information to farmers. This concurs with findings by Balangaliza, (2014) where the use of trainings was found as an important means of information dissemination on the uptake of technology on legume production. Agricultural workshops are organized at local sub-county levels at regular intervals during which participants are exposed to new farming technologies.

About 8.0% of the respondents indicated print media as represented by brochures and newspapers. Brochures were the most commonly accessed form of print media. This is so because it has been proved to be an effective means for disseminating information, especially in introducing new technologies to target users (Irfan et al., 2006). Information in the brochures if well processed and packaged could be relevant to farmers’ need or interest. Presently in Kenya, a lot of printed materials are being published regularly by public and private organizations for the dissemination of agricultural information, for example Seeds of Gold by the Daily Nation, The Organic Farmer (TOF) by the International Centre of Insect Physiology and Ecology (icipe) and Biovision Africa Trust (BvAT), and Smart Farming by the daily.

Table 4: Channels used to disseminate information from the source to farmers

<table>
<thead>
<tr>
<th>Agricultural Information Channels</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Print Media</td>
<td>8.0</td>
</tr>
<tr>
<td>Personal Media</td>
<td>67.6</td>
</tr>
<tr>
<td>Electronic Media</td>
<td>17.2</td>
</tr>
<tr>
<td>Did not access</td>
<td>6.3</td>
</tr>
</tbody>
</table>

Factors influencing the Type of Agricultural Information Sources
The empirical findings in Table 4 show that gender, age, experience and education of household head, farm size, land ownership, employment/off-farm activities, access to credit facility and group membership significantly influenced agricultural information sources.

Gender of household head positively influenced researchers/CBOs (7.3%) but negatively influenced fellow farmer (10.1%) as agricultural information sources. A male headed household had a higher probability of accessing researchers but a lower probability of choosing fellow farmer. This is probably because male headed households are endowed with resources to attend trainings facilitated by researchers mostly in research centres. Female
headed households are known to control assets particularly important for household food security and for child outcomes and rarely for trainings. Women invest substantially in nutrition, education and healthcare for their children (Shroff et al., 2009) and therefore they would seek for information from nearer sources like fellow farmers.

### Table 5: Marginal effect results of Multinomial logit on factors influencing the choice of agricultural information Pathways

<table>
<thead>
<tr>
<th>Variable</th>
<th>Training</th>
<th>Brochures</th>
<th>Farmer-to-farmer</th>
<th>Radio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dy/dx</td>
<td>P&gt;</td>
<td>z</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>0.034</td>
<td>0.268</td>
<td>0.006</td>
<td>0.592</td>
</tr>
<tr>
<td>Age</td>
<td>-0.049</td>
<td>0.000</td>
<td>-0.011</td>
<td>0.234</td>
</tr>
<tr>
<td>Experience</td>
<td>0.000</td>
<td>0.907</td>
<td>-0.003</td>
<td>0.152</td>
</tr>
<tr>
<td>Education</td>
<td>0.040</td>
<td>0.012</td>
<td>0.039**</td>
<td>0.003</td>
</tr>
<tr>
<td>Farm Size</td>
<td>0.005</td>
<td>0.616</td>
<td>0.029</td>
<td>0.012</td>
</tr>
<tr>
<td>Land Ownership</td>
<td>-0.022</td>
<td>0.435</td>
<td>-0.025</td>
<td>0.681</td>
</tr>
<tr>
<td>Off farm income</td>
<td>0.051</td>
<td>0.348</td>
<td>0.048</td>
<td>0.297</td>
</tr>
<tr>
<td>Group Membership</td>
<td>0.129**</td>
<td>0.050</td>
<td>0.097**</td>
<td>0.003</td>
</tr>
</tbody>
</table>

n = 379; Wald chi²(36) = 160.38; Log likelihood = -491.746; Prob> chi² = 0.0;

Note: ***, **, * = significant at 1%, 5%, and 10% level, respectively

Age of the household head had a positive influence on agricultural extension officers (96%) and fellow farmers (67%) while negatively influencing researchers/CBOs (6%) as sources of information. This is probably because the agricultural extension officers were willing to train and visit farmers in the baraza. It could also be as farmers become older they become immobile to go for trainings facilitated by researchers therefore opting for nearer source like fellow farmers. Age of the household head had a positive and significant influence on the choice of agricultural extension officers as sources of information. More educated and experienced farmers are in a better position to assess the relevance of new technologies. Extension staff is educated and are more likely to communicate and be trusted by the educated farmers. As farmers gain higher education, they are able to interpret and decipher new information faster hence making better decisions on adoption. Furthermore, one focuses on getting training, building skills on new technology.

Farming experience had a significant but negative influence on the choice of agricultural extension as a source of information. When one advances in age, the number of extension contacts decrease by 0.5% due to the years of farming experience acquired. This implies that as farmers gain more farming experience, the number of demand driven extension contacts reduced. More experienced farmers are able to evaluate the usefulness of the extension information received in the past, thus guiding their future demand for extension services (Gido, 2014). This concurs with findings by Murage et al., (2012) that farmers who are experienced are more likely to adopt new farming methods from fellow farmers.

Farm size significantly influenced the choice of agricultural extension, researcher/CBO and fellow farmers as sources of information. An increase in farm size by one hectare increased the probability of choosing agricultural extension (2.2%) but reduced the probability of choosing fellow farmer (3.8%). Farmers with large size are more likely to adopt technologies than farmers cultivating small land sizes since they can afford to devote part of their fields to try the improved technology. Mariano et al. (2012) and Kansiime et al., (2014) noted that access to extension has been linked to improved technologies. Moreover, farm size is often taken as indicator of better resource base. The decrease in choosing fellow farmer as a source of information is attributed to farmer’s belief that fellow farmers are more likely to adopt new farming methods from fellow farmers.
farmer’s indigenous knowledge is not accurate, credible and reliable (Davis et al., 2012).

Access to credit facilities significantly influenced the choice of agricultural extension and fellow farmer as a source of information. Agricultural extension was positively influenced because farmers who accessed credit facilities could seek for extension services like trainings, technologies and information materials. Credit facilities could also be used to purchase farm inputs and produce surplus for markets (Kansiime, et al., 2014). Momanyi et al., (2015) also cite access to credit as a vital role in the process of small holder commercialization. On the other hand, access to credit negatively influenced the choice of fellow farmer as a source of information. Credit loaned to farmers enables them to source for more credible, authentic, and reliable information from agricultural extensionist and not fellow farmers.

Group membership had a positive influence on the use of agricultural extension, researchers/CBOs and fellow farmer by 22.1%, 11.1% and 30.1% respectively. Farmers who belonged to a group may influence one another to choose latest technologies. In addition, farmers who belonged to farmers’ organization were able to access inputs at slightly lower rates and encourage members to work very hard. Farmer related groups and organizations increase the chances with which extension agents contact members, thus reducing cost of service delivery and service providers. In addition, agricultural extension service and researchers/CBOs enhance knowledge base of farmers through various ways, such as demonstrations, specific training and group meetings. According to Ofuoku & Agbamu (2012), farmers join farmer associations with the objective of accessing extension services, credit facilities, information and capacity building.

The variables age of household head, education of household head, farm size, farming experience of household head, membership and access to credit facilities had a significant influence on the choice of pathways (Table 6).

Age of the household head was significant and negatively influenced training but positively influenced farmer-to-farmer as a pathway of information. The negative influence of age on training could be because older farmers were less mobile to attend the trainings. Younger farmers are more receptive to new ideas, active, adventurous and mobile and thus they preferred training. In regards to farmer-to-farmer approach, older farmers have less mobility and would prefer nearer sources like farmer-to-farmer. This result is consistent with what Daudu et al., (2009) found out that older farmers interacted with those nearer to them. Education level of the household head had a positive and significant influence on the choice of brochures as information pathway. This could be attributed to the household heads with higher levels of education engaging in off-farm activities which limit the time available to learn agricultural technologies. Higher level of formal education equips farmers with knowledge and skills thus facilitating awareness of the innovation and making informed decision concerning a particular technology. It further equips them with ability to read and write, hence using print as a source of information like brochures. Brochures provide them with the necessary information they can comprehend at their convenient time. The results are consistent with Faturoti et al., (2006) who found higher level of formal education facilitating awareness of innovation in agriculture. Education is expected to positively influence a farmer’s ability to source and decipher information. Rehman et al., (2011) found a highly positive significant relationship between the respondents’ education and level of awareness.

Factors Influencing Choice of Agricultural Information Pathways

Table 6: Marginal effect results of Multinomial logit on factors influencing the choice of agricultural information Pathways

<table>
<thead>
<tr>
<th>Variable</th>
<th>Training</th>
<th>Brochures</th>
<th>Farmer-to-farmer</th>
<th>Radio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dy/dx</td>
<td>dy/dx</td>
<td>dy/dx</td>
<td>dy/dx</td>
</tr>
<tr>
<td>Gender</td>
<td>0.034</td>
<td>0.268</td>
<td>0.006</td>
<td>0.592</td>
</tr>
<tr>
<td>Age</td>
<td>-0.049</td>
<td>0.000</td>
<td>-0.011</td>
<td>0.234</td>
</tr>
<tr>
<td>Experience</td>
<td>0.000</td>
<td>0.907</td>
<td>-0.003</td>
<td>0.152</td>
</tr>
<tr>
<td>Education</td>
<td>0.040</td>
<td>0.012</td>
<td>0.039***</td>
<td>0.003</td>
</tr>
<tr>
<td>Farm Size</td>
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<td>Land Ownership</td>
<td>-0.022</td>
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<td>-0.025</td>
<td>0.681</td>
</tr>
</tbody>
</table>

11th Egerton University International Conference and Innovation Week
Farm size had a negative influence on the choice of farmer-to-farmer (5.3%) approach while positively influencing the choice of brochures (2.9%) as information pathways. Increasing the farm size by 1 hectare meant that farmers had a higher likelihood to source agricultural information from brochures as they are perceived to be credible, reliable and accurate. The negative influence of farm size on farmer-to-farmer approach of information dissemination is probably due to smaller farms having lower levels of diversification and competition of land for other uses and probably doing the same things as their neighbours or fellow farmers. Farmers with larger farms are likely to uptake a technology than those with small farms (Balangaliza, 2014). Farm size is also an indication of resource endowment in Western Kenya (Sanginga and Woomer, 2009).

There was significant influence of land ownership rights on choice of farmer-to-farmer dissemination approach as an information pathway. Farmer-to-farmer interaction provides information that helps in making the right decision on investment. In addition, the local language is understandable hence influencing the decision to share with a fellow farmer. Land rights are essential in motivating farmers to make short and long-term fixed investments that will increase agricultural productivity and rural household incomes (Akudugu et al., 2012). Land ownership indicates that land enhances chances of diversification into a variety of enterprises, impacting on farm profitability and poverty reduction.

Group membership positively and significantly influenced trainings and brochures while negatively influenced farmer-to-farmer dissemination model as information pathway. Organizations normally train farmers in groups which help in cutting down on costs. Further, farmers in groups are capable to request to be trained mostly by extension service providers in their area of interest. During trainings, brochures are distributed to members for further references. The findings agrees with Troung (2008) who cites farmers in associations could be trained easily without considering the geographical locations of the farmers thus making it cheaper on the cost of transporting farmers. According to Okuthe et al., (2013), social participation is important because it indicates the extent of contact farmers have with organized groups. However, group members decreased the likelihood of sourcing for information from farmer-to-farmer dissemination because they perceived them as not being authentic and credible. Bukenya et al., (2008) also noted that more educated farmers were often more reluctant to learn with other farmers or in groups. Sanginga & Woomer (2009) also found that technological packages are best distributed through existing community-based and farmer organizations that provide peer support to participating farm households. An individual small scale farmer is a weak player in the market hence belonging to a group would increase their bargaining power.

**CONCLUSION AND RECOMMENDATION**

Agricultural information plays a central role in building a strong, self-sufficient and sustainable agricultural economy. It impacts on agricultural production, marketing and thus improves livelihoods. Agricultural information contributes to solving food security, hunger and poverty problems while impacting on agricultural production and marketing in Ndhiwa Sub-County. It is therefore vital for farmers to possess such information to meet their needs. It can be concluded that the appropriate sources and pathways be combined to bring the force in adopting the new technologies. Fellow farmers, agricultural extension services, and the researchers/CBOs were the major sources of information on sorghum production. The main pathways however were farmer-to-farmer, barazas, radios, trainings/workshops i.e. personal and print were the main media of information and electronic pathway was rarely used. The main reason for this may be that the alternative channels are expensive and not easily accessible. Extension service was not as effective probably because of the poor infrastructure.

The following factors: gender, age, farming experience and level of education of the household head, farm size, land ownership, employment/off-farm activities, and access to credit facility and group membership positively and significantly influenced the choice of agricultural information sources.
A focal farmer be selected using a set of criteria and a centre established so as to link the sources and farmers for ease and quick accessibility of information. The organization of farmers into associations by government and NGOs, provision of agricultural information and communication, training and education to farmers may increase farmers’ access to the use of agricultural information.

Therefore, for sorghum production to be increased in Ndziwa Sub-County, effective dissemination of agricultural information from the source and by the pathways, ought to be timely, cost effective and accurate. NGOs organizing women into groups for capacity building can empower and make them have “voice” in agricultural development. The sorghum farmers from Ndziwa Sub-County and Kenya at large should liaise with researchers from agricultural institutions, service providers and develop local contents for farmers’ needs to be fed to tele-centres and later communicated to farmers in rural areas.

FURTHER RECOMMENDATION

Need for supply and marketing system to be put in place and promotion done on the sorghum and the improved varieties. The research and extension agents should embark on campaigns of the importance of sorghum since it is gluten free and good for health.

ACKNOWLEDGEMENT

I owe special gratitude to my husband, the late Prof. R. K. Obura, for his support, insight and wisdom throughout the research. I wish to acknowledge and appreciate my employer, Egerton University for allowing me to study whilst keeping my job. I would like to sincerely thank my supervisors Professor Isaiah Masinde Tabu and Dr. David Mulama Amudavi during the write up of the thesis from which this paper is published. They tirelessly shared much knowledge and guided me through this work. Be blessed abundantly. Finally, I thank God for His wonderful mercies to enable me complete my study successfully.

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Demiriyurek, K. (2010). Information Systems and Communication Networks for Agriculture and


EFFECTIVENESS OF AGRICULTURAL EXTENSION WILDLIFE MITIGATION STRATEGIES ON HUMAN-WILDLIFE CONFLICT AMONG SMALLHOLDER AGRO-PASTORALISTS: A CASE OF SMALLHOLDER MAIZE FARMERS IN LAIKIPIA COUNTY, KENYA

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Email: ronnyorare@yahoo.com

ABSTRACT

Agriculture is critical in achieving food security, creating employment opportunities, economic growth, and also supplying raw materials for agro-based industries in many Sub-Saharan countries. However, farmers experience various challenges which undermine agricultural productivity and production. One of the most pressing challenges that smallholder maize farmers face in some parts of Kenya is human-wildlife conflict (HWC). Human-wildlife conflict arises from either human encroachment on wildlife habitats or wildlife movement from their habitat into neighboring farmland. Smallholder farmers use various agricultural extension strategies to mitigate the conflict. However, the effectiveness of the mitigation strategies used by smallholder maize farmers in Laikipia County had not been studied and information on the same was inadequate and poorly documented. This study sought to establish the effectiveness of the agricultural extension wildlife conflict mitigation strategies used by smallholder maize farmers in Laikipia County. Primary data was collected from farmers and extension agents using semi-structured questionnaires while secondary data was collected using a document review guide. Descriptive statistics were used to analyze primary data. It was established that crop damage was on an increasing trend although farmers used various mitigation strategies such as growing of unpalatable plants along edges of their farms, live fences and digging trenches that are promoted through extension service. This study concluded that the agricultural extension mitigation strategies used were not effective. It therefore recommends concerted efforts between all stakeholders in the conflict zone to realize the benefits of synergies so as to stem crop damage and give the smallholder farmers in Laikipia County a chance to be food secure.

Key words: Effectiveness, human-wildlife conflict, mitigation strategies, smallholder farmer

INTRODUCTION

The agriculture sector is critical for the achievement of food security (AGRA, 2013), growth of world economies, in addition to employing more than 2 billion people and contributing about 30% of the Gross Domestic Product (GDP) (Hanson, 2013). The sector employs 65% of African workforce and is a source of the total GDP (Huho & Kosonei, 2013). In developing countries, growth of the agriculture sector significantly increases income generation and poverty reduction (World Bank, 2012). It is therefore considered pivotal in achieving sustainable development goal (SDG) 1, which seeks to reduce the level of poverty in the world. In Kenya, agriculture is a major source of food, income and employment besides accounting for 65% of the total national export, 18% of formal employment and 70% of informal employment (Biwott et al., 2009). Although agriculture contributes significantly towards achieving food security, economic development and employment creation, smallholder farmers in different parts of the world experience various challenges. Smallholder farmers in Africa suffer from effects of wildlife menace (Lamarque et al., 2009). Smallholder farmers in Kenya, including Laikipia County also experience the problem of human-wildlife conflict (GoK, 2010; GoK, 2012; MFW, 2012). Human-wildlife conflict is a phenomenon experienced in different parts of the world where wildlife and people compete for limited resources as well as share boundaries (Eniang et al., 2012; Musimbi, 2013). An occurrence of human-wildlife conflict results in injury or death of livestock or even humans, loss of crops, damage to infrastructure or disease transmission.

To mitigate human-wildlife conflict, farmers are trained on various Agricultural Extension Wildlife Mitigation Strategies (AEWMS) by agricultural...
extension service providers. Extension workers in the Ministry of Agriculture, Livestock and Fisheries (MoALF) promote growing of crops that are unpalatable to wildlife such as chilli, pyrethrum and tobacco and growing of hairy or spiked crop varieties. Other strategies include growing of tightly covered maize cobs/husks, construction of trenches round the farm to form a barrier against wildlife and also growing of live fences round the farm using mauritius thorn, kai apple or sisal. Although the Kenya Wildlife Service (KWS) is mandated to conserve wildlife, it also promotes human-wildlife conflict strategies such as construction of trenches round the farm to form barriers against wildlife (KWS, 2016). The other mitigation strategies include planting natural fences such as sisal and growing of unpalatable crops such as chilli. In Kenya, human settlement and agricultural activities are allowed in forest areas and the areas bordering forests such as in Rumuruti Forest (Ministry of Land and Physical Planning, 2016). Further, wildlife are conserved in areas not gazetted or protected as wildlife habitats. Further, the Forest Act of 2005 (Republic of Kenya, 2014) permits conversion of forest land to other uses such as agriculture. In addition, although existing wildlife conservation policy emphasizes conservation of wildlife in protected areas, it does not reduce human-wildlife conflict in unprotected areas and areas bordering protected wildlife habitats. The incompatible land uses have resulted in land use conflicts, including human-wildlife conflict. This could be due to lack of a land use policy in Kenya. This shows that the challenges facing farmers are being addressed by uncoordinated legal and policy frameworks. Consequently, smallholder farmers continue to experience human-wildlife conflict. However, the effectiveness of the agricultural extension wildlife mitigation strategies being used by smallholder maize farmers in Laikipia County had not been studied and the information about the same was inadequate and poorly documented.

STATEMENT OF THE PROBLEM

Agriculture is important in Kenya’s economic development, generation of income and employment and provision of raw materials for industries. However, the agriculture sector is facing various challenges, one of them being human-wildlife conflict. It results from human encroachment on wildlife habitats or movement of wildlife out of their unprotected habitats such as Rumuruti Forest or protected areas into surrounding farmland. Wildlife moves freely out of their habitats into the neighboring farmland where they damage crops, injure or kill livestock or even people. Although farmers experience human-wildlife conflict, the government of Kenya considers the tourism industry as one of key engines of economic development, with wildlife being the base for the industry. Available information on the effectiveness of Agricultural Extension Wildlife Mitigation Strategies used by smallholder maize farmers was inadequate and poorly documented. This study sought to avail the information to policy makers and agricultural extension service providers to enable them plan better on how to reduce human-wildlife conflict among smallholder farmers.

OBJECTIVES OF THE STUDY

This study was guided by the following objectives:

i) To determine the Agricultural Extension Wildlife Mitigation Strategies used by smallholder maize farmers in Laikipia County.

ii) To establish the severity of crop damage among smallholder maize farmers in Laikipia County

iii) To establish the effectiveness of the Agricultural Extension Wildlife Mitigation Strategies used by smallholder maize farmers in Laikipia County.

RESEARCH METHODOLOGY

This study was conducted through administration of semi-structured questionnaires and document review and analysis using a document review guide. Both the document review guide and questionnaires were developed by the researcher and validated by agriculture education and extension experts at Agricultural Education and Extension Department of Egerton University. One questionnaire was administered on 203 smallholder maize farmers while the other was administered to 10 extension agents in Laikipia County. The document review guide and questionnaires were used to collect data on the severity of crop damage, agricultural extension wildlife mitigation strategies used and their effectiveness among smallholder maize farmers in Laikipia County. Primary data was analysed using frequencies, percentage and mean.

Agricultural Extension Wildlife Mitigation Strategies (AEWMS) Used by Farmers

The major wildlife in Laikipia County which attack maize includes monkeys, elephants, buffalo, squirrel, porcupine, hippotamus and birds. Smallholder maize
farmers use various AEWMS strategies against wildlife attack, as shown in Table 1.

Table 1: Agricultural Extension Wildlife Mitigation Strategies Used

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Wildlife</th>
<th>Farmers (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integration of unpalatable crops in a crop rotation cycle: sunflower, beans, pyrethrum</td>
<td>Monkey</td>
<td>0.9</td>
</tr>
<tr>
<td>Growing 2-3 lines of chilli round the main crop, as a repellent</td>
<td></td>
<td>9.0</td>
</tr>
<tr>
<td>Growing live fence such as Mauritius thorn to serve as a barrier</td>
<td></td>
<td>10.9</td>
</tr>
<tr>
<td>Growing unpalatable crop such as chilli, tobacco, pyrethrum and sunflower round the main crop</td>
<td>elephant</td>
<td>10.4</td>
</tr>
<tr>
<td>Incorporating fodder fodder in a crop rotation cycle</td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>Digging trenches 2m wide, 1.5m deep round the farm to form barrier</td>
<td></td>
<td>12.2</td>
</tr>
<tr>
<td>Growing live fence using Mauritius thorn round the farm to form barrier</td>
<td></td>
<td>12.7</td>
</tr>
<tr>
<td>Growing unpalatable crop such as pyrethrum and sunflower as main crop</td>
<td>buffalo</td>
<td>11.7</td>
</tr>
<tr>
<td>Growing unpalatable crop such as pyrethrum and sunflower round the farm to form barrier</td>
<td>zebra</td>
<td>8.4</td>
</tr>
<tr>
<td>Growing unpalatable crop such as pyrethrum and sunflower round a crop to act as a repellant</td>
<td>zebra</td>
<td>10.0</td>
</tr>
<tr>
<td>Dressing seeds with pesticides to make them unpalatable and poisonous</td>
<td>squirrel</td>
<td>0.5</td>
</tr>
<tr>
<td>Using correct seed rate to attain correct plant population, having strong stems to resist bending when climbed</td>
<td>porcupine</td>
<td>0.5</td>
</tr>
<tr>
<td>Digging trenches 6ft x 6ft x 6ft round the farm to form barrier</td>
<td>hippos</td>
<td>9.5</td>
</tr>
<tr>
<td>Growing maize varieties which have tightly covered husks or cobs</td>
<td>birds</td>
<td>1.8</td>
</tr>
</tbody>
</table>

These findings agree with other studies which showed that in African countries small-scale farmers grow unpalatable crops such as chilli to mitigate elephants (Hocking & Humle, 2009; King et al., 2011). Chilli is also used in Queen Elizabeth Park Area (QEPA) (Babaasa et al., 2013). Live fences are used in Kibale and Bwindi areas of Uganda against elephants, baboons and gorillas while trenches are used against elephants and buffaloes in Kibale and QEPA regions.

Severity of Crop Damage
This study established that maize crop damage among smallholder maize farmers in Laikipia County experience severe crop damage of even up to 70% per acre, as shown in Table 2.

Table 2: Maize Crop Damage

<table>
<thead>
<tr>
<th>Year</th>
<th>Damage/acre (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>68 (n=167)</td>
</tr>
<tr>
<td>2013</td>
<td>69 (n=174)</td>
</tr>
<tr>
<td>2014</td>
<td>70 (n=187)</td>
</tr>
<tr>
<td>2015</td>
<td>69 (n=182)</td>
</tr>
</tbody>
</table>

These findings agree with those in Nigeria which showed that crop damage by wildlife is up to 98% per acre per year (Eniang et al., 2011) and 65% of maize crop per year in Tomboro area of Cameroon (Eyebe et al., 2012). These high crop damage values could mean that the agricultural extension mitigation strategies used by smallholder farmers are not effective.

Effectiveness of Agricultural Extension Wildlife Mitigation Strategies Used by Farmers
In this study effectiveness referred to the degree to which the AEWMS could reduce crop damage by at least 10%. The AEWMS were ranked on a five-point Likert scale by both sampled farmers and extension agents. This study established that the AEWMS used by maize farmers in Laikipia County have low effectiveness. For instance growing a live fence round a maize crop is 25% effective, growing unpalatable crops such as sunflower, chilli, pyrethrum or tobacco round a maize field is 25% effective while digging trenches round a maize crop to serve as a barrier against wildlife is 33% effective (Table 3).
Table 3: Effectiveness of Agricultural Extension Wildlife Mitigation Strategies

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Wildlife(s)</th>
<th>Not effective</th>
<th>Effective</th>
<th>Very effective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrating unpalatable crops such as sunflower, beans, pyrethrum in a crop rotation</td>
<td>monkey</td>
<td>25</td>
<td>30</td>
<td>15</td>
</tr>
<tr>
<td>Growing 3 lines of chilli round the main crop to serve as a repellant</td>
<td></td>
<td>23.8</td>
<td>28.6</td>
<td>15</td>
</tr>
<tr>
<td>Growing live fence using Mauritius thorn to serve as a barrier</td>
<td>Buffalo, elephant</td>
<td>16.7</td>
<td>25</td>
<td>16.7</td>
</tr>
<tr>
<td>Growing unpalatable crop round the main crop: sunflower, pyrethrum, tobacco as repellant</td>
<td>elephant</td>
<td>20.83</td>
<td>25</td>
<td>12.5</td>
</tr>
<tr>
<td>Growing fodder such as Rhodes grass</td>
<td>elephant</td>
<td>16.7</td>
<td>25</td>
<td>16.7</td>
</tr>
<tr>
<td>Growing unpalatable crops such as tobacco, onion as main crop</td>
<td>Elephant</td>
<td>20.8</td>
<td>25</td>
<td>12.5</td>
</tr>
<tr>
<td>Digging trenches round the farm to form barrier</td>
<td>Elephant, impala, gazelle, hippo elephant</td>
<td>14.81</td>
<td>33.3</td>
<td>7.41</td>
</tr>
<tr>
<td>Growing live fence such as Mauritius thorn round the farm to form barrier against entry</td>
<td>buffalo</td>
<td>14.3</td>
<td>21.4</td>
<td>14.3</td>
</tr>
<tr>
<td>Growing live fence such as Mauritius thorn round the farm to form barrier against entry</td>
<td>zebra</td>
<td>18.2</td>
<td>27.3</td>
<td>18.2</td>
</tr>
<tr>
<td>Growing unpalatable crops such as sunflower, pyrethrum as main crop</td>
<td>zebra</td>
<td>26.3</td>
<td>31.6</td>
<td>15.8</td>
</tr>
<tr>
<td>Growing live fence using Mauritius thorn round the farm to form a barrier</td>
<td>zebra</td>
<td>18.2</td>
<td>27.3</td>
<td>18.2</td>
</tr>
<tr>
<td>Dressing seeds with pesticides to make them unpalatable or poisonous</td>
<td>squirrel</td>
<td>50</td>
<td>45</td>
<td>35</td>
</tr>
<tr>
<td>Growing live fence using Mauritius thorn to form barrier round the farm</td>
<td>Antelope, gazelle, impala</td>
<td>17.4</td>
<td>26.1</td>
<td>17.4</td>
</tr>
<tr>
<td>Digging trenches 6ft x 6ft x 6ft round the farm</td>
<td>Antelope, gazelle, impala</td>
<td>18.2</td>
<td>27.3</td>
<td>18.2</td>
</tr>
<tr>
<td>Growing maize varieties which have husks/ cobs tightly covered</td>
<td>Antelope, gazelle, impala</td>
<td>17.4</td>
<td>26.1</td>
<td>17.4</td>
</tr>
</tbody>
</table>

The low effectiveness indices imply that the AEWMS used by smallholder farmers in Laikipia County are not effective. Farmers are therefore likely to experience significant crop losses resulting from wildlife attacks hence the high crop damage as shown in Table 2.

A study in the Greater Virunga Landscape (GVL) showed that live fence such as growing Mauritius thorn is effective against baboons, gorillas and bushpigs (Andama, 2009; Babaasa et al., 2013). This is possible only when it is placed in 3 rows, 30cm apart, when branches are layered and intertwined to form an animal-proof barrier.

**RESEARCH RESULTS, CONCLUSION AND RECOMMENDATIONS**

In Laikipia County, wildlife is conserved in Rumuruti Forest which is not a protected area or gazette wildlife habitat. Further, humans are settled and are also allowed to undertake farming in areas bordering unprotected wildlife habitats. Wildlife therefore moves out of their habitats into farmland neighboring their habitats thereby damaging crops. This study also established that small-scale maize farmers use various agricultural extension wildlife mitigation strategies promoted by agricultural extension agents. These strategies include growing of crops that are unpalatable to wildlife such as chilli, pyrethrum, sunflower and tobacco as main crop and growing of unpalatable crops as barrier to main crop. The other strategies used include constructing trenches round the farm to form barrier against wildlife entry, growing crop varieties which have tightly covered cob or husk. However, farmers still experience severe crop losses of up to 70% per acre annually to wildlife attack. Additionally, this study established that AEWMS used by small-scale farmers have very low effectiveness of 33% or
even less. It was therefore concluded that smallholder small-scale maize farmers in Laikipia County could be suffering from human-wildlife conflict resulting from the use of Agricultural Extension Wildlife Mitigation Strategies that are not effective. It was therefore recommended that a study be done to establish factors contributing to the low effectiveness of AEWMS used by smallholder farmers in Laikipia County.

REFERENCES


ANALYSIS OF THE EFFECT OF AGRICULTURAL EXTENSION DEVELOPMENT INITIATIVES ON HOUSEHOLD’S AGRICULTURAL FOOD PRODUCTIVITY AND SUFFICIENCY AMONG SMALL-SCALE FARMERS: A CASE OF KILIFI COUNTY, KENYA

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ABSTRACT

The present study assessed the contributions of the numerous agricultural extension and development initiatives on household agricultural food crop production and its sufficiency among small-scale farmers in Kilifi County in Kenya. Multi-stage sampling techniques namely purposive and proportionate sampling were used to select the study area and the sample size for the study. Data were analysed using descriptive statistics and inferential statistics t test at p value of 0.025. The results show that agricultural food productivity among small-scale farmers’ households in most of the produce except for small seeded cereals (sorghum and millet), cassava and dairy produce were statistically insignificant. The paper recommends for development of a policy that emphasise the need for the government and development partners to carry out situation analysis prior to implementation of agricultural development initiatives. Situation analysis will ensure promotion of crop varieties and livestock breeds whose performance is supported by the local ecological characteristics, crop varieties that are suitable for the market and at the same time have qualities for long shelf life, last longer in the field after attaining its physiological maturity to allow for piecemeal harvesting. A policy framework should also be developed to provide guidelines on funding of livestock production projects and programmes by the Kenya Government to ensure provision of regular services to farmers.

Key words: Agricultural Development Initiatives, Agricultural Productivity, Household’s Food Sufficiency, Small-Scale Farmers.

INTRODUCTION

The global demand for food is expected to rise steeply due to burgeoning population and shifting dietary preferences. In 2009, the Food and Agriculture Organisation of the United Nations estimated that global food production must increase by 70% to meet demands in 2050 (Schmidhuber & Tubiello, 2007). The most important prospects for increased food production in the short-term are seen in areas where the current land productivity is significantly lower than the potential (Lobell, Cassman & Field, 2009). These differences between actual and potential production are believed to be especially wide in sub-Saharan agricultural systems where large portions of the land are still under subsistence farming mostly among small-scale farmers who form the bulk of food crop producers in this part of the world. Improving food production for the African small-scale farmer remains one of the biggest and most important challenges. This is because low levels of agricultural productivity are at the root of the problems of food security in sub-Saharan Africa (Sasson, 2012; Rosegrant & Cline, 2003). Both developed and developing countries have advanced agricultural technologies aimed at improving agricultural productivity through research institutions that disseminate knowledge to farmers through extension agents. However, agricultural production has continued to be low and even declined in most of the developing countries, especially in Africa and Asia (Madukwe, 2006).

In Kenya, the performance of agriculture, which remains the backbone of the economy, has been sporadic. The production has slackened dramatically over the post-independence years from an average of 4.7% in the first decade to only below 2% in the 1990s. This decline culminated in a negative growth rate of -2.4% in 2000 and then rose to 6.4% in late 2000s and subsequently declined from 6.4% in 2010 to 1.5% in 2011 (Alila and Atieno, 2006; Kenya National Bureau of Statistics [KNBS], 2012). To address the decline, the Kenya government through its Ministry of Agriculture, has developed and disseminated numerous
Agricultural Development Initiatives (ADI) to farmers. The initiatives include National Agricultural Extension Policy (NAEP) which was implemented under National Agricultural and Livestock Programme (NALEP), a national umbrella framework for implementation of programmes and projects supported by Swedish International Development Agency (Government of Kenya, 2016).

Other ADIs include: 1) National Agricultural Sector Extension Policy (NASEP), a reviewed NAEP whose objective is to emphasise on the objectives of NAEP, 2) Strategies for Revitalisation of Agriculture (SRA) whose purpose was to transform Agriculture into a viable and vibrant sector that is commercially oriented and internationally competitive. SRA seeks to boost agriculture sectors’ contribution towards attaining the objectives of the Economic Recovery Strategy for Wealth and Employment Creation. 3) ‘Njaa Marufuku’ Kenya; a 10-year programme formulated in the context of Millennium Development Goal number one (MDG-1), was implemented from 2005-2015. 4) Kenya Agricultural Productivity Programme (KAPP) which was a 12 year multi-sectoral and multi-institutional project implemented in three phases from 2004-2012. Its main objective was to improve the overall agricultural system by dissemination and adoption of agricultural technology aimed at synchronisation of research, extension and farmers’ empowerment initiatives. 5) Kenya Agricultural Productivity and Agribusiness Project (KAPAP) is also another initiative. It aimed to empower stakeholders to transform smallholder agricultural production and marketing systems for increased productivity and incomes in the project areas (GoK, 2016). 6) and the National Accelerated Agricultural Inputs Access Programme (NAAIAP), a collaborative approach by both public and private sector as well as development partners whose primary objective was to improve input access and affordability of the key inputs for millions of smallholder farmers (Sheahan et al., 2014).

Despite all these ADIs aimed at increasing agricultural productivity, availability of food at household level remains a national concern (FAOSTAT, 2013). The initiatives have not achieved the desired objectives in some parts of the country such as Kilifi County, which is ranked among the counties with high incidences of food poverty households in KNBS economic survey on basic report on wellbeing in Kenya of 2005-2006 (KNBS, 2007). Kilifi County’s household food poverty population is 66.1% which is high and therefore of concern. The County household food poverty rating in the year 2005-2006 was 50.0% (KNBS, 2007). 15% of the county’s population relies on relief food most of the time due to poor performance of agricultural food production (Kilifi County Integrated Development Plan [KCIDP], 2013).

THE OBJECTIVE OF THE STUDY

The study was guided by the following specific objectives: To identify the demographic characteristics of the small-scale farmers, and to establish the contributions of ADIs disseminated among small-scale farmers on household agricultural food productivity among small-scale farmers.

METHODOLOGY

The study was conducted in Kilifi County which is located in the coastal region of Kenya. The County covers an area of 50,448 km² (GoK, 2013) with an estimated population of 63,218 individual families. Most of the farmers are mainly small-scale farmers. The study used a combination of purposive sampling, simple random and proportionate random sampling techniques. First, purposive sampling was used to select the County in which the development initiatives were implemented but did not translate to increased agricultural productivity. Simple random sampling was then used to select the three sub-counties. Proportionate random sampling was used to select representative sampling unit from each selected sub-county. One hundred and fifty (150) small-scale farmers were sampled from a sampling frame obtained from the selected focal areas and arrangements. Data were collected using one set of semi-structured questionnaire which was administered to small-scale farmers. Observation schedule was used to collect data on the performance of the crop and livestock activities in the respondents’ field. A focus group discussion was used to provide insights on information elicited from the study sample. Data collected were analysed using descriptive statistics such as percentages, frequencies and graphics. Hypotheses were analysed using t test at α 0.05 using the SPSS version 20.0.

RESULTS AND DISCUSSION

Small-Scale Farmers Personal Profile

The study sought to identify the personal profile that were crucial characteristics that could influence the objective of agricultural development initiatives implemented to increase agricultural productivity.
Biodata of Small-Scale Farmers: Table 1 (Appendix 1) presents summary of statistics of farmers according to gender, age, and education level. From Table 1, there were slightly more (50.3%) female farmers than male farmers. This implies that participation in agricultural development initiatives among small-scale farmers is by both gender. Findings agree with those of Lastarria-Cornhiel (2006) who observed that half of the labour force in agriculture, particularly in rural Africa and Asia are women. Majority (36.3%) of respondents were over 50 years of age. The findings indicate that most of the small-scale farmers who participate in agricultural development initiatives are of advanced age. Most of respondents (65.7) had formal education. The high percentage of farmers with formal education is a pointer to anticipation of high rate of adoption of technology for enhancing agricultural production as it encourages interaction and engagement in negotiations that take place among farmers and outsiders who introduce interventions to the farming community. These findings agree with those of Lock heed et al. (1988, cited in King, 2004) who identified that primary schooling is required to have a significant effect on farm productivity in terms of efficiency and generates skills useful for adoption of innovations.

Land Tenure, Agricultural and operational Holding
Table 2 (Appendix 2) presents the summary statistics of small-scale farmers according to land tenure system, agricultural holding and operational holding. The most common land tenure system was found to be individual ownership (66.7%). The type of land tenure systems may influence farmers’ response and adoption of development initiatives and consequently the crop and livestock productivity. Observations made in the field indicated that the individual land tenure system influenced the type of farming activities a farmer engaged in. The findings are supported by studies done by Garrity, Okono and Parrott (2006) who found that farmers applied somewhat more labour and intensive use of sustainable inputs such as manure, which has long-term positive impact when cultivating their private plots than on hired and communal land. Majority (70.0%) of the respondents owned more than one hectare of land. The highest percentage (64%) of farmers utilised less than two hectares of land. Observations made in the field indicated that vast hectares of land were fallow.

Crop and Livestock Diversification

Table 3 (Appendix 3) shows the variation in the number of crops grown by small-scale farmers in the sampled study area. Only a fraction (2.1%) of the small-scale farmers grew one type of crop with the rest of them engaging in diversified food crop production. Most (62.1%) of the respondents kept one type of livestock. Observations made in the field showed that most of the crops were cultivated on small portions of land and very few of the households kept a combination of cattle, shotes, local poultry, pigs and domestication of birds especially guinea fowls.

Agricultural food Production and Household Food Sufficiency
The findings on household agricultural food production and adequacy are presented and discussed in the following sub-sections. A three months’ period was used to determine the adequacy of produced agricultural food for individual household’s because this is the seasonal period most of the annual crops take to attain maturity in the study area.

Agricultural Food Crop Production
Table 4 (Appendix 4) shows the percentages of households in different categories of the number of bags for commonly grown food crops harvested per hectare prior to and after the implementation of development initiatives in the study area. The results show that production of maize in most households was between 8-16 bags per hectare while sorghum production in most households declined resulting in 85.3% of households with seven or less than seven bags per hectare. Over 80% of households produced 7 or less bags of legume per hectare. Field observation indicated that although the crop is given more priority in most of the development initiatives and small-scale farmers primarily grow it as the major cereal crop, the ecological characteristics do not provide very conducive conditions for it to flourish very well. According to FAOSTAT (2013), technology innovation for increased maize production in Kenya is driven by the value of the crop to the farmers compared to small-seeded cereals such as sorghum and millet which are regarded inferior with very minimal usage. Sorghum as a drought resistant crop and a primary poverty eradication vehicle is promoted as a special project by the Ministry of Agriculture (MoA) and development partners and by projects implemented to promote it in the marginal agricultural areas of Eastern, Nyanza and Coastal regions of Kenya (MoA, 2010). However, millet receives minimal support from the government since it is not a popular cereal among households with very
low demand in the local market (Mukarumbwa and Mushunje, 2010). Legumes among the sampled farmers were grown as intercrop with the cereal crops. The most common legume is cowpeas and pigeon pea grown on very low hectare. A paired sample t-test was performed at a significance level of 0.05 to ascertain any significant differences between the percentage of households in different categories of cereal and legume production before and after the implementation of the development initiatives. The results are summarised in Table 5(Appendix 5). The results indicate that there was a statistically significant difference at $\alpha = 0.05$. The difference could be attributed to the sustained increase in maize production, a staple food and of high value with immediate market demand.

Table 6 (Appendix 6) shows the percentages of households in different categories of number of MT harvested per hectare for commonly grown root crops prior to and after the implementation of development initiatives. The percentage of households with production of 5-7 metric tonnes of cassava increased while those with 10 or more metric tonnes, 2-4 metric tonnes per hectare and without declined. The percentage of households with 5-7 and 2-4 metric tonnes per hectare of sweet potato production and without increased while those with 8 or more metric tonnes declined. According to data collected from FGDs, root crops such as orange flesh potatoes and cassava that were introduced by development initiatives were the early maturing varieties, attained their maturity at the same time and for ready market. The crop had to be harvested immediately to avoid deterioration and this resulted in their glut in the local market. Lack of market may affect the productivity of a particular crop. One variety of cassava could not be cooked or chewed in its fresh form and therefore farmers feared growing it. The implication of the findings is that qualities of some of the crops may discourage farmers from adopting the technological packages.

A paired sample t-test was performed at a significance level of 0.05 to ascertain any significant differences between the level of households’ root crops production per hectare before and after the implementation of the ADI. The results are summarised in Table 7(Appendix 7). The results indicate that there were statistically significant differences at $\alpha = 0.05$. The statistically significant difference could be attributed to promotion of cassava and sweet potato variety meant for ready market which consequently attracted the male members of the family into growing them and therefore the observed increase in the percentage of households engaged in their production. However, difference in cassava production was statistically insignificant. This could be attributed to the decline in production caused by implementation of projects that promoted cassava variety that could not be cooked or chewed in its fresh form or last long in the farm on attaining its maturity.

**Livestock Production**

Table 8 (Appendix 8) shows the average households that kept various livestock production prior to and after implementation of ADIs. The results show that the percentage of households that engaged in production of various livestock before and after the implementation of ADIs was generally below 50% except for poultry production which was over 60%. Observation in the field showed that most households kept an average of one cow, less than three goats or sheep mainly for security purposes. Poultry served immediate needs that may have required special attention in terms of food. Observation also showed that most ADIs did not have a specific component on addressing cattle rearing and this contributed to the inadequate implementation of livestock projects among farmers. Further observation showed that introduction of cost sharing of veterinary services and failure to implement livestock projects may have resulted to households keeping either none or few livestock consequently inadequate or lack of dairy products in most households. This finding agreed with those of World Bank (WB) (2007) who found that insufficient livestock as direct and indirect source of food was due to inadequate funding of the livestock sector in developing countries. WB (2007) noted that only four percent of loans given to agriculture and rural development sector were for livestock projects.

A paired sample t-test was performed at a significance level of 0.05 to ascertain any significant differences between the level of households’ livestock production before and after the implementation of the ADI. The results are summarised in Table 9(Appendix 9).The results indicate that the differences in 80% of the statements that were used to measure the effect of ADIs on small-scale farmers’ household livestock production were statistically significant at0.05.

**Households’ Agricultural Food Crop Sufficiency**

Table 10(Appendix 10) shows the averages of households in various categories of commonly utilised food crop sufficiency prior and five years after implementation of programmes, projects and policy reforms aimed at increasing agricultural productivity at household level. Results in Table 10 show that after
the implementation of the programmes, projects and policy reform, all the households experienced a surplus in various types of food crops except for sorghum. The increase was more than 5% except for maize and cassava, which increased by more than two (20.7%) and three (26.7%) folds respectively. The percentage of households with enough for three months declined to below 10%. Except for households with sorghum and cassava, the percentage of households with inadequate maize, legume and other crops increased. Households’ with insufficient sweet potato remained more less the same. Except for maize which all households did not lack, the percentage of households without various food crops increased by 30%. Observation made during farmers’ FGD indicated that sorghum and millet crops were not a common food crop at household level due to inadequate knowledge on its preparation or utilisation. In addition, some of the new maize varieties were susceptible to weevil attack resulting in heavy post-harvest losses especially when stored for a reasonable period of over three months. The sweet potato and cassava varieties bred for early maturing and ready market could not remain in the field long after attaining physiological maturity to allow piece meal harvesting, a common traditional practice among most small-scale farmers. The implications of the findings are that the crop varieties that were promoted by ADI could not be stored for a longer time. Most of the households experienced surplus of fresh crops which they immediately disposed by either selling or sharing with relatives, leaving very little in store due to the fear of post-harvest losses. To avoid post-harvest losses caused by weevil attack and lack of processing, the crops were either disposed soon after harvest by selling, being given as gifts to relatives or not growing it.

A paired sample t-test was performed at significance level of 0.05 to ascertain any significant differences between the households’ commonly utilized food crop sufficiency before and after the implementation of the ADI. The results are summarised in Table 11 (Appendix 11). The results indicate that there was no statistically significant difference in all the statements that were used to measure the effect of ADI on small-scale farmers’ households’ commonly utilized food crop sufficiency.

The study findings agreed with those of Veteto and Skarbø (2009) who found that availability of various food crops in households is influenced by the processing, storability and perceived risk of the crop or yield instability. Dube and Sigauke (2015) found that most families shunned new sorghum varieties introduced in demonstration plots due to its perception as a traditional food that is considered ancient with no place in modern society. According to Nazarea, (1995, cited in Nazarea, et al. 2013) and Immink and Alarcón (1992, as cited in Carr, 2005), insufficient food at household level has been due to the displacement of many native varieties by the modern cultivars of the green revolution, the so-called miracle or high yielding varieties of the crops integrated into markets and by cash crops. The more recent cause of loss of traditional varieties that is due to the contamination of native crops with genes from genetically modified organisms that have been introduced to improve agriculture and food security has also been attributed to food crop insufficiency (Scurrah et al. 2008 and Chandler and Dunwell, 2008 as cited in Nazarea et al., 2013).

**Households’ Sufficiency in livestock and Dairy Produce**

Table 12 (Appendix 12) shows the averages of households with livestock and dairy products in terms of adequacy, surplus or inadequate, or not available before and after five years after implementation of agricultural production initiatives. The results show that before and after the implementation of the initiatives, 59.0% and 66.4% of households respectively did not have livestock for use either directly or indirectly as a source of food. More than 40% of households did not have dairy produce and the percentage increased (47.2%) after the implementation of the development initiatives. Over 20% of the households had inadequate livestock and dairy produce. Majority of households did not have other types of livestock. It was observed that most households kept poultry and the number of livestock ranged between one to two animals. Information gathered during FGD indicated that due to insecurity, harsh climatic conditions and lack of funds to meet the cost of feeds and veterinary services, most of the projects (pilot) and programmes implemented in the field placed less emphasis on livestock production.

A paired sample t-test was performed at significance level of 0.05 to ascertain any significant differences between the households’ livestock and dairy produce sufficiency before and after the implementation of the development initiatives. The results are summarised in Table 13(Appendix 13).The results indicate that there were statistically significant differences at $\alpha = 0.05$.

**CONCLUSIONS AND RECOMMENDATIONS**
The overall increase in households’ agricultural food production due to implementation of development initiatives was statistically significant. The increase was observed in most of the produce except for small seeded cereals (sorghum and millet), cassava and dairy produce that were statistically insignificant. However, the increase in productivity in these households did not translate to household food sufficiency due to:

1. Most farmers utilised less than two hectares of land with vast hectares of land left fallow with none or very low numbers of livestock despite the large acreage of individual land ownership and most of household members being in the active age bracket with formal education enabling them to interact and engage in negotiations amongst farmers and outsiders who introduce development initiatives.
2. Projects and programmes implemented by the government and development partners placed more emphasis on maize production than on drought resistant crops such as sorghum, cowpeas, pigeon peas and cassava yet the harsh ecological characteristics could not support high yielding maize production.
3. The insufficient food in most households was caused by the unfavourable storage characteristics of improved food crop varieties promoted by projects and programmes.
4. Most households kept a low number of livestock due to the less emphasis placed on the livestock production projects and inadequate government and development projects support to farmers. This could be caused by the failure of development initiatives to have a specific component addressing cattle (dairy and beef) production and farmers’ inability to afford the cost sharing of veterinary and demand driven approach mode of extension services.

POLICY RECOMMENDATIONS

The government and development partners engaged in implementation of development initiatives should carry out a situation analysis prior to promotion of crop varieties and types of livestock whose ecological requirements for their performance is supported by the local ecological characteristics. This will allow for the crops and livestock to perform well based on the prevailing weather conditions.

Agricultural programmes and project practitioners should identify how farmers form opinions on technologies introduced for crop improvement to promote crop varieties that fit in their way of life. This will play a crucial role in ensuring household food security.

The Government of Kenya should put in place effective mechanisms that allow livestock farmers accessibility to livestock and veterinary services and are cushioned against livestock losses.

REFERENCES

Appendix 1

Bio data of the Small-scale Farmers in Kilifi County (n=150)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>50.3%</td>
</tr>
<tr>
<td>Male</td>
<td>49.7%</td>
</tr>
<tr>
<td>Age in years</td>
<td></td>
</tr>
<tr>
<td>Young (18-35)</td>
<td>34.7%</td>
</tr>
<tr>
<td>Middle age</td>
<td>29.0%</td>
</tr>
<tr>
<td>Old (over 50)</td>
<td>36.3%</td>
</tr>
<tr>
<td>Education Level</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>34.3%</td>
</tr>
<tr>
<td>Primary</td>
<td>36.7%</td>
</tr>
<tr>
<td>Secondary</td>
<td>18.4%</td>
</tr>
<tr>
<td>Tertiary</td>
<td>10.6%</td>
</tr>
</tbody>
</table>

*Source: Survey Data, 2014*

Appendix 2

Small-scale Farmers’ Land Tenure, Agricultural and Operational Land Holding in Kilifi County (n=150)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Tenure System</td>
<td></td>
</tr>
<tr>
<td>Hired</td>
<td>2.3%</td>
</tr>
<tr>
<td>Individual (inherited, bought)</td>
<td>66.7%</td>
</tr>
<tr>
<td>Communal</td>
<td>31.0%</td>
</tr>
<tr>
<td>Agricultural Land Holding (Hectares):</td>
<td></td>
</tr>
<tr>
<td>≤ One</td>
<td>40.7%</td>
</tr>
<tr>
<td>&gt; One</td>
<td>59.3%</td>
</tr>
<tr>
<td>Operational Land holding (Hectares):</td>
<td></td>
</tr>
<tr>
<td>two</td>
<td>64.0%</td>
</tr>
<tr>
<td>≥ two</td>
<td>36.0%</td>
</tr>
</tbody>
</table>

*Source: Survey Data, 2014*

Appendix 3

Small-scale Farmers’ Crop and Livestock Diversification in Kilifi County (n=150)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Crops grown per household:</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>0.0%</td>
</tr>
<tr>
<td>one</td>
<td>2.1%</td>
</tr>
<tr>
<td>&gt;one</td>
<td>97.9%</td>
</tr>
<tr>
<td>Number of Livestock reared per household:</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>23.2%</td>
</tr>
<tr>
<td>one</td>
<td>62.1%</td>
</tr>
<tr>
<td>&gt;one</td>
<td>14.7%</td>
</tr>
</tbody>
</table>

*Source: Survey Data, 2014*

Appendix 4

Percentage of Households with different Number of Bags harvested per hectare for commonly grown Cereals and Legumes before and after implementation of agricultural development initiatives in Kilifi County (n=150)

<table>
<thead>
<tr>
<th>Food crops grown</th>
<th>Period</th>
<th>% of H/H with 25 Bag/ha</th>
<th>% of H/H with 17-25 Bag/ha</th>
<th>% of H/H with 8-16 Bag/ha</th>
<th>% of H/H ≤ 7 Bag/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>Before</td>
<td>19.0%</td>
<td>12.4%</td>
<td>72.3%</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>7.7%</td>
<td>19.7%</td>
<td>75.6%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Sorghum</td>
<td>Before</td>
<td>4.6%</td>
<td>0.0%</td>
<td>22.4%</td>
<td>73.0%</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>3.7%</td>
<td>0.0%</td>
<td>10.7%</td>
<td>85.3%</td>
</tr>
<tr>
<td>Millet</td>
<td>Before</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>100.0%</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Legumes</td>
<td>Before</td>
<td>11.3%</td>
<td>1.0%</td>
<td>5.2%</td>
<td>81.3%</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>1.3%</td>
<td>6.0%</td>
<td>9.0%</td>
<td>80.7%</td>
</tr>
<tr>
<td>Others</td>
<td>Before</td>
<td>15.0%</td>
<td>30.2%</td>
<td>20.1%</td>
<td>34.7%</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>12.3%</td>
<td>10.7%</td>
<td>52.3%</td>
<td>24.7%</td>
</tr>
</tbody>
</table>

*Source: Survey Data, 2012*
Appendix 5
Paired Sample Statistics t test on Percentage of Households with different Number of Bags harvested per hectare for commonly grown Cereals and Legumes in Kilifi County

<table>
<thead>
<tr>
<th>Effect of the implemented development initiatives</th>
<th>Development initiatives implementation</th>
<th>Mean</th>
<th>t-test</th>
<th>df</th>
<th>Sig (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 If the general cereal and legume production was better before or after implementation of development initiatives</td>
<td>before 1.67</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2. If maize production was better before or after of implementation of development initiatives vis. NAEP, SRA-Strategies for Revitalising Agriculture, KAPAP, NAAIAP, NASEP.</td>
<td>before 1.67</td>
<td>0.67</td>
<td>4.000</td>
<td>149</td>
<td>0.004</td>
</tr>
<tr>
<td>3 If the production of Sorghum was better before or after implementation of development initiatives vis. NAEP, SRA-Strategies for Revitalising Agriculture, KAPAP, NAAIAP, NASEP.</td>
<td>before 1.33</td>
<td>0.67</td>
<td>2.060</td>
<td>149</td>
<td>0.061</td>
</tr>
<tr>
<td>4 If the production of Millet was better before or after implementation of development initiatives vis. NAEP, SRA-Strategies for Revitalising Agriculture, KAPAP, NAAIAP, NASEP</td>
<td>before 1.67</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5. If the production of legume was better before or after implementation of development initiatives vis. NAEP, SRA-Strategies for Revitalising Agriculture, KAPAP, NAAIAP, NASEP.</td>
<td>before 1.38</td>
<td>0.63</td>
<td>4.033</td>
<td>149</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Note: p ≤ 0.025

Appendix 6
Households with different Metric Tonnes of Root crops harvested per hectare before and after implementation of agricultural development initiatives in Kilifi County (n=150)

<table>
<thead>
<tr>
<th>Root crops grown</th>
<th>Period</th>
<th>% of H/H with ≥0MT/ha</th>
<th>% of H/H with 5-7MT/ha</th>
<th>% of H/H with 2-4 MT/ha</th>
<th>% of H/H ≤1MT/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cassava</td>
<td>Before</td>
<td>6.6</td>
<td>6.0</td>
<td>33.7</td>
<td>53.7</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>0.0</td>
<td>26.7</td>
<td>18.6</td>
<td>51.2</td>
</tr>
<tr>
<td>S/potatoes</td>
<td>Before</td>
<td>8.3</td>
<td>0.0</td>
<td>10.0</td>
<td>81.3</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>0.0</td>
<td>10.0</td>
<td>10.3</td>
<td>82.7</td>
</tr>
</tbody>
</table>

Source: Survey Data, 2014

Appendix 7
Paired Sample Statistics t test on Percentage of Households with different Metric Tonnes of Root crops harvested per hectare in Kilifi County (n=150)

<table>
<thead>
<tr>
<th>Effect of the implemented development initiatives</th>
<th>Development initiatives implementation</th>
<th>Mean</th>
<th>t-test</th>
<th>df</th>
<th>Sig (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 If the production of root crops was better before or after implementation of development initiatives vis. NAEP, SRA-Strategies for Revitalising Agriculture, ‘Njaa maarufuku Kenya’, KAPAP, NAAIAP, NASEP.</td>
<td>before 1.90</td>
<td>0.67</td>
<td>4.00</td>
<td>149</td>
<td>0.004</td>
</tr>
<tr>
<td>2. If the production of cassava was better before or after implementation of development initiatives vis. NAEP, SRA-Strategies for Revitalising Agriculture, KAPAP, NAAIAP, NASEP</td>
<td>before 1.63</td>
<td>0.36</td>
<td>2.06</td>
<td>149</td>
<td>0.051</td>
</tr>
<tr>
<td>3 If the production of sweet potatoes was better before or after implementation of development initiatives vis. NAEP, SRA-Strategies for Revitalising Agriculture, KAPAP, NASEP</td>
<td>before 1.38</td>
<td>0.13</td>
<td>2.43</td>
<td>149</td>
<td>0.016</td>
</tr>
</tbody>
</table>

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Appendix 8
Households with different number of Livestock for Various types before and after the implementation of development initiatives in Kilifi County (n=150)

<table>
<thead>
<tr>
<th>Food crops grown</th>
<th>Period</th>
<th>% of H/H with ≥8</th>
<th>% of H/H with 5-7</th>
<th>% of H/H with 2-4</th>
<th>% of H/H ≤1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>Before</td>
<td>9.0</td>
<td>7.7</td>
<td>12.3</td>
<td>71.0</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>6.6</td>
<td>9.0</td>
<td>10.7</td>
<td>73.7</td>
</tr>
<tr>
<td>Poultry</td>
<td>Before</td>
<td>28.6</td>
<td>24.0</td>
<td>22.4</td>
<td>35.0</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>29.0</td>
<td>28.3</td>
<td>19.7</td>
<td>23.0</td>
</tr>
<tr>
<td>Goats</td>
<td>Before</td>
<td>6.6</td>
<td>6.0</td>
<td>23.7</td>
<td>63.7</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>6.4</td>
<td>16.0</td>
<td>18.3</td>
<td>59.3</td>
</tr>
<tr>
<td>Sheep</td>
<td>Before</td>
<td>0.0</td>
<td>2.4</td>
<td>10.3</td>
<td>87.3</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>0.0</td>
<td>3.0</td>
<td>10.7</td>
<td>86.3</td>
</tr>
<tr>
<td>Others (pigs, guinea fowl)</td>
<td>Before</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>99.7</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>0.0</td>
<td>18.0</td>
<td>10.0</td>
<td>72.0</td>
</tr>
</tbody>
</table>

Source: Survey Data, 2014

Appendix 9
Paired Sample Statistics t test on Percentage of Households with different number of Livestock for Various types before and after the implementation of development initiatives in Kilifi County (n=150)

<table>
<thead>
<tr>
<th>Effect of the implemented development initiatives</th>
<th>Implementation of Development initiatives Mean</th>
<th>t-test</th>
<th>df</th>
<th>Sig (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. If livestock production was better before or after implementation of development initiatives vis. NAEP, SRA-Strategies for Revitalising Agriculture-'Njaa Marufuku Kenya', KAPAP, NASEP</td>
<td>before 1.37 -0.01 -0.242 149 0.809</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. If cattle production was better before or after implementation of development initiatives vis. NAEP, SRA-Strategies for Revitalising Agriculture, KAPAP, NASEP</td>
<td>before 1.56 0.36 2.060 149 0.061</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. If Poultry production was better before or after implementation of development initiatives vis. NAEP, SRA-Strategies for Revitalising Agriculture-'Njaa Marufuku Kenya', KAPAP, NASEP.</td>
<td>before 1.55 -0.37 8.010 149 0.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. If goat production was better before or after implementation of development initiatives vis. NAEP, SRA-Strategies for Revitalising Agriculture-'Njaa Marufuku Kenya', KAPAP, NASEP.</td>
<td>before 1.67 0.67 4.000 149 0.004</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. If sheep production was better before or after implementation of development initiatives vis. NAEP, SRA-Strategies for Revitalising Agriculture-'Njaa Marufuku Kenya', KAPAP, NASEP.</td>
<td>before 1.48 - - 149 -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. If the production of Others (pigs, guinea fowl) was better before or after implementation of development initiatives vis. NAEP, SRA-Strategies for Revitalising Agriculture-'Njaa Marufuku Kenya'. KAPAP, NASEP</td>
<td>before 1.38 0.13 2.433 149 0.016</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: p ≤0.025
Appendix 10
Households’ Food Crop Sufficiency in Kilifi County (n=150)

<table>
<thead>
<tr>
<th>Food crops grown</th>
<th>Period</th>
<th>H/H % with surplus for market</th>
<th>H/H % with adequate food for 3 months</th>
<th>H/H % with inadequate for 3 months</th>
<th>H/H % without food crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>Before</td>
<td>7.7</td>
<td>40.0</td>
<td>52.3</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>20.7</td>
<td>6.7</td>
<td>72.6</td>
<td>0.0</td>
</tr>
<tr>
<td>Sorghum</td>
<td>Before</td>
<td>0.0</td>
<td>4.6</td>
<td>22.4</td>
<td>73.0</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>0.0</td>
<td>3.7</td>
<td>10.7</td>
<td>85.3</td>
</tr>
<tr>
<td>Cassava</td>
<td>Before</td>
<td>6.0</td>
<td>6.6</td>
<td>33.7</td>
<td>53.7</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>26.7</td>
<td>0.0</td>
<td>18.6</td>
<td>54.7</td>
</tr>
<tr>
<td>Legumes</td>
<td>Before</td>
<td>1.0</td>
<td>10.3</td>
<td>7.4</td>
<td>81.3</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>6.0</td>
<td>4.3</td>
<td>9.0</td>
<td>80.7</td>
</tr>
<tr>
<td>S/potatoes</td>
<td>Before</td>
<td>0.0</td>
<td>8.3</td>
<td>10.0</td>
<td>81.7</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>9.0</td>
<td>0.0</td>
<td>10.3</td>
<td>80.7</td>
</tr>
<tr>
<td>Others</td>
<td>Before</td>
<td>30.2</td>
<td>15.0</td>
<td>20.1</td>
<td>34.7</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>10.7</td>
<td>12.3</td>
<td>52.3</td>
<td>24.7</td>
</tr>
</tbody>
</table>

Source: Survey Data, 2014

Appendix 11
Paired Sample Statistics t test on Households’ Food Crop Sufficiency in Kilifi County (n=150)

<table>
<thead>
<tr>
<th>Effect of the agricultural development initiatives on households’ food crop sufficiency</th>
<th>Implementation of Development initiatives</th>
<th>Sig</th>
<th>Mean</th>
<th>t-test</th>
<th>df</th>
<th>Sig (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 If households’ food crop sufficiency was better before or after implementation of agricultural development initiatives</td>
<td>before 1.67</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>after 1.67</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. If households’ maize crop sufficiency was better before or after implementation of agricultural development initiatives</td>
<td>before 1.80</td>
<td>0.212</td>
<td>-0.13</td>
<td>-0.459</td>
<td>149</td>
<td>0.653</td>
</tr>
<tr>
<td></td>
<td>after 1.93</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 If households’ sorghum crop sufficiency was better before or after implementation of agricultural development initiatives</td>
<td>before 2.20</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>after 2.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 If households’ root crop sufficiency was better before or after implementation of agricultural development initiatives</td>
<td>before 1.89</td>
<td>0.000</td>
<td>0.11</td>
<td>1.000</td>
<td>149</td>
<td>0.347</td>
</tr>
<tr>
<td></td>
<td>after 1.78</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. If households’ legumes sufficiency was better before or after implementation of agricultural development initiatives</td>
<td>before 1.38</td>
<td>0.0125</td>
<td>0.13</td>
<td>2.010</td>
<td>149</td>
<td>0.083</td>
</tr>
<tr>
<td></td>
<td>after 1.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: p ≤ 0.025

Appendix 12
Households Sufficiency in Livestock and Dairy Produce in Kilifi County (n=150)

<table>
<thead>
<tr>
<th>Livestock and Dairy produce</th>
<th>Period</th>
<th>H/H % with adequate</th>
<th>H/H % with Surplus</th>
<th>H/H % with Inadequate</th>
<th>H/H % without</th>
</tr>
</thead>
<tbody>
<tr>
<td>Livestock (Cattle, Shoats, Poultry)</td>
<td>Before</td>
<td>7.3</td>
<td>6.3</td>
<td>27.4</td>
<td>59.0</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>8.3</td>
<td>4.0</td>
<td>21.3</td>
<td>66.4</td>
</tr>
<tr>
<td>Dairy produce (Milk, Eggs)</td>
<td>Before</td>
<td>10.5</td>
<td>16.0</td>
<td>38.2</td>
<td>44.9</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>11.5</td>
<td>8.0</td>
<td>33.3</td>
<td>47.2</td>
</tr>
<tr>
<td>Others</td>
<td>Before</td>
<td>2.6</td>
<td>0.0</td>
<td>0.3</td>
<td>97.1</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>2.3</td>
<td>9.7</td>
<td>18.0</td>
<td>70.0</td>
</tr>
</tbody>
</table>

Source: Survey Data, 2014
### Appendix 13

**Paired Sample Statistics t test on Households Sufficiency in Livestock and Dairy Produce in Kilifi County (n=150)**

<table>
<thead>
<tr>
<th>Effect of the agricultural development initiatives on households’ food crop sufficiency</th>
<th>Implementation of Development initiatives</th>
<th>Mean</th>
<th>t-test</th>
<th>df</th>
<th>Sig (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. If households’ livestock produce sufficiency was better before or after implementation of agricultural development initiatives</td>
<td>before</td>
<td>1.79</td>
<td>-0.13</td>
<td>.093</td>
<td>149</td>
</tr>
<tr>
<td></td>
<td>after</td>
<td>1.85</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. If households’ dairy sufficiency was better before or after implementation of agricultural development initiatives</td>
<td>before</td>
<td>1.80</td>
<td>-0.15</td>
<td>-</td>
<td>149</td>
</tr>
<tr>
<td></td>
<td>after</td>
<td>1.93</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. If households’ other types of livestock produce was better before or after implementation of agricultural development initiatives</td>
<td>before</td>
<td>1.27</td>
<td>-0.13</td>
<td>.090</td>
<td>149</td>
</tr>
<tr>
<td></td>
<td>after</td>
<td>1.45</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: p ≤ 0.025
CHARACTERIZATION OF INTRA-HOUSEHOLD GENDER RELATIONS IN AGRICULTURE IN KENYA: ACCESS TO INSTITUTIONAL SUPPORT FACTORS AND DECISION-MAKING

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ABSTRACT

Research on gender in agriculture has revealed a gender gap in productivity as women are disadvantaged when it comes to accessing key resources and services required for agricultural production resulting in low productivity compared to men. This is partly due to underlying social norms and traditions. There is, however, scarce literature on intra-household gender relations in agriculture. The purpose of this study was to characterise intra-household access to institutional support factors in agriculture as well as gender roles in decision-making. The study used a random sample of 276 small-scale farming households in rural Kenya for which gender-disaggregated data was collected through face-to-face interviews and semi-structured questionnaires. Analysis was done by calculation of frequencies, percentages and presented in tables and graphs. The results of the study show that more women than men belong to agricultural development groups, while more men than women received extension services, were involved in off-farm income generating activities and made household savings. About two-thirds of both men and women contribute to the main farm production decisions, however, men have more input compared to women. These results show that there is a gender gap in access to institutional support factors and decision-making within households. Gender-based interventions such as empowerment programmes need to be undertaken in order to ensure fairness in access to key resources and services required in production as well as inclusivity in all aspects of decision-making, in order to realise higher agricultural productivity.

Key words: gender, access to institutional factors, decision-making, Kenya

INTRODUCTION AND PROBLEM STATEMENT

Research on gender in agriculture has received increased attention in recent years since the realisation that women were not exactly benefiting from economic development and were being left behind (Okali, 2011). This prompted an increase in a wide range of activities and projects aimed at improving the welfare of women and the inclusion of gender into many development policies and plans (Quisumbing, 2014). As a result, the term gender is often associated with the promotion of women.

According to the World Bank, (2014), there exists a gender gap in agricultural productivity because women face barriers in accessing resources, markets and opportunities in agriculture. This is due to embedded social and cultural norms and institutional barriers. Bridging this gap can lead to worldwide yield increases of about 20 to 30% and improve household food security and livelihoods (FAO, 2011).

While gender refers to the socially established roles of men and women, gender relations are the ways in which societies define rights, responsibilities and identities of men and women (Behrman, et al. 2014), and can change over time. Intra-household gender relations are mainly influenced by social, cultural and economic factors and this in turn affects access to resources, division of labour, time use, roles in decision-making and overall household welfare (Sikod, 2007).

Kinkingninhou-Medagbe, et al. (2008), in a study on gender discrimination in Benin, found that women were discriminated against in form of group membership to rice irrigation schemes, access to land and equipment. Koirala, et al. (2015), found that women faced constraints in accessing land and other resources in rice production hence they incurred higher variable costs. A study in Kenya by Muriithi (2015), found that few women were members of farmer groups and they also faced difficulties in accessing credit, horticultural training and extension services, compared to men.
Gender roles in intra-household decision-making also differ across cultures and societies. Within households, decisions are not made in a unitary manner and men and women do not always have the same preferences in resource allocation and division of labour (Van Aelst, 2014). According to the International Food Policy Research Institute (IFPRI, 2014), women who have more power on decision-making on crops to grow and inputs to use have higher productivity. Eerdewijk and Danielsen (2015), found that men were the ultimate decision makers in rural Ethiopian households, while in Kenyan households, joint decision-making in agriculture was common. This, however, did not amount to an equal voice in decisions as major decisions on resources were still undertaken by men. Ngigi, et al. (2016), found that a majority (77%) of men undertook decisions in the household solely, in Kenya. A study by Sneyers and Vandeplas (2013), found that women participated more in decisions on dairy production than in crop production in India, and this was significantly affected by religion, education level and access to technology.

Most of the studies on gender in agriculture have compared access to resources and services by male and female farmers, but the literature on intra-household gender dynamics in Kenya remains scarce. The present study assessed intra-household access to institutional support factors such as group membership, access to credit, extension, household savings and off-farm income and gender roles in household decision-making. This is expected to provide valuable insights on the gender dynamics in households.

**METHODOLOGY**

This study used secondary data which was collected in the Adoption Pathways Project by the International Maize and Wheat Improvement Centre (CIMMYT) together with the Kenya Agricultural and Livestock Research Organization (KALRO) in 2013. The data collected was gender-disaggregated, meaning that both the husband and wife in the household were interviewed separately. Some of the variables on which data was collected include: household composition and characteristics, participation in rural institutions, social capital and networks, access to key services such as credit and extension, household income and roles in household decision-making. The survey covered five counties in Kenya, which are: Bungoma and Siaya counties in Western Kenya and Embu, Meru and Tharaka Nithi counties in Eastern Kenya. The sample size for this study was 276 households. Almost equal number of households were selected from either region – Western and Eastern. These are the households which have both a head and a spouse, hence households where the head is either single, widowed, divorced or separated, are excluded. This is because the study analysed intra-household gender relations. The analysis involved calculation of frequencies, percentages, cross-tabulations and presentation in tables and graphs using SPSS software version 22.

**RESULTS AND DISCUSSION**

**Socio-demographic Characteristics**

The men are, on average, 8 years younger than the women. Most of the respondents, both male and female have reached primary level education, but fewer women than men have studied beyond primary level. This is significant at 5% level, as shown in Table I. According to the FAO (2011), women are generally less educated than men and this leads to them having less access to resources and a weaker voice in making decisions in the household.

**Access to Institutional Support Factors**

From Table II, we see that more women than men are members of groups. The groups considered here were savings and credit associations, farmer groups, cooperatives, merry go rounds, women groups and youth groups. This is significant at 5% level ($\chi^2 = 7.667, p=0.006$). These are similar to the results of Eerdewijk and Danielsen (2015), who found that more women than men were members of groups such as self-help groups and community-based organisations in Bungoma and Laikipia in Kenya. The reason given for this was that they needed to support each other in managing their households as well as bringing development to their communities. Being part of groups helps to strengthen social capital and networking, which is important in accessing key resources and services required for agricultural production (FAO, 2011, Seebens, 2011).

Figure 1 shows the types of groups to which the men and women sampled in the study belong. It shows that savings associations and farmer groups are the main groups for men, while women groups and merry go rounds, are the main groups for the women. Similarly, Ngigi et al. (2016), found that a higher percentage of men belonged to farmers’ associations and group-based welfare associations, while a higher percentage of women belonged to women’s groups.
About 70% of women in the households received credit compared to 64% of men. The sources of credit are illustrated in Figure 2. The main credit sources are money lenders, farmer groups and merry go rounds. An interesting observation from here is that a significantly higher number of women than men obtained credit from banks and microfinance institutions. This could be because of the existence of loan features that target female borrowers.

About 64% of men earned off-farm income compared to 54% of women. Women make up 60-80% of the agricultural labour force worldwide. In addition, they perform most of the household chores leaving them with little or no time for off-farm activities (Ogunlela and Mukhtar, 2009; Sikod, 2007).

Roles in Decision-making
Table III shows the percentage of men and women who participate in making various decisions in the household. It shows that in almost all the decisions, men and women participate almost equally. In the main decisions in agricultural production such as food and cash crops to grow, inputs (seed and fertilizer) to buy and rearing of livestock, over 90% of both men and women contribute. This is the same for minor household expenditures.

About 60% of both men and women contribute to decisions on cash crop and livestock marketing, while about 40% contribute to decisions on major household expenditures.

This agrees with results of Meijer, et al.(2015), who found that over 80% of both men and women in Malawi contributed to decisions on crop planting, weeding and fertilizer use. Angel-Urdinola and Wodon, (2010), however, found that only about 20% of women contributed to decisions on crops sale and land use compared to 80% of men.

Amount of Input in Decision-making
From Table IV, we can see that even though both men and women participate in making household decisions, they do not contribute in equal measures. In all the decisions on crop farming, crop sale, seed, fertilizer, livestock rearing and sale and major household expenditures, men have more input in the decisions than women. The Pearson Chi-square values are significant indicating that there is a significant association between gender and amount of input in decision-making. This is true except for non-farm business activities and own wages.

For minor household expenditures, women contribute more input compared to men. This is to be expected considering that in African societies women are the primary custodians of home care and carry great responsibility on most domestic chores; some including planning and managing household expenditures. This is contrary to results by Ajewole (2015), who found that men dominated decision-making on productive resources, plot management and household income among rice farming households in Nigeria.

Amount of Input in Decision-making on Income Generated
Figure 3 below shows the proportion of men and women who contribute to most decisions on income generated from various activities. It shows that more men than women contribute to most decisions on income generated from sale of food crops, cash crops and livestock. Women and men contribute almost equally to decisions on non-farm business activities and own wages. These results show that men have a higher decision-making power than women in the household over income generated.

CONCLUSIONS AND POLICY IMPLICATIONS
The purpose of this study was to characterise intra-household access to institutional support factors and gender roles in decision-making. The results have shown that more women than men belong to groups and have access to credit from such social networks. Encouraging men to join groups such as farmer cooperatives and savings associations through provision of incentives such as subsidised inputs to group members can help improve men’s membership in groups. This will in turn improve social capital, improve exchange of information and resources which will help improve farm productivity.

Regarding household decision-making, it was noted that over 80% of both men and women contribute to the main agricultural decisions on food and cash crops to grow, seed and fertilizer to purchase and livestock rearing. However, men have higher decision-making power as the proportion of men who contribute their input to most or all decisions is higher than the proportion of women. Men also have higher decision-making power on the use of income generated from crop and livestock sale. This shows that within households, women do not have same access as men to
the resources generated from sale of farm produce, despite them being the primary caretakers of the home. This can cause conflicts. In order to strengthen women’s voice in decision-making, there is a need for programmes to sensitize people on the importance of women’s education as women who are more educated have higher decision-making power in households. Enhancing women’s access to resources such as extension services through training programmes that are specifically targeted to women can help improve their decision-making power. This will in turn help to improve intra-household harmony and overall household welfare. Farm productivity will also be increased when women have greater access to valuable information that can also promote farming practices that promote sustainable development.

REFERENCES


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TABLES

Table 1: Socio-economic characteristics of the respondents

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Male (n=276)</th>
<th>Female (n=276)</th>
<th>$\chi^2$ measure of difference</th>
<th>Significance level ($p$-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average age</td>
<td>52.0</td>
<td>43.7</td>
<td>10.270</td>
<td>0.006**</td>
</tr>
<tr>
<td>Education level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>3.3</td>
<td>6.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary level</td>
<td>61.1</td>
<td>69.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-primary level</td>
<td>35.7</td>
<td>24.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**: Significant at 5% level
Source: CIMMYT survey data, (2013)

Table 2: Intra-household access to institutional support factors

<table>
<thead>
<tr>
<th>Percentage (n=276)</th>
<th>Men</th>
<th>Women</th>
<th>$\chi^2$ measure of difference</th>
<th>Significance level ($p$-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group Membership</td>
<td>67.4</td>
<td>77.9</td>
<td>7.667</td>
<td>0.006**</td>
</tr>
<tr>
<td>Received extension</td>
<td>66.9</td>
<td>63.6</td>
<td>0.667</td>
<td>0.414</td>
</tr>
<tr>
<td>Received credit</td>
<td>64.1</td>
<td>70.4</td>
<td>0.169</td>
<td>0.681</td>
</tr>
<tr>
<td>Earned off farm income</td>
<td>63.8</td>
<td>53.8</td>
<td>4.664</td>
<td>0.036**</td>
</tr>
<tr>
<td>Saved money in past two years</td>
<td>92.4</td>
<td>90.3</td>
<td>0.448</td>
<td>0.489</td>
</tr>
</tbody>
</table>

**: Significant at 5% level; Source: CIMMYT survey data (2013)

Table 3: Participation of men and women in various household decisions

<table>
<thead>
<tr>
<th>Decision</th>
<th>Male participation (%) (n=276)</th>
<th>Female participation (%) (n=276)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food crops to grow</td>
<td>97.5</td>
<td>98.2</td>
</tr>
<tr>
<td>Cash crops to grow</td>
<td>68.4</td>
<td>65.1</td>
</tr>
<tr>
<td>Type of seed to buy</td>
<td>91.9</td>
<td>89.6</td>
</tr>
<tr>
<td>Type of fertilizer to buy</td>
<td>93.0</td>
<td>97.5</td>
</tr>
<tr>
<td>Food crop sale</td>
<td>81.3</td>
<td>82.1</td>
</tr>
<tr>
<td>Cash crop sale</td>
<td>61.2</td>
<td>56.8</td>
</tr>
<tr>
<td>Livestock raising</td>
<td>92.0</td>
<td>92.6</td>
</tr>
<tr>
<td>Livestock sale</td>
<td>68.4</td>
<td>62.6</td>
</tr>
<tr>
<td>Non-farm business activity to engage in</td>
<td>46.1</td>
<td>51.7</td>
</tr>
<tr>
<td>Own wage or salary employment</td>
<td>38.1</td>
<td>35.0</td>
</tr>
<tr>
<td>Major household expenditure e.g. large appliances</td>
<td>43.0</td>
<td>35.4</td>
</tr>
<tr>
<td>Minor household expenditures e.g. food for daily consumption</td>
<td>97.1</td>
<td>97.4</td>
</tr>
</tbody>
</table>

Source: CIMMYT survey data (2013)

11th Egerton University International Conference and Innovation Week
<table>
<thead>
<tr>
<th></th>
<th>Input in few decisions (% of farmers)</th>
<th>Input in most/all decisions (% of farmers)</th>
<th>$\chi^2$ measure of difference</th>
<th>Significance level (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food crops</td>
<td>Male 41.4</td>
<td>58.6</td>
<td>17.661</td>
<td>0.000**</td>
</tr>
<tr>
<td></td>
<td>Female 59.4</td>
<td>40.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash crops</td>
<td>Male 39.3</td>
<td>60.7</td>
<td>23.752</td>
<td>0.000**</td>
</tr>
<tr>
<td></td>
<td>Female 65.3</td>
<td>34.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seed to buy</td>
<td>Male 42.1</td>
<td>57.9</td>
<td>15.863</td>
<td>0.000**</td>
</tr>
<tr>
<td></td>
<td>Female 59.9</td>
<td>40.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertilizer to buy</td>
<td>Male 41.2</td>
<td>58.8</td>
<td>18.056</td>
<td>0.000**</td>
</tr>
<tr>
<td></td>
<td>Female 60.2</td>
<td>39.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food crops sale</td>
<td>Male 44.5</td>
<td>55.5</td>
<td>8.632</td>
<td>0.003**</td>
</tr>
<tr>
<td></td>
<td>Female 58.5</td>
<td>41.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash crops sale</td>
<td>Male 45.2</td>
<td>54.8</td>
<td>13.748</td>
<td>0.000**</td>
</tr>
<tr>
<td></td>
<td>Female 66.2</td>
<td>33.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Livestock raising</td>
<td>Male 38.8</td>
<td>60.4</td>
<td>23.463</td>
<td>0.000**</td>
</tr>
<tr>
<td></td>
<td>Female 58.5</td>
<td>41.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Livestock sale</td>
<td>Male 37.7</td>
<td>62.3</td>
<td>14.657</td>
<td>0.000**</td>
</tr>
<tr>
<td></td>
<td>Female 58.4</td>
<td>41.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-farm business activity</td>
<td>Male 55.5</td>
<td>44.5</td>
<td>0.177</td>
<td>0.674</td>
</tr>
<tr>
<td></td>
<td>Female 52.9</td>
<td>47.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Own wage/salary</td>
<td>Male 40.2</td>
<td>59.8</td>
<td>1.850</td>
<td>0.174</td>
</tr>
<tr>
<td></td>
<td>Female 50.0</td>
<td>50.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major household expenditure</td>
<td>Male 39.8</td>
<td>60.8</td>
<td>4.289</td>
<td>0.038**</td>
</tr>
<tr>
<td></td>
<td>Female 54.5</td>
<td>45.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minor household expenditure</td>
<td>Male 54.7</td>
<td>45.3</td>
<td>7.676</td>
<td>0.006**</td>
</tr>
<tr>
<td></td>
<td>Female 43.8</td>
<td>55.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**: Significant at 5% level

Source: CIMMYT survey data (2013)
FIGURES

Figure 1: Types of groups to which the men and women belong

Figure 2: Distribution of credit sources used by men and women
Figure 3: Amount of contribution to most decisions on income generated
SMALL HOLDER FARMERS’ PERCEPTIONS ON THE IMPACT OF SUSTAINABLE AGRICULTURAL PRACTICES ON PRODUCTIVITY AND WELLBEING: EVIDENCE FROM THE CENTRAL KENYA HIGHLANDS

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ABSTRACT

There exists compelling literary evidence the world over on the benefits of sustainable agricultural practices. This study adds to this wealth of knowledge by examining smallholder farmers’ perceptions of the effect of selected sustainable farming practices on soil fertility, pest management, yield and overall food security situation, incomes and amounts and farm inputs use of small holder farming households in Central Kenya. Both multi-stage and purposeful sampling techniques were employed to generate a sampling frame of all eligible respondents. Using the method by D.G. Israel (2009), a sample of 275 farmers was drawn from 3 counties, namely, Kiambu, Murang’a and Kirinyaga. Respondents were interviewed using a semi-structured interview schedule. Most of the farmers perceived that their soil status had improved with about 97% indicating that maize yield had increased. Reduced stem borer infestation in maize was reported by 89% of the respondents. Sales and by extension, incomes from farm produce had significantly increased for over 50% of the farmers interviewed. Although overall farm input use increased, farmers indicated that use of purchased inputs like CAN, certified maize seed, and NPK fertilizer actually reduced or remained the same. Generally, a higher proportion (90%) of the respondents felt that their household wellbeing had improved. The results of this study indicate that sustainable agricultural practices have the potential of increasing productivity through improving soil fertility, and by extension, crop production. In addition, their use has the potential of contributing to overall wellbeing of the small-scale resource poor farmers through improved food security, increased incomes and reduced use of purchased inputs.

Key words: Sustainability, perceptions, agriculture, impact, small holder.

INTRODUCTION

The use of external inputs as a means of increasing food production has been emphasized by agricultural professionals over the past 50 years. As a result, pesticides have replaced biological, cultural and mechanical methods for controlling pests, weeds and diseases, while inorganic fertilisers have been substituted for livestock manures, composts and Nitrogen fixing plants (Pretty, 1995). While these inputs are associated with high yields and economic returns, their prolonged use has been reported to speed up the acidification process in soils and land degradation, leading to reduced productivity in the long term. In addition, their use has been associated with contamination with heavy metals (Krall, 2015).

The environmental and biological consequences of these practices, as well as renewed interest in environmental conservation, has led experts to increasingly interrogate the conventional farming methods to increase production (Matson, 1997). The main concern is how to guarantee food security without compromising the resource base on which farming depends such as water, land and nutrient/soil fertility. This has heightened the need for productive, yet sustainable agricultural practices that conserves resources (Krall, 2015). Sustainability has been defined as the ability to meet current production goals without compromising the future in terms of resource degradation or depletion (Matson, 1997). In relation to agriculture, therefore, sustainable agriculture is one that produces abundant food without depleting the earth’s resources or polluting the environment. It is agriculture that follows the principles of nature for raising crops and livestock that are like nature, self-sustaining (Earles, 2005). Examples of the sustainable agricultural practices include integrated pest management, cover crops, crop rotation, manure use, conservation agriculture, use of green manure, organic farming, among many others.
There is emerging and compelling evidence that sustainable agricultural technologies and practices can bring both environmental, health and economic benefits for farmers, communities and nations. For instance, in high input lands of industrialised countries, farmers have maintained yields while substantially reducing their input use (Pretty, 1995). In addition, crop rotation provides better insect control, less disease build-up and efficient nutrient cycling (Reganold, et al.1990). Furthermore, use of organic manure increases organic matter, water storage capacity, enhances fertility and promotes good soil physical properties. Similarly, in an extensive review of the benefits of sustainable agriculture, cover crops have been reported to contribute to reduced weed infestation as well as accumulation of organic matter in the soil (Robbs et al, 2008). Similar findings are reported by Teasdale (1996). Moreover, though the yields from sustainable agriculture may be slightly lower than those from conventional agriculture, they are frequently offset by lower production costs which lead to equal or greater net returns (Reganold, et al. 1990).

The highlands of Central Kenya are the third most populated regions in Kenya hosting about 4.4 million people (KNBS, 2012). Mixed farming is the main economic activity. Due to high population pressure, farms are small, about 0.9-2.0 ha/household, (Gitau et al, 1994) which are intensively cultivated (Lekasi et al 1998). Maize is the staple food crop but has increasingly become an important source of fodder for dairy animals in form of dry maize stover, thinnings and green stover (Methu et al 1996). Maize yields are low, about 1-2 t/ha against a potential of 6t/ha (Makokha et al, 2001) due to impoverished soils, unfavourable climatic conditions, pests and diseases (Ampofo, 1986).

To sustainably address the issue of soil fertility and pest infestation in maize, a project to disseminate push-pull technology and other sustainable farming practices was initiated in three counties of Central Kenya between 2008 and 2014. The push-pull technology, initially developed by the International Centre of Insect Physiology and Ecology (ICIPE), involves intercropping maize with *desmodium* (the push) and Napier grass (the pull) as a border crop around the intercrop to control stem borers. *Desmodium*, besides being a good cover crop, fixes Nitrogen into the soil, improving soil fertility (Khan et al 2010). Using the farmer field school (FFS) approach, farmers were trained on establishment and management of the push-pull systems, manure and fertiliser use and application of other organic sources of Nitrogen. This study was conducted to document, small holder farmers’ perceptions on the impact of these practices on production, soil fertility and overall food security situation of households. The results are useful for research and extension as well as policy makers. The specific objectives were to establish farmers’ perceptions on effect of sustainable agricultural practices on soil fertility, determine farmers’ perception on the effect of push pull on stem borer infestation in maize, determine farmers’ perception on the effect of sustainable agricultural practices on incomes and establish farmers’ perception on the effect of sustainable agricultural practices on input costs and use.

**MATERIALS AND METHODS**

The study population included all members of Farmer Field Schools (FFS) groups established by the project and non-FFS members drawing technologies from neighbouring FFS members in 7 sub-counties of 3 counties in central Kenya. These were; Gatundu North in Kiambu County, Gatanga, Kandara, Kahuro, Kigumo and Kiharu in Murang’a County and Kirinyaga Central in Kirinyaga County. Multi-stage sampling was used to select the wards within sub-counties and FFS groups within the wards. Purposive sampling was employed to generate a list of the non-FFS members within each ward. Sampling was done proportional to size such that large groups had proportionately more representation in the sample and vice versa. Using the method by D.G. Israel (2009), a sample of 275 FFS and non-FFS farmers was drawn and interviewed using a semi-structured questionnaire. Data analysis was done using descriptive statistics such as means and proportions in cross tabulations.

**RESULTS AND DISCUSSION**

**Socio-Economic Characteristics of Respondents**

More (66%) female than male (34%) respondents were interviewed. The age categories of the respondents are represented in Table 1. Over 70% of the respondents were aged 50 years and above. Those who could be considered youthful (40 years and below) constituted only about 11%. This implies an aging farming community with very little youth participation. This may have implications for future agricultural activities if deliberate efforts are not instituted to encourage the youth in agriculture. About 46% of the households sampled were male headed. Female headed and female headed-male managed households constituted
Murang’a County had a higher proportion of male headed-female managed households than the other counties (Table II). This could be attributed to rural-urban migration of men in search of job opportunities. The increased use of illicit brews in the region could also plausibly be associated with the high female headship and management in households.

Overall literacy levels were high among the farmers interviewed with 92% having some form of schooling. However, only about 5% had gone beyond secondary school. Kiambu County had a higher proportion of respondents who had secondary and tertiary education than in any other county as shown in Table III. This is plausibly due to its proximity to Nairobi city, which has well developed education infrastructure.

Farmers’ Perception on Effects of Sustainable Agricultural Practices on Soil Fertility
The soil fertility indicators identified by the respondents are as shown in Table IV. Generally, the indicators were characteristics they could see, feel and were based on their own experiences in cultivating the fields. Crop performance was the most important indicator of soil fertility (56%). Potential and actual yield, strong stems, and fast growth/early maturity, amount of fodder, and deep green colour of the leaves were all associated with good crop performance, hence good soil fertility. Other important indicators were soil colour and texture (28%) and presence or absence of weeds (5%). It was reported that dark colour and soft feel of the soil was indicative of a fertile soil. Similarly, abundance of weeds was a sign of high soil fertility. The results indicate that farmers’ perception of soil fertility is not limited to the soil nutrient status, but, rather, a broader concept incorporating crop productivity (Corbeels, et al. 2000). Similar soil fertility indicators have been documented in other parts of the world. In Nepal, for example, farmers distinguish between fertile and infertile soils based on indicators such as texture, colour, yield, presence of weeds, weed species among others (Desblez et al., 2004). In Kenya, soil productivity criteria include ease of tillage, soil moisture retention and presence of weeds (Murage et al., 2000). Based on these indicators, an overwhelming majority (94%) of the respondents indicated that their soil fertility status had improved and only 1% reported deterioration or remained the same (≤ 1%) after adoption of the sustainable agricultural practices (Table V).

Farmers’ Perception on Effects of Sustainable Agricultural Practices on Yield and Food Security
In order to triangulate soil fertility status given by the farmers, respondents were asked to indicate whether there was a change in crop and livestock production. Over 80% of the respondents said that their maize yield had increased with significant increase reported by over 50%. Only about 3% reported that yields had remained the same or reduced (Table VI). Similarly, 79% of the respondents indicated that fodder shortage had decreased while milk production had increased (68%). The results are consistent with similar studies in which yield advantage of conservation agricultural systems compared to conventional systems have been observed (ICRISAT, 2009). In Kenya and Uganda, push-pull farmers increased maize yield by more than 50% in areas where striga weed and maize stem borers were a problem. Livestock production (milk and meat) increased significantly because of more fodder and different crop residues (Khan, et al, 2003). Table VII shows the food security indicators identified by the respondents. Ability to feed oneself/family without buying food, having all the three meals in a day, surplus food to sell and not requiring relief food was the principal indicator of food security of a household (44%). Having food in the store was also indicative of food security (13%). Other important food security indicators were healthy, clean and happy family members free of diseases and pests (13%), having food reserve always and actual/potential yield in the field (8%). It was reported that households whose members often suffered from sicknesses and diseases, were not well groomed, presence of frequent fights between parents and/or siblings in the family and jigger, bedbugs and other human pests infestation were all signs of food insecurity. Based on these indicators, the respondents’ perception of the change in their food security situation after application of the sustainable agricultural practices was assessed as in Table VIII. Nearly 94% of the respondents indicated that their food security status had improved, 54% of them significantly. Less than 1% indicated that there was no change in their food security situation.

Farmers’ Perception on Effects of Sustainable Agricultural Practices on Stem Borer Attack in Maize
Table IX represents perceived effect of push-pull technology on maize stem borer attack. Seventy-nine (79%) percent of the respondents reported a reduction in attack. Among these, 43% said that stemborer attack had significantly reduced while 9% and 1%, respectively, reported that stemborers had remained the
same or increased. The results agree with other studies showing that stem borer infestation had reduced from 40-60% to between 10-20% after application of push-pull technology (Njihia, et al. 2014).

Farmers’ Perception on Effects of Sustainable Agricultural Practices on Amounts of Farm Inputs Used
A central attribute of many sustainable agricultural technologies and systems is that they economise on the use of external inputs (Lee, 2005). This study revealed an overall increase in amounts of inorganic fertilisers, organic manure, certified and recycled seed used as farmers adjusted to the project recommendations. For instance, 82% of the respondents indicated that the amounts of manure used had increased. The project promoted preparation and use of quality organic manure in form of composts and farmyard in combination with small doses of inorganic fertilisers at planting. This could have led to increased manure use by the farmers. Conversely, about 34% and 41% of the respondents reported that their use of Di-Ammonium Phosphate (DAP) and Nitrogen Phosphorus Potassium (NPK) fertilisers, respectively, had reduced. About 45% of the respondents had increased the use of recycled maize seed as shown in Table X. This was attributed to climatic uncertainties arising from climate changes being experienced in the project area. Farmers reported having planted recycled seed of an open pollinated variety (OPV), alongside the certified hybrid varieties to balance the need to have high yields and evade risk.

Table XI shows the perceived effects of sustainable agricultural practices on commonly purchased dairy cattle feeds. Majority of the respondents indicated that amounts of all feeds had reduced. Generally, a higher proportion of the respondents reduced significantly the purchase of energy sources such as grass (60%), maize bran (56%) and maize germ (66%), possibly due to increase in fodder quantity from the push-pull system. It is critical to note that about 60% of the respondents reduced their Dairy meal purchases possibly due to a shift towards the use of desmodium for dairy supplementation. The reduction in amounts of inorganic fertilisers and purchased dairy feeds implied lower production costs and by extension, higher returns to farmers. In a study to compare the variable costs and net returns of conventional system vis-a-vis low-input legume based system in Palouse region Washington, fertilisers and pesticides accounted for 56% of the costs in the former and only 26% in the latter, hence, generating higher net returns due to its lower production costs (Goldstein and Young, 1987).

Farmers’ Perception on Effects of Sustainable Agricultural Practices on Sales
It had been hypothesised that the application of sustainable agricultural practices would contribute to increased production and by extension sales and incomes of small holder farmers. On the extent to which farm produce sales had changed, over 80% of the respondents reported that their sales had increased, owing to increased yield. Sales increased significantly for about 50% of the respondents and only 13% felt that their sales had remained the same. Maize stover sales were reported to have increased by about 89% of the respondents, followed by maize grain (85%) and milk (80%). The results are presented in Table XII.

Perceptions on Overall Effect of Sustainable Agricultural Practices on Livelihoods
Respondents were asked whether or not the sustainable agricultural practices disseminated had improved their lives and in what ways. About 90% indicated that their livelihoods had improved and only 1% thought otherwise. Table XIII shows how farmers’ lives had changed. Most (48%) of the respondents reported improved farm production, food security and health status. Other important benefits were increased incomes (16%), increased livestock fodder and production (14%), improved farming methods (6%), and increased knowledge (6%).

CONCLUSION
The results of this study indicate that sustainable agricultural practices have the potential to increase productivity of small holder farmers by improving soil fertility, and by extension, crop production. In addition, their application has the potential of contributing to the well-being of small scale resource poor farmers through improved food security and nutrition. Sustainable agricultural practices contribute to reduced use of purchased inputs, hence, lower production costs and higher net returns.

ACKNOWLEDGEMENTS
The authors are grateful to the Biovision Foundation of Switzerland for funding this study. Many thanks to the Centre Director, KALRO Muguga South for his logistical support to the project team to ensure smooth implementation of this study. The invaluable contribution of the agricultural extension officers in
Kiambu, Murang’a and Kirinyaga counties in mobilising the farmers and administering the questionnaires is highly appreciated. Finally, we recognize the many farmers who provided the relevant information without which this study would not have been a success.

REFERENCES


Robbs, P.R., Sayre, K. and Gupta, R. (2008). The role of conservation agriculture in sustainable agriculture. In Philosophical Transactions of the
LIST OF TABLES

Table I: Distribution of respondents by age-groups

<table>
<thead>
<tr>
<th>County</th>
<th>Less than 30</th>
<th>30&lt;Age&lt;41</th>
<th>40&lt;Age&lt;51</th>
<th>50&lt;Age&lt;61</th>
<th>Over 60</th>
</tr>
</thead>
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<td>6.67</td>
<td>0.00</td>
<td>6.67</td>
<td>30.00</td>
<td>56.67</td>
</tr>
<tr>
<td>Murang’a</td>
<td>3.17</td>
<td>4.23</td>
<td>17.46</td>
<td>23.28</td>
<td>51.85</td>
</tr>
<tr>
<td>Kirinyaga</td>
<td>7.27</td>
<td>12.73</td>
<td>23.64</td>
<td>18.18</td>
<td>38.18</td>
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<tr>
<td>Total Households</td>
<td>4.73</td>
<td>5.45</td>
<td>17.45</td>
<td>22.91</td>
<td>49.45</td>
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</table>

Table II: Types of households (HH) by county (% of responses)

<table>
<thead>
<tr>
<th>County</th>
<th>Female headed</th>
<th>Male headed</th>
<th>Male headed female managed</th>
<th>HH type not indicated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiambu</td>
<td>23.33</td>
<td>56.67</td>
<td>20.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Murang’a</td>
<td>24.73</td>
<td>44.09</td>
<td>31.18</td>
<td>0.00</td>
</tr>
<tr>
<td>Kirinyaga</td>
<td>22.22</td>
<td>44.44</td>
<td>27.78</td>
<td>5.56</td>
</tr>
<tr>
<td>Total Households</td>
<td>24.07</td>
<td>45.56</td>
<td>29.26</td>
<td>1.11</td>
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</table>

Table III: Distribution of respondents by education levels

<table>
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<tr>
<th>County</th>
<th>None</th>
<th>Primary</th>
<th>Secondary</th>
<th>Tertiary</th>
<th>University</th>
<th>*Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiambu</td>
<td>16.67</td>
<td>26.67</td>
<td>43.33</td>
<td>10.00</td>
<td>3.33</td>
<td>5.33</td>
</tr>
<tr>
<td>Murang’a</td>
<td>6.88</td>
<td>47.62</td>
<td>34.92</td>
<td>4.76</td>
<td>5.82</td>
<td></td>
</tr>
<tr>
<td>Kirinyaga</td>
<td>7.27</td>
<td>52.73</td>
<td>36.36</td>
<td>1.82</td>
<td>1.82</td>
<td></td>
</tr>
<tr>
<td>Total Households</td>
<td>8.00</td>
<td>46.18</td>
<td>36.00</td>
<td>4.73</td>
<td>5.09</td>
<td></td>
</tr>
</tbody>
</table>

*Other education categories include common entrance, adult education, vocational training and pre-primary

Table IV: Soil fertility indicators

<table>
<thead>
<tr>
<th>Description of indicator</th>
<th>Response (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop performance(yield, health, vigour, colour, biomass, maturity period)</td>
<td>56.02</td>
</tr>
<tr>
<td>Soil colour</td>
<td>17.82</td>
</tr>
<tr>
<td>Soil texture</td>
<td>9.49</td>
</tr>
<tr>
<td>Abundance/absence of weeds</td>
<td>4.63</td>
</tr>
<tr>
<td>Soil test results that are consistent with fertile soil</td>
<td>3.01</td>
</tr>
<tr>
<td>Water retention capacity</td>
<td>2.55</td>
</tr>
<tr>
<td>Type of weeds</td>
<td>2.31</td>
</tr>
<tr>
<td>Manure application</td>
<td>1.16</td>
</tr>
<tr>
<td>Extent of soil erosion</td>
<td>0.93</td>
</tr>
<tr>
<td>Weeds growth vigour</td>
<td>0.93</td>
</tr>
<tr>
<td>Minimal use of fertiliser</td>
<td>0.46</td>
</tr>
<tr>
<td>Crack formation</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Table V: Change in soil fertility status (% of households)

<table>
<thead>
<tr>
<th>County</th>
<th>Significantly improved</th>
<th>Improved</th>
<th>Somewhat improved</th>
<th>Remained the same</th>
<th>Deteriorated</th>
<th>Opinion not expressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiambu</td>
<td>43.33</td>
<td>53.33</td>
<td>3.33</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Murang’a</td>
<td>59.04</td>
<td>36.17</td>
<td>1.60</td>
<td>1.06</td>
<td>0.00</td>
<td>2.13</td>
</tr>
<tr>
<td>Kirinyaga</td>
<td>53.70</td>
<td>25.93</td>
<td>1.85</td>
<td>0.00</td>
<td>1.85</td>
<td>16.67</td>
</tr>
<tr>
<td>Total Households</td>
<td>56.25</td>
<td>36.03</td>
<td>1.84</td>
<td>0.74</td>
<td>0.37</td>
<td>4.78</td>
</tr>
</tbody>
</table>

Table VI: Farmer perception on changes in maize yields (% of households)

<table>
<thead>
<tr>
<th>County</th>
<th>Significantly increased</th>
<th>Increased</th>
<th>Remained the same</th>
<th>Reduced</th>
<th>Significantly reduced</th>
<th>Opinion not expressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiambu</td>
<td>50.00</td>
<td>36.67</td>
<td>3.33</td>
<td>3.33</td>
<td>6.67</td>
<td></td>
</tr>
<tr>
<td>Murang’a</td>
<td>57.22</td>
<td>26.74</td>
<td>1.07</td>
<td>0.53</td>
<td>14.44</td>
<td></td>
</tr>
<tr>
<td>Kirinyaga</td>
<td>54.90</td>
<td>25.49</td>
<td>3.92</td>
<td>0.00</td>
<td>15.69</td>
<td></td>
</tr>
<tr>
<td>Total Households</td>
<td>55.97</td>
<td>27.61</td>
<td>1.87</td>
<td>0.75</td>
<td>13.81</td>
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</tbody>
</table>

Table VII: Respondents’ indicators of food security in households

<table>
<thead>
<tr>
<th>Description of indicator</th>
<th>Response (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not buying food/selling food/eat all meals/relief</td>
<td>43.58</td>
</tr>
<tr>
<td>Food in store</td>
<td>13.32</td>
</tr>
<tr>
<td>Healthy/clean/happy family members/disease/pest incidence</td>
<td>12.83</td>
</tr>
<tr>
<td>Actual/potential yield</td>
<td>7.51</td>
</tr>
<tr>
<td>Ready crops in the field</td>
<td>4.84</td>
</tr>
<tr>
<td>Extra source of income(support from children/pension/diversification, business, employment)</td>
<td>4.60</td>
</tr>
<tr>
<td>Healthy livestock/domestic animals</td>
<td>4.60</td>
</tr>
<tr>
<td>Ability to buy other food stuffs</td>
<td>4.60</td>
</tr>
<tr>
<td>Generosity to visitors</td>
<td>1.94</td>
</tr>
<tr>
<td>Hire/hired in casual labour</td>
<td>0.73</td>
</tr>
<tr>
<td>Ability to pay school fees</td>
<td>0.48</td>
</tr>
<tr>
<td>Weather condition</td>
<td>0.48</td>
</tr>
<tr>
<td>Theft of crops on farms</td>
<td>0.24</td>
</tr>
<tr>
<td>Type of house</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Table VIII: Improvement on food security status of households (% of HH)

<table>
<thead>
<tr>
<th>County</th>
<th>Significantly improved</th>
<th>Improved</th>
<th>Somewhat improved</th>
<th>Remained the same</th>
<th>Deteriorated</th>
<th>Opinion not expressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiambu</td>
<td>30.00</td>
<td>66.67</td>
<td>0.00</td>
<td>3.33</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Murang’a</td>
<td>55.32</td>
<td>37.23</td>
<td>1.60</td>
<td>1.06</td>
<td>4.79</td>
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</tr>
<tr>
<td>Kirinyaga</td>
<td>65.38</td>
<td>21.15</td>
<td>3.85</td>
<td>0.00</td>
<td>9.62</td>
<td></td>
</tr>
<tr>
<td>Total Households</td>
<td>54.44</td>
<td>37.41</td>
<td>1.85</td>
<td>1.11</td>
<td>5.19</td>
<td></td>
</tr>
</tbody>
</table>

Table IX: Perception on extent of stemborer attack (% of respondents)

<table>
<thead>
<tr>
<th>County</th>
<th>Significantly reduced</th>
<th>Reduced</th>
<th>Remained the same</th>
<th>Increased</th>
<th>Significantly increased</th>
<th>Opinion not expressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiambu</td>
<td>33.33</td>
<td>43.33</td>
<td>13.33</td>
<td>3.33</td>
<td>6.67</td>
<td></td>
</tr>
<tr>
<td>Murang’a</td>
<td>45.74</td>
<td>38.83</td>
<td>6.38</td>
<td>1.06</td>
<td>7.98</td>
<td></td>
</tr>
<tr>
<td>Kirinyaga</td>
<td>38.00</td>
<td>22.00</td>
<td>16.00</td>
<td>0.00</td>
<td>24.00</td>
<td></td>
</tr>
<tr>
<td>Total Households</td>
<td>42.91</td>
<td>36.19</td>
<td>8.96</td>
<td>1.12</td>
<td>10.82</td>
<td></td>
</tr>
</tbody>
</table>
Table X: Perception on effect of sustainable agricultural practices on amounts and costs of inputs used for maize production

<table>
<thead>
<tr>
<th>Farm Input</th>
<th>n</th>
<th>Significantly increased</th>
<th>Increased</th>
<th>Remained the same</th>
<th>Reduced</th>
<th>Significantly reduced</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN</td>
<td>164</td>
<td>28.83</td>
<td>22.09</td>
<td>17.18</td>
<td>22.09</td>
<td>9.82</td>
</tr>
<tr>
<td>Certified Seed</td>
<td>176</td>
<td>27.01</td>
<td>18.97</td>
<td>40.80</td>
<td>11.49</td>
<td>1.72</td>
</tr>
<tr>
<td>DAP</td>
<td>103</td>
<td>24.24</td>
<td>29.29</td>
<td>12.12</td>
<td>30.30</td>
<td>4.04</td>
</tr>
<tr>
<td>Manure</td>
<td>94</td>
<td>53.09</td>
<td>28.40</td>
<td>9.88</td>
<td>8.64</td>
<td>0.00</td>
</tr>
<tr>
<td>NPK</td>
<td>131</td>
<td>29.46</td>
<td>14.73</td>
<td>14.73</td>
<td>31.01</td>
<td>10.08</td>
</tr>
<tr>
<td>Other inputs</td>
<td>4</td>
<td>50.00</td>
<td>0.00</td>
<td>0.00</td>
<td>50.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Recycled Seed</td>
<td>45</td>
<td>25.00</td>
<td>20.00</td>
<td>32.50</td>
<td>10.00</td>
<td>12.50</td>
</tr>
<tr>
<td>Grand Total</td>
<td>717</td>
<td>30.52</td>
<td>21.51</td>
<td>21.95</td>
<td>20.06</td>
<td>5.96</td>
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Table XI: Change in purchase of dairy feeds

<table>
<thead>
<tr>
<th>Dairy feed</th>
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<th>Reduced</th>
<th>Remained the same</th>
<th>Increased</th>
<th>Significantly increased</th>
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<tr>
<td>Napier Grass</td>
<td>78</td>
<td>41.03</td>
<td>15.38</td>
<td>20.51</td>
<td>19.23</td>
<td>3.85</td>
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<tr>
<td>Maize Stover</td>
<td>44</td>
<td>45.45</td>
<td>9.09</td>
<td>13.64</td>
<td>29.55</td>
<td>2.27</td>
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<tr>
<td>Grass</td>
<td>15</td>
<td>53.33</td>
<td>6.67</td>
<td>6.67</td>
<td>33.33</td>
<td>-</td>
</tr>
<tr>
<td>Hay</td>
<td>10</td>
<td>40.00</td>
<td>10.00</td>
<td>-</td>
<td>50.00</td>
<td>-</td>
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<tr>
<td>Dairy Meal</td>
<td>88</td>
<td>44.32</td>
<td>15.91</td>
<td>12.50</td>
<td>25.00</td>
<td>2.27</td>
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<tr>
<td>Maize Bran</td>
<td>71</td>
<td>50.70</td>
<td>5.63</td>
<td>14.08</td>
<td>29.58</td>
<td>-</td>
</tr>
<tr>
<td>Maize Germ</td>
<td>41</td>
<td>51.22</td>
<td>14.63</td>
<td>9.76</td>
<td>21.95</td>
<td>2.44</td>
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<tr>
<td>Other Feeds</td>
<td>80</td>
<td>47.50</td>
<td>11.25</td>
<td>37.50</td>
<td>3.75</td>
<td>-</td>
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</table>

Table XII: Change in sales of farm produce

<table>
<thead>
<tr>
<th>Farm produce</th>
<th>n</th>
<th>Significantly increased</th>
<th>Increased</th>
<th>Remained the same</th>
<th>Reduced</th>
<th>Significantly reduced</th>
</tr>
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<tbody>
<tr>
<td>Desmodium</td>
<td>1</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>Maize</td>
<td>125</td>
<td>54.40</td>
<td>30.40</td>
<td>10.40</td>
<td>4.00</td>
<td>0.80</td>
</tr>
<tr>
<td>Maize stover</td>
<td>9</td>
<td>33.33</td>
<td>55.56</td>
<td>11.11</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Milk</td>
<td>89</td>
<td>47.19</td>
<td>32.58</td>
<td>13.48</td>
<td>6.74</td>
<td>0.00</td>
</tr>
<tr>
<td>Napier</td>
<td>20</td>
<td>45.00</td>
<td>20.00</td>
<td>30.00</td>
<td>5.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Grand Total</td>
<td>244</td>
<td>50.41</td>
<td>31.15</td>
<td>13.11</td>
<td>4.92</td>
<td>0.41</td>
</tr>
</tbody>
</table>

Table XIII: Respondents’ perceived change in livelihoods

<table>
<thead>
<tr>
<th>Perceived change</th>
<th>% of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved farm productivity/ food security/improved health status</td>
<td>47.67</td>
</tr>
<tr>
<td>Increased income</td>
<td>15.62</td>
</tr>
<tr>
<td>Increased livestock fodder/productivity</td>
<td>14.25</td>
</tr>
<tr>
<td>Improved farming</td>
<td>6.30</td>
</tr>
<tr>
<td>Increased knowledge/information</td>
<td>5.48</td>
</tr>
<tr>
<td>Reduced costs</td>
<td>3.56</td>
</tr>
<tr>
<td>Improved manure production /soil fertility</td>
<td>1.92</td>
</tr>
<tr>
<td>Reduced stem borer incidence</td>
<td>1.64</td>
</tr>
<tr>
<td>Improved energy</td>
<td>0.82</td>
</tr>
</tbody>
</table>
MATUMIZIYAUDHAANIA KATIKA WALENISI NA MAFUTA

Matthew Kwambai1, Prof. Furaha Chai2, Prof. Wendo Nabea3 and Dave Bowen4

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IKISIRI


Maneno Makuu: uamilifu, udhahania, uhalisia, ujamaa, uwakilishi.

UTANGULIZI


Nadharia ya Usasaleo na ya Uamilifu

Kulingana naWaugh (1984) na Hutcheon (1988), Usasaleo ni vuvugu linalihitilafiana na Usasa, kwa ambavyo Usasa unajikita katika uwakilishi wa/Kungo la uaalimu na njia maalum na njia maalum ya kuendesha ujumbe wa matumizi. Wanasema kuwa Usasa unakupa mkopo hali za inawezesha utafiti wengine wakati uchanganuzi wa data wakati wa ndani ya ujambo la uchanganuzi, utafiti wa ndani ya kipengele cha data wengine. Nadharia ni vuvugu na kipengele cha uchapisho wa uchanganuzi fulani, ambavyo unachukua uchanganuzi wengine. Nadharia hii ina mihimili mingi kama vile: uandishi wa/data, wakati wa ndani ya ujumbe la ndani ya data, utafiti wa ndani ya ujumbe la ndani ya data, utafiti wa ndani ya ujumbe la ndani ya data, utafiti wa ndani ya ujumbe la ndani ya data.

Nadharia hii ina mihimili mingi kama vile: uandishi wa/data, wakati wa ndani ya ujumbe la ndani ya data, utafiti wa ndani ya ujumbe la ndani ya data, utafiti wa ndani ya ujumbe la ndani ya data, utafiti wa ndani ya ujumbe la ndani ya data. Nadharia hii ina mihimili mingi kama vile: uandishi wa/data, wakati wa ndani ya ujumbe la ndani ya data, utafiti wa ndani ya ujumbe la ndani ya data, utafiti wa ndani ya ujumbe la ndani ya data, utafiti wa ndani ya ujumbe la ndani ya data. Nadharia hii ina mihimili mingi kama vile: uandishi wa/data, wakati wa ndani ya ujumbe la ndani ya data, utafiti wa ndani ya ujumbe la ndani ya data, utafiti wa ndani ya ujumbe la ndani ya data, utafiti wa ndani ya ujumbe la ndani ya data.
Egerton University International Conference and Innovation Week

MAJUKUMU YA UDHAHANIA KATIKA WALENISI NA MAFUTA

Uwakilishi wa udhahania kama ilivyojadilwa kwa kifupi, unalenga kutumia majukumu kama vile: Kukejeli mifumo ya jamii na kupendekeza maisha ya ujamaa na usosiolisti, kupuka unambatana na mzuri kama inayotumika inatekeleza katika jamii. Ufahamu wa udhahania wao unahitaji vigumu kwa mabinguni wa mazingaombwe asili, sasa sio chini chini wa kwa chini.

Walibora (2010), wanaonyesha hali mbalimi ya uwasilishaji wa udhahania, wakati ufahamu wa udhahania wao wakilisha fantasia katika jamii. Hali hizi ilivyojadilwa kwa majukumu kwa mbinguni, kwa sababu wao wakilisha fantasia katika jamii, wakati ufahamu wa udhahania wao wakilisha fantasia katika jamii.

Walenisi inatumia jazanda za majabali mabubuhi na mabidi, na mabidili, na mabidi mabibuhi na mabidi mabidi. Jazanda hizi zimecheza mawazo mengi katika mazinga na ujeadhi wa mabidi, wakati Walibora (2010), wanaonyesha hali mbalimi ya uwasilishaji wa udhahania.

Hali kadhalika, udhahania unaonyeshwa kwa uwasilishaji wa udhahania, Walibora (2010), wanaonyesha hali mbalimi ya uwasilishaji wa udhahania, na hali hizi ilivyojadilwa kwa majukumu kwa mbinguni, sasa sio chini chini wa kwa chini.

Aidha, uhusiano wa kijinsia na tofauti za kitabaka unalinganuliwa katika Walenisi na duniani, alipofurushwa Dzombo. Kulikwa na usawa wa kijinsia na tofauti wa kitabaka, kama inavyoshukuru, dhuluma na uwongo katika Walenisi yanaweza kufananishwa na yanayotafitiwa na Walibora (2010), anapolinganisha riwaya ya Gunter Grass na za Said A. Mohamed. Anagundua kuwa kazi hazi zinadhiriwa enzi ya usasaleo ambapo hakuna mwingi linalowalimiana wa nyakati zilizopita na za sasa katika uwakilishi wa mambo kutokana na utandawazi, sayansi na maendeleo ya kitenziolojia. Walibora anasema kuwa uamiliifu wa riwaya za kisasaleo alizotafiti ni kudhirihiwa dunia iliyoendelea kila uchao.

Hali kadhalika, matumizi ya udhahania yanamwepushia mwandishi na kuchukua jekumu iwapo serikali itaona kuwepeni. Udhahania unalaleta kwamba kwa ambapo am.
MAREJELEO


SUBTERTERNITY AND RESISTANCE IN THE KENYAN POLITICAL AUTOBIOGRAPHY: A CRITICAL LOOK AT NOT YET UHURU AND THE FLAME OF FREEDOM

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ABSTRACT

An interrogation of the autobiographies by leaders who write from the margins of power show that subaltern political autobiographies inhabit a privileged position that enable one to see the effect of power on subaltern subjects. Their writings, thus, resist and mount a challenge to hegemonic structures that encroach and sustain the materiality of domination. In this regard, their political autobiographies can be said to be engaged in the quest for dismantling the silence of the “Other.” This paper contends that the Kenyan subaltern political autobiographies are not merely literary but political acts, and examining these texts will lead to a better understanding of the current political frameworks that help in the conceptualizing the Kenyan nation. The unit of analysis will be two Kenyan political autobiographies, particularly Jaramogi Odinga’s Not Yet Uhuru and Raila Odinga’s The Flame of Freedom. Biographical method of analysis will be employed. The perspectives and experiences of Jaramogi and Raila are used as the basis for a critique of the dominant discourse of the post-independence political elites. In particular, the emergence of these autobiographical works are interrogated here as counter-narratives of Kenyan politics and society, alongside the persisting elite structures of politics and culture extending from the colonial through to the post-colonial eras. The analysis of the autobiographical reflections of Jaramogi and Raila demonstrate levels of resistance which have not been recognised until now.

Key words: subalternity, autobiography, representation, self, autobiographical pact

INTRODUCTION

“The book is a collection of memories, and memory is, of course, imperfect, but I have rendered this story of my life the way I remember it…”

Raila A Odinga

“Truth depends not only on who listens but on who speaks.”

Birago Diop

In the recent past, the Kenyan literary stage has witnessed an upsurge of political autobiographies. What is clearly notable in these productions is the political quest that they are engaged in. Fronting the self, the genre of autobiography becomes a privileged source of information about the past of a country like Kenya. This is so because the genre provides a personal perspective on information that cannot be mined from the official history. This is, in a way, to argue that stories about detention and political assassinations would not be found in official history textbooks because the education system and curriculum are sanctioned by the state and therefore children would only be taught what the government would want them to know. The autobiography, thus, complements historical records as it offers the unofficial history of a nation in the making.

The genre of autobiography has always elicited a flurry of debate in literary circles, and especially in the current critical and theoretical space. Autobiographies have increasingly become popular literary documents which calls for sustained interrogation and analysis of the narratives produced. The Kenyan political autobiography is not only the story of the narrating subject but can be read as a quest for resistance in the society within which the subject writes or lives. This paper interrogates the autobiography as a historical document written by a representative individual which serves more purposes than just a historical record. Historians, like autobiographers, are writers assembling a story about the past from archives available to them. However, as Muchiri (2014) argues, while historians place themselves outside or at the margins of the historical picture, autobiographers are at the centre of the pictures they assemble and are
interested in the meaning of larger forces, conditions, or events for their own stories.

THEORETICAL UNDERPINNINGS

The advent of the twentieth century saw the dawn of an era, which presented the fertile ground for autobiographical writings (Smith & Watson, 2001; Weintraub, 1972). Autobiography is a genre that tries to capture such complex, complicated and elusive phenomena called life and self. Its patterns change, its formal qualities change, the contours and textures change from one life to another, from one self to the other. Misch (1950) notes:

Autobiography is unlike any other form of literary composition. Its boundaries are more fluid and less definable in relation to form. In itself it is a representation of life that is committed to no definite form. It abounds in fresh initiatives, drawn from actual life: it adopts the different forms with which different periods provide the individual for his self-revelation and self-portrayal. (p. 2)

However, attempts have been made to define the genre, to describe the common threads to be found in the genre called autobiography. Autobiography usually denotes the story of one’s life written by oneself (Lejeune, 1989). Lejeune identifies four elements constitutive of autobiography: prose as the medium, real life as the subject matter, author as narrator and retrospective as the point of view. The autobiographies of Mahatma Gandhi (The Story of My Experiments with Truth, 1927), Jawaharlal Nehru (An Autobiography, 1936), and Kwame Nkrumah (Ghana: The Autobiography of Kwame Nkrumah, 1957) formed a new dawn in autobiographical writing by public figures, more specifically, political leaders in the third world societies. These autobiographies went beyond a sub-genre of history and attempted to introspect and reflect on personal dilemmas and crises. They take to an explanation of “the self” in their autobiographies and portray a self that is knowledgeable. In this regard, the autobiographies can be thought of as the attempt to forge a national self.

The history of autobiography has almost always pointed to the elusive fallacy that most autobiographies are a docket of men who belong to the public sphere and enjoying a prime status in society. This tradition neglects the autobiographies of the downtrodden. The determinants of class, race and gender are excluded from the record of autobiography. The autobiographies of the marginalized have been silenced in the historical process; their narratives have been sucked into the metanarratives of the state. This paper endeavors to recover the lost tradition of the nationalist leader’s autobiographies, leaders who reigned but never ruled. The autobiographies of the leaders who reigned but never ruled, just like the gay and lesbian autobiographies, autobiographies of the disabled, autobiographies of geisha and sex workers, autobiographies of ethnic minorities and so on attain complex magnitudes; for, they question not only political hegemony, heterosexual, patriarchal, normative regimes but also bring an alternative sense of the self and identity, worldview and perspective into existence (Pascal, 1960; Olney, 1980; Gusdorf, 1980, Freeman, 1993). Analysis of works like these necessarily makes autobiographical criticism transdisciplinary. Marginalised groups reside in a negative relationship to power. The degree and kind of power and powerlessness may differ, but they do inhabit structures of power. An interrogation of the spaces that the subaltern autobiographies inhabit enables one to see the effect of power on subaltern subjects and the element of resistance written into them. This makes the subaltern autobiography not merely a literary act but a political act.

Subaltern autobiography is synonymous with survival literature, and is thus, narrative of resistance. The state of subordination of a community/group entails that its identity is conditioned by the dominant community/group. In this context, Jaramogi Oginga Odinga’s (hereafter referred to as Jaramogi) and Raila Odinga’s (hereafter referred to as Raila) autobiographies are subaltern political autobiographies, and as such, are narratives of resistance. Janice Morgan argues, “... to be marginalized to a dominant culture is also to have had little or no say in the construction of one’s socially acknowledged identity” (Perkins, 2000: 44). What Valerie Smith speaks about the African-American autobiography becomes pertinent to all those who occupy subaltern position and attempt to construct a narrative of the self:

Simply to write the story of his or her own life represent[s] an assault’ on the line of reasoning that assumes and perpetuates the construct that African Americans do not live...as fully imaginative, significant, intellectual, and complex lives as the dominant American community, ‘since to make oneself the subject of a narrative
presumes both the worth of that self and its interest for a reader. (Danahay, 1991:67)

Basing our argument on the conceptualization above, this paper contends that Jaramogi and Raila are autobiographers who “re-write” selfhood, in their description of their lives and the life of their community. Hence the act of writing autobiographies by these leaders becomes a measure of resistance against oppression and hegemony. It is an act imbued with political connotations. These autobiographies thus call for more complex and equipped critical and reading strategies. They are not mere explications of the self, but intricate platforms of political performance. Autobiography as a genre has an important place in subaltern ideology as it proves that there are many versions of reality:

Autobiography now has the potential to be the text of the oppressed, the culturally displaced, forging a right to speak both for and beyond the individual. People in positions of powerlessness—women, black people—have more than begun to insert themselves into the culture via autobiography via the assertion of the personal voice…. (Swindells, 1995: 7)

Autobiography is thus a platform for the exploration and explication of the self. The subjects of subaltern autobiographical narratives speak from marginal locations. Subjectivity of subaltern autobiography is constructed in the encounter between power and powerlessness, domination and subjugation. The leaders who reigned but never ruled have been relegated to the margin, being treated as “the other” by the political rulers. There has always been a political line drawn between “we” the rulers and “they” the leaders who reigned but never ruled. This demarcating line not only divides people into two categories but also implies a hierarchy. Their “self” often remains effaced or defaced.

**RESISTANCE IN THE KENYAN POLITICAL SUBALTERN AUTOBIOGRAPHIES**

Resistance is a term that is largely associated with Edward Said in his groundbreaking work, *Orientalism* (1978). In this paper we argue that the autobiographies of Jaramogi and Raila are texts that are involved in political resistance, reconstructing the Kenya’s political past, and in a way sanitizing the political image of the writer. *Orientalism* is mainly interested in showing the existence of political ideology that governs and uses orientalism to rule and impose hegemony over the orient. “Hegemony” as referred to by Said is pertinent in this study. Said shows how orientalism distributes assumptions and prejudices about the orient to the western audience, without a corresponding challenge from the “Other” (209; 324). It also demonstrates that every agency involved in the production of orientalism is guilty, either by association, or by themselves is central in the making and sustaining of imperialism. Judging from this, Said felt it was warranted to claim “Orientalism is fundamentally a political doctrine willed over the Orient because the Orient was weaker than the West” (204). Jaramogi and Raila are thus weak, and we argue, thus, they write to reject this position.

As we are going to show in the course of this paper, the writers explored here assert an independent or “an oppositional critical consciousness” (Said, 1978: 326-7). The aspect of “oppositional consciousness” was identified by Ashcroft & Ahluwalia (1999) as a strategy of resistance. Wan-Ahmad (2010) contends that it is a strategy of “writing back” to the orientalists by exposing their political connection disguised under the academic pretension of pure knowledge. In writing their autobiographies, therefore, Jaramogi and Raila subvert what is commonly regarded as oriental muteness that has led to more oppression of the orient in this power relationship. For this reason, the potential for resistance is present when “the history that resisted its ideological as well as political encroachments” is brought into life. In short, it requires the revival of repressed or resistant history that can mount challenges to hegemonic structures such as orientalism (Said, 1985: 93-94). This means that studying the autobiographies of Jaramogi and Raila as documents of political resistance and providing an alternative history is very important, especially so, when Kenya is undergoing various political cultural, social, and economic changes.

**The Politics of Betrayal: Not Yet Uhuru and The Flame of Freedom**

In this paper, the study gravitates towards interrogating the way writing has been used by the leaders to deconstruct the Kenyan elite narrative. In it, Jaramogi’s and Raila’s autobiographies are contextualized within the narratives of politics of betrayal. The phrase is borrowed from the title of Khamisi’s (Khamisi was the Member of Parliament for the coastal constituency of Bahari from 2003 to 2007) autobiography *The Politics of Betrayal: Diary of a Kenyan Legislator* (2011)
which explores the leadership betrayals that he believes are responsible for the political, social, and economic rot that are pervasive in Kenya.

Politics of betrayal in Kenya is one of the major themes that define the country since independence. According to Branch (2011) and Hornsby (2012) political betrayal in Kenya began even before the Union Jack was lowered and the Kenyan flag hoisted in the midnight of 12th December, 1963. Specifically, Hornsby observes that the narratives of betrayal are discernible when Kenya’s alternative history is interrogated. This is the history of popular resistance to an alliance of comprador elites and foreign rulers. This history was sustained by academics, socialists and nationalists, who believed that the leadership had made fundamental errors from the beginning. This narrative begins with resistance to the colonial conquest, then the struggle for land and identity leading to the Mau Mau war. It challenges the concept of ‘development’ as growth and argues that Kenya has been exploited and abused by the comprador elite. After independence, the victory of the conservative ‘home guards’ was a betrayal of independence, and attempts to reverse this civilian coup led to repression and murder in the years after independence.

The attempt to change this state of affairs is followed up by Kenya’s novelists, poets and playwrights. After uhuru, an upsurge of new novels, poems and plays that examined the postcolonial betrayal in Kenya and the role that the comprador elite played to cause this situation emerged. Examples of these are novels, which Manghan-Brown identifies as “novels of Freedom” (1985: 206), include Meja Mwangi’s Taste of Death (1975), G. Wachira’s Ordeal in the Forest (1968), and Charles Mwang’a’s A Tail in the Mouth (1972). All were written between 1967 and 1975, reflecting a time in Kenya when the neocolonial bourgeoisie consolidated its power.

Jared Angira’s poem “No Coffin, No Grave” evinces a critical concern with social injustice in post-independence Kenyan society. The poem is a chronicle of events that marked the death of a traitor-ruler who was “buried without a coffin” (line 1) and whose post-mortem was carried out by scavengers, vultures in the open, outside a place where people go to celebrate and have fun. A night club! (line 6). This gives a sense that his death may have been wished and when it came, it was a necessary party for his people. The poem records that politics was for the “experts” while the common man was cursed to brood on books, think about schoolgirls and hunger, sleeping under torn mosquito nets (lines 15-22). And if our politician should step into a bar, he is the lord (line 24) and woman magnet (line 25) who speaks the language of money; the people’s money. The masses are portrayed as powerless and can only cover the darkness of their mouths and tell their prayers to the devil for all the post-independent politician cares. This poem is thus an insight to the wanton theft and betrayal of the masses by the leaders after independence.

Angira’s poem reads into Kresse’s (2016) examination of Sauti ya Dhiki (Voice of Agony), a collection of poems by Abdilatif Abdalla written in 1973. This scholar rightly observes that Abdilatif’s poetry condemns what he sees as dictatorial features of Jomo Kenyatta’s KANU government. The poems in Sauti ya Dhiki illustrates a fundamental turning point in Kenya’s early postcolonial politics, and bears witness to the demise of democratic structures and processes that had been implemented only five years after independence. One of the vices that bring about the demise of democracy and thwart development in Kenya is tribalism.

The same line of argument can be raised and sustained in Ngugi wa Thion’o (1988) I Will Marry When I Want, a play that critiques politics, corruption and economic exploitation in postcolonial Kenya. The play became an interrogation of ‘the poisoned gift of independence’ and an examination of political betrayal through land grabbing, arrogance and the greed of the political ‘big-wigs.’ Notably too is Francis Imbuga’s (1976) Betrayal in the City in which the author examines the wanton betrayal of the masses through exploitation, nepotism and inefficiency that characterized the post-independence state.

Looking at this post-independent literature in Kenya, two levels upon which betrayal in Kenya occurred, thus, can be discerned. The neocolonial elite betrayed the masses through the failure to provide frameworks within which Kenya would forge ahead and attain an all-round development. The post-independent Kenyan elite laid the foundation of negative ethnicity and advanced it within the contexts of ideological differences. This is because by the end of 1965, Kenya had restored the ‘command and control’ system that the British had tried to replace as independence dawned. A system of state regulation would dominate an otherwise capitalist society, with the President at the apex of power. The tension between Kikuyu and Luo that had begun before independence had deepened, and the foundations of Kikuyu dominance had been.
established (Opondo, 2014). Negative ethnicity became the lenses that defined Kenya’s future. Political structures and economic institutions would continue to mirror the pre-independence model, with a new elite at the apex rapidly arrogating to itself the wealth and privileges that the Europeans had enjoyed, and calculatingly isolating the other ethnic groups who could threaten their hegemony.

Also, betrayal occurred among the neocolonial elites themselves. After independence, Hornsby (2012) reiterates that Kenya African National Union’s (KANU) leadership was becoming more conservative and Western oriented. According to Opondo (2014), class, power and ethnicity became increasingly intertwined and thus displaced race as a factor in the political process hence the Kenyan society became deracialised but not de-ethnicised (Kanyinga, 2007: 86). Kanyinga asserts that at independence, “the concept of tribe became more important as the new elites turned to their ethnic groups for support in their competition with each other” (86). Subsequently and for the sake of power, ethnicity became a toll for political survival. There was variance between key policy decisions made on land, defense and Western investment during 1962–5 between the ruling elite and the masses. The masses felt alienated by the policies made by their leaders and this brought out a section of leaders among the ruling elite who started championing the interests of the masses. This chapter delves in the literature that interrogates this betrayal of the masses by the post-colonial elite leaders.

The paper contends that ethnicity provided the historical context that gave an impetus to the rise of subaltern political autobiographical writings in Kenya. Imbued in this objective is the assumption that Jaramogi’s and Raila’s autobiographies are a critique of the Kenyan nationhood. The argument advanced in the chapter is that Kenyan nationhood has slid into ethnicity, and this has given birth to the avalanche of political autobiographies in Kenya. The paper gets its thrust from the ability of the genre to engage the concept of negative ethnicity from a personal perspective, and how this vice has been perpetuated in successive regimes and how this impinges on development and unity. However, the term ethnicity is used synonymously with the terms tribalism and negative ethnicity in Kenya, and this study has adopted this Kenyan view.

In their autobiographies, Jaramogi and Raila are involved in constructing a single narrative: that Kenya as a country has been betrayed since 1963. The common man, the wretched of Kenya has been betrayed by the ruling class. As we read through Not Yet Uhuru and The Flame of Freedom, we learn the clarion call that Kenya as a nation has undergone four political miscarriages. The first miscarriage happened in 1963, independence and the first republic, 1992, the second republic and the reinstatement of pluralism, the exit of Moi and the National Rainbow Coalition (NARC) dream of 2002 and the new constitutional dispensation of 2010. Michael Wainaina argues that all babies die at birth the political class entrusted to midwife the process of the birth of modern Kenyan state is too invested in the primitive tribal state to give the new, modern Kenya a chance for survival (Wainaina, 2016: 12).

The four missed chances have, therefore, not been by default but by design. The political class midwifing the process has deliberately strangled the baby to protect the status quo. They have consistently squandered the opportunities for renewal. In most cases politicians are given the job of midwifing the modern state because people think that they are statesmen and not just regular politicians. These leaders are so heavily and hopelessly invested in politics of ethnicity, impunity and mediocrity for them to midwife a modern Kenya. In their autobiographies, Jaramogi and his son Odinga, present themselves as leaders whom Kenya should regret for not having. In their texts, they are the statesmen per excellence.

In his autobiography, Not Yet Uhuru, Jaramogi comes out from the pages of his autobiography as an unrepentant patriot at heart, a pan-africanist, a staunch anti-white domination in Kenya’s pre-independence politics, a genius, a father, a writer, and a leader whom we would regret for not having (Nyairo, 2015). Reading through the text it becomes clear that Jaramogi seems to be fighting what he takes to be a misrepresentation by many a modern scholar. In this authoritative, sometimes brutal autobiography, the author re-writes the Kenyan history; the history often times meticulously contorted to suite British Imperial propaganda; the history that is guilty of vilifying saints, and exalting villains; the history whose dying embers must be rekindled. (Odinga, 1)

Not Yet Uhuru recounts that although many of his British-Sponsored early scholars (through the several church missions) succumbed to the allure of the colonial staggering material wealth, prestige, and promises of overnight riches, Jaramogi remained
steadfast in his resolve. It highlights his contribution to the welfare of the Kenyan scholars by sourcing for scholarship opportunities, and highlighting the plight of Kenyans.

In the text, it is recorded, when James Gichuru (in alliance with Mboya, Moi, Ngala, through KANU) joined forces with the self-proclaimed settler minority led by Blundel and company, it was Jaramogi who remained unmoved with Kenya African National Union, especially with respect to KANU’s demands of ‘Kenyatta na Uhuru.’ It was Jaramogi who, through endless petitions, conferences in London, trips overseas, public speeches, engineered the release of the Kapenguria Six. These assertions make Jaramogi stand out. The assertions aim to counter the misrepresentations of the Kenyan past by the mainstream state-sanctioned narrative. In this regard, Jaramogi’s autobiography serves the function of self-clarification and self-justification (Gusdorf, 1980; Freeman, 1993).

As it appears from the text, Jaramogi amplifies what he has done to the Kenyan state, the roles he has played and the sacrifices he supposedly done for the Kenyan nation. For the sake of Kenyans, and Kenya’s unity, Jaramogi ignored countless attempts made by KADU technocrats (on behalf of their Imperial Masters) to wage a rift between him and Kenyatta once the latter assumed office, first as Prime Minister in 1963, then later as President in 1964, and when he couldn’t take it anymore, like a gentleman, Jaramogi left KANU without causing a scene (Ogot, 1996: 196; Odinga, 1967: 300). In his resignation letter he stated:

> I have a conscience and this in fact does prick me when I earn public money but with no job to do. I consider this a waste of public money and I am worried lest the future generation questions my sincerity, when they would learn that I allowed myself to hold a sinecure post in the midst of poverty and misery in our country. With this realisation, I cannot continue to hold this position any longer and I hereby tender my resignation. (300)

As it will be recalled from the foregoing, the rift between Jaramogi and Jomo Kenyatta had started few years into independence. This paper notes that to understand these two leaders’ differences it is illustrative to interrogate the ideological frameworks within which they operated. According to Jaramogi, the rift between him and Kenyatta was caused by the operatives that surrounded the Presidency. This group of politicians opposed him because he had earlier on advocated for Kenyatta’s release from detention (292). Ideologically speaking however, Jaramogi and Kenyatta’s rift could have been caused by their differences in their ideological persuasions.

Not Yet Uhuru, therefore, is a portrayal of Jaramogi’s frustration with Kenyatta’s turn-about that had turned fellow Kapenguria Convicts such as Bildad Kaggia into his foes. Kenyatta, like KADU political stooges, had betrayed the people, and there was no way Jaramogi was going to be a part of such grand betrayal. The formation of Kenya Peoples Union (KPU) and his resigning from the Government are narrated here to highlight his patriotism. The same argument can be raised in regard to Raila Odinga, Jaramogi’s son.

The Flame of Freedom chronicles the remarkable journey of one of Africa’s leading politicians and statesmen. Raila’s life-story mirrors the triumphs and tragedies of Kenya’s struggle to entrench multi-party
democracy and the rule of law into the fabric of the State. The book is a testament to his courage, determination and sacrifice in the cause of peace, development and public service. It is a bold call to action for all African leaders.

Raila’s autobiography takes an in-depth look of how the former prime minister of Kenya has struggled to end corruption and bring freedom. It reveals the life journey of Raila (His family and political life) and gives an account of how he, Raila suffered while inside the government. In his autobiography, Raila paints an image of how Party of National Unity (PNU) used every means to frustrate and humiliate him and his coalition party Orange Democratic Movement (ODM). Odinga reveals of how the ODM ministers were undermined by PNU associates. The autobiography also indicates how PNU machines used propaganda to politically kill him. It mostly talks about Raila’s time in the coalition government with Mwai Kibaki and the betrayals he has undergone all through to bring him down. The Flame of Freedom also gives a history of Odinga’s challenges since the death of his father and how he managed to overcome the challenges. It gives a slight hint of his role in the 1982 coup.

Raila’s autobiography (re)brands him as the intellectual custodian of Kenya’s pro-democracy struggles, and the founding father of democracy. The photographs he selects, the stories he tells, the way he tells them and the stories that he does not tell, seem to establish Odinga as the authority on the making of Kenya. Raila’s story gives clear justification for the constitutional changes that this country finally made. The text portrays how Raila stands tall against terror of a dictatorship where sycophancy, fear and silence reigned supreme. It is an examination of “the government’s long vendetta against the Odingas” (Nyairo, 2015). Successive governments have successfully isolated the Odingas from power. As one reads through the text the refrain tumeonewa lingers in the background.

Undoubtedly, this is a story of courage and determination but in the end, it fills one with an overwhelming sense of pity. The humiliation that Raila has suffered is partly in the brutality of detention, so he gives very few details of his second and third stints therein. Understandably, there is an even more harrowing pain. You hear it in the number of times Raila reports, “[they] attacked Jaramogi”. As one reads through the text, the weight of his father’s unfulfilled dreams is evidently on Raila’s shoulders. The two autobiographies are, without doubt, classic examples of subaltern political autobiographies. They deconstruct history, subvert common knowledge and vilify the main stream state narrative.

The Flame of Freedom is a continuation of a journey has to end when the Kenyan dream is realized. This dream is tied to the Odinga family. In one of the moving instances in Freedom Raila writes:

The task of keeping the flame of freedom burning had been passed to us, and already, down the years, we had fought so hard and come so far. But I knew there was still a long and difficult road ahead. As I spoke on that day in 2007, I rededicated my life to travelling that road, so that, one day, the Kenyan dream, in all its glory, would become reality. It is the dream of a fundamentally transformed society, not only in our land but across the entire African continent. (p. 4)

Although the two autobiographies the study has examined here are written by representative individuals, Jaramogi representing the old guards, and Raila standing for the new brand of Kenyan leaders, the two presents their authors as leaders who are down to earth, working closely with the masses and leading normal lives. This portrayal is a case of autobiographers presenting only the version of history that favours the subject and erasing that which is not in their favour. This is the case for instance with Njenga Karume’s autobiography which allows him to erase certain aspects of Kenyan history such as the Mau Mau war and projects himself as a successful businessman. His narrative as Muchiri (2014) argues demonstrates the possibility of convenient truths in autobiographies; it would be an inconvenient truth for him to state that the mere closeness to the ruling elite predisposes one to opportunities not necessarily available to other citizens. By narrating his story and highlighting his efforts in business, Karume camouflages the truth that opportunities are often aided by how close one is to power. The same can be said in respect to Uhuru and Freedom, especially as regards the truth in their autobiographies. Although Jaramogi and Raila try hard to convince the reader that they are subalterns, their elevated status in the society cannot be wished away, they are privileged more than the masses they claim to represent. They are as ethnic as the leaders they vilify.

CONCLUSION
This paper has clearly shown that there is a consensus among the autobiographers interrogated here that they feel misrepresented by previous and subsequent writings, by friends and critics alike. These autobiographies seem to follow the same creed that people have failed to unravel the real person behind Jaramogi and Raila. These autobiographies are therefore narratives of resistance. In them, these leaders refuse the misrepresentations of their lives and construct images of who they think they are. This desire to self-explication seems to be the central goal of penning the Kenyan subaltern political autobiographies. As we have succinctly shown in this paper, the writers explored here assert an independent and “an oppositional critical consciousness” as a strategy of resistance. They write back to the mainstream narrative, deconstructing it, subverting it and constructing, for themselves identities that are consistent to what the masses need in an ideal leader. They present themselves as the best alternatives of the leadership. They are the most wise, consistent, intuitive, ideologically wealthy and incorruptible. In writing their autobiographies, therefore, Jaramogi and Raila subvert what is commonly regarded as oriental muteness that has led to more oppression of the orient in this power relationship. For this reason, the potential for resistance is present when “the history that resisted its ideological as well as political encroachments” is brought into life. In short, it requires the revival of repressed or resistant history that can mount challenges to hegemonic structures such as orientalism (Said, 1985: 93-94). This means that studying the autobiographies of Jaramogi and Odinga as documents of political resistance and providing an alternative history is very important, especially so, when Kenya is undergoing various political cultural, social, and economic changes.

REFERENCES


ROLE OF GLOBALIZATION IN THE DIMINISHING OF AFRICAN INDIGENOUS EDUCATION SYSTEMS: AN EXAMPLE OF ABAGUSII CIRCUMCISION CEREMONY

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ABSTRACT

Various African communities had different ways of passing their knowledge from one generation to another before formal education was introduced. The Abagusii community used circumcision of boys to impart knowledge on their culture, economic, political and social activities. Circumcision is a stage in life for one to pass from childhood to adulthood. Boys between the age of 8 years to 16 years were ready for circumcision. The night before circumcision, the boys spent a night in their friend’s house. At night, their elders measured their patience and stamina by sending them into the dark night, beating them and administering physical exercises. At dawn, the boys were picked up by men who led them to the river where the circumciser was waiting. After all boys were circumcised, the journey home began. At home, the seclusion period began. During seclusion, they were taken through several rituals by their seniors and elderly men. They were taught and informed of their enemies as a society, how to fight, sex life, marriage among others. However, with time these ceremonies have reduced in number and intensity. The few that are still practiced are a blend of Abagusii culture with other African and Western cultures. Gradually, Abagusii have moved from circumcising at home to hospitals. Some of the teachings have been considered backward and evil. It is against this background that this paper sought to investigate the role of globalization in the diminishing of African indigenous education systems with interest on Abagusii circumcision ceremony. Data was collected from the field using participant observation and interviews. Library research was done too. Globalization theory was used to analyse data. Data was presented using a descriptive approach. This investigation sought to inform stakeholders of the impact of globalization on Abagusii and other African oral literatures.

Keywords: Indigenous, Education, Globalization, Abagusii, Circumcision

INTRODUCTION

Globalization

Mazrui (2001) opines that there are three distinct ways that globalization is interpreted; as economic interdependence across vast distances: information availability and movement across vast distances; and reduction of the world into a global village. Forms of globalization according to Mazrui are economic and cultural. Globalization therefore is multi-dimensional with economics, culture and politics. For the purposes of this paper, we focused on the cultural form by investigating the role globalization has played in the diminishing of African indigenous education systems. Several scholars have tried to explain what globalization is. For a better understanding, we will focus on a couple of definitions to build our argument on. Nsibambi (2001) explains globalization as a process of advancement and increase in interaction among the world’s countries and people facilitated by progressive technological changes in locomotion, communication, political and military power, knowledge and skills, as well as interfacing of cultural values, systems and practices. From this definition it is clear that globalization has been driven by developments in information technology which have eased the process of interaction between people who are far apart. Interaction between people with different cultures has been made easier through social media sites.

According to Alhaji (2013) globalization is the movement of people, languages, ideas and products around the world. He goes on to explain that this movement has had negative impacts on African countries. They are losing their cultural identity and therefore their ability to interact with other cultures on an equal and autonomous basis. When two cultures interact, one is strengthened by weakening the other. This is the case of African cultures versus Western cultures. Africans have copy pasted western cultures in every aspect. This paper sought to investigate how true this claim is by studying the death of indigenous education systems among the Abagusii community.
Wilfred (1997) explains globalization as a continuation of a long tradition of over 500 years, the tradition of imperialism. Globalization is only the latest phase and expression of this uninterrupted history of domination and subjugation of peoples, nations, cultures through conquistadors and colonizers. It is a tradition of political, economic and cultural domination of some nations over others.

Globalization therefore is the push to have a homogenous world culture and beliefs. Some of the manifestations of a global culture in our world today include global sports like the Olympic Games, World Cup among others. Global social problems like terrorism and AIDS have cemented these efforts. Unfortunately, almost always, Africa has let go her culture to adopt a westernized, modern culture at the expense of hers. It is against this background that this paper sought to investigate how globalization has affected African indigenous knowledge.

African Indigenous Education
Before the arrival of Europeans in Africa, Africans had their system of education although not formal. Education is essential in transformation of a society’s norms and values. Through education, the new generation gains knowledge on a number of things. Maduagwu (1999) opines that traditional education was essentially functional. By functional he means that learners were taught things that affected their daily life. He goes on to say that this kind of education was in preparation for them to meet the challenges of the society. Through indigenous education, Africans were trained on skills like hunting and gathering, house making, gardening among others. However, with the introduction of Western education, Africans were taught to view education as emancipation from village life and a passport to a white-collar job in the cities. Education was no longer a way of life. The Western education dismissed undocumented knowledge as unscientific. All skills that the boys were taught in the indigenous system became useless in the new system of education. Introduction of Western education was as result of globalization.

Moahi (2007) explains indigenous knowledge as the knowledge and practices that are peculiar to a particular community and embody the community identity and ways of surviving and maintaining the environment they find themselves in. For example among the Abagusii community, the circumcision period marked the training of boys on a number of issues. Some of the knowledge learnt during this period was top secret. Haralamboos (1980) in support of Moahi’s idea explains that the state of education before the colonialists’ was at a small scale level and among non-literate societies such as hunters and gatherers. Formal education was unknown. Young people learnt their lessons for life largely by joining in the daily round of the social group. For the purposes of this paper, we concentrate on how boys were taught indigenous knowledge among Abagusii community, a Bantu community in South Western Kenya.

Abagusii Circumcision Ceremony
Abagusii is a Western Bantu community occupying Kisi and Nyamira Counties to the South Western Kenya. Circumcision is a stage in life for one to pass from childhood to adulthood. Boys between the age of 8 and 16 years are ready for circumcision. It is the duty of the boys to inform their parents through their uncle when they were ready for circumcision. According to Akama (2006) a Kisii male who has not been circumcised can’t marry, inherit nor will he command any respect in society. Circumcision among the Abagusii is mandatory. It is a very important stage of passage of life among the Abagusii. Once the boy informed his uncle that he was ready for the cut, preparations began. A circumciser was identified. A male friend who had already been circumcised but was yet to marry was identified as the sponsor to be guiding the initiate in the whole process and be an intermediary during seclusion between the initiate and the outside word.

The night before circumcision, the boys spent the night in their friend’s house. At night, their courage and stamina was tested by sending them into the dark night, beating them and administering physical exercises. At dawn, the boys were picked up by men who led them to the river where the circumciser was waiting. After all boys had been circumcised, the journey home began. On their way home Esimbore song was sung as people danced, cheered, whistled and women ululated. At home, the seclusion period began. During seclusion, they were taken through several rituals by their seniors and elderly men. For example on their first day in seclusion they lit a sacred fire. The fire was lit by rubbing a soft wood which lay on the ground against a hardwood. This act conveyed a message of having a sexual intercourse. This fire was to be taken care of by the initiate; it was not to go off for the whole seclusion period. It was believed that if it went off, the initiate would have trouble in his
marriage life. This act instilled discipline among the initiates.

On the fourth day, *esubo* ritual was administered. Initiate was fed with meat which had a lot of pepper. He was not to complain. This tested their obedience. They were taught and informed of their enemies, how to fight, sex life, marriage among others during seclusion. It is through this stage that Abagusii community imparted knowledge on various aspects of life on their young generation.

**LITERATURE REVIEW**

This section analyses various texts that have been published on globalization and its impacts on African culture, Abagusii circumcision, research methodologies and globalization theory.

Maduagwu (1999) claims that since their experience with colonialism, African countries have been unable to, independently, articulate or chart their own history, culture and identity. In this perspective therefore, it is evident that Abagusii indigenous knowledge is no longer there due to infiltration of Western education system that has taken over our education system. He goes on to explain that negative influence of colonial education was based on technology and secularistic acquisition of skills against character formation which was the corner stone of indigenous education. This paper sought to investigate how dependency on Western culture has led to the demise of Abagusii circumcision ceremony which served as an indigenous school from this community.

Isola (2003), states that before the incursion of the West into the cultural nerve centre of the now extant great African empires, these empires were dynamically culturally developed. There existed a consistent tradition of knowledge dissemination and acquisition. From this statement, it is clear that Western culture which has found its way into Africa has led to the decline of indigenous education systems. This paper therefore, in this light sought to investigate what happened to the tradition of knowledge dissemination among the Abagusii community. Globalization has been around for ages. Although according to Ajayi (2003) globalization has had three phases; 1870-1914, 1945-1980 and 1980 to present. Our main focus is on the third phase of globalization.

Daramola and Babatunde (2015) claim that attempts to conceptualize globalization have resulted in diversity of world views. This argument has resulted into the formation of two schools of thought that now dominate the impact of cultural globalization. One school of thought contends that globalization is destructive since the flow of information has been viewed as one dimensional. The other school argues that it’s constructive. However, unlike the author, we believe that globalization has had negative impacts on the culture of African cultures. It is on this basis that we disagree with Ritzer (2008) when he argues that among and between cultures there are lasting differences that are largely unaffected by globalization in this perspective, globalization occurs only on the surface and the deep structure of culture is largely if not totally unaffected by it. The effect of globalization is deep and African communities can feel it.

Akama (2006) explains how indigenous education was imparted on young men among the Abagusii community before the colonialists. The initiates were taught to respect their seniors, obedience to elders, moral values and the moral code of conduct among the Abagusii, *chinsoni*, rules and regulations guiding interactions, marriage life, sex life among other practical skills.

Other scholars who have researched on the impact of globalization on African indigenous education and culture include; Motlhankane (2101) who studied demise of traditional initiation schools of the Batswana of South Africa, Ademola (2006) who investigated culture education and the challenges of globalization in modern Nigeria among many other related studies that have been done.

**THEORITICAL ANALYSIS**

Theories are meant to guide studies. In this study, Globalization theory as was proposed by Giddens (1997) was used to collect and analyse data. Giddens opines that globalization leads to intensification of worldwide social relations which link distant localities in such a way that local happenings are shaped by events occurring many miles away and vice-versa. Using this tenet, we collected data on how happenings in Western countries have influenced the demise of African indigenous education with reference to Abagusii circumcision ceremony and how technology, religion, trade among other aspects of globalization have affected indigenous education systems in Africa. According to Giddens (2006), in sociological and economic terms, globalization impacts on various forms, from the traditional to the modern aspects of
life. It has led to the widening and deepening of the international flow of trade, finance and information within a single, integrated global market. The outcome of this process is the easing and reduction of nationally and culturally determined barriers, the expansion of capital flows and the escalation of technology transfer. From this perspective therefore, as Giddens talks of a single market, we try to construct how globalization is trying to construct a single, global culture by eroding the existing African cultures. The global market in cultural terms could mean a homogenous culture.

APPLICATION

Before the coming of Europeans, Africans and Abagusii specifically taught their boys apprenticeship and other practical life skills during circumcision period. After circumcision, the boys went into seclusion until the wound was completely healed. During this period of seclusion, which lasted for about one month, boys were taught how to construct houses, graze animals, engage in sex, seduce girls, they were informed of their community enemies, marriage life, how to make tools, fighting skills, obedience, respect among many other political, economic, socio-cultural and moral values.

Globalization has had impacts on the economy, politics and culture or social aspects of a people’s life. Impacts on the three aspects have contributed to the demise of indigenous education among African communities and for this case on Abagusii circumcision ceremony. On the social aspect the colonial government introduced formal educational terming the African informal education as backward and uncivilized. Under formal education, children spend more time at school rather than at home with their grandparents who would be telling them stories about their community origin, migration and other stories focusing on daily life. With more time being spent in schools, there was not enough time for African kids to attend indigenous education. Due to lack of time, most initiates don’t have enough time to spend in seclusion and undergo all the teachings.

Globalization has also led to common social problems like cancer, HIV/Aids, terrorism among others. Apparently, there is an increased number of viral diseases and therefore the traditional practice of circumcision has increasingly become risky. Need arose for a safer way of carrying out this culturally important exercise of circumcising boys. Gradually, Abagusii began with a blended, safer way of circumcising by calling a doctor to their homes and the initiates proceeded to seclusion as it was before. Nowadays, rarely do initiates spend the seclusion period in their huts but in hospitals. Seclusion period spent in hospitals has locked out all the rituals that were performed initially. These rituals taught the boys something on their culture. It also locked out elderly men who lectured the boys in their huts. Instead, during seclusion in hospitals the initiates spend time watching foreign television programs with no moral or cultural lessons.

With the introduction of Christianity, some of the skills boys were taught at indigenous schools became evil, uncivilized and backward for example fighting skills. Christians advocate for peaceful co-existence and resolution of any disagreement. The art of making weapons therefore became unnecessary. The whole exercise was disregarded and an alternative way had to be sought. Christians also consider it immoral to prepare boys for sex, a preserve of the married according to their beliefs.

From the economic point, in modern days people are more capitalistic than ever. Circumcision is no longer a communal thing but an individual responsibility. With the burden of feeding a large group of people that comes with it, people who cannot afford to feed the whole village on their own have shied away from this practice. On the other hand, there has been high inflation of prices making commodities unaffordable all over the world. This has made this function very expensive and unaffordable to many.

CONCLUSION

Globalization is taking over our culture. If quick remedies are not sought, we might be left without a culture and therefore lose our community identity as a people. Worse still, we might be left in confusion with a blended culture of foreign and local components. Institutions tasked with safeguarding culture should take the campaign of protecting African cultures to the people. The idea of a homogenous culture does not exist when we let go of our culture and embrace a new culture with foreign components. African initiation ceremonies helped shape the character and future life of initiates positively something that is missing in modern circumcision ceremonies.

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ABSTRACT

Culture which defines communities and gives them identity is a feature that is common to societies world over. The Luo Community that inhabits the lake region of Kenya, Sudan, Tanzania and other parts of East and Central Africa have as one of their cultural pillars the practice of widow inheritance. This involves the union of a widow with a relative of the deceased husband preferably a cousin who becomes in almost all respects the new husband. This paper examines the foundations of this practice and tries to find its justification. In the process an analysis of its possible grounds, its current status and factors that have affected its continuation as a valued aspect of this society is undertaken. An application of various philosophical theories on this practice is attempted to assess the moral value of this phenomenon. Underlying this assessment is the theoretical assumption that there must have existed certain grounds for this practice that were based on the community’s socio-economic and political underpinnings that made it a cherished tradition. At the end, an attempt is made to support the position that widow inheritance could have been a noble practice that has simply been challenged by the changing socio-economic and political milieu that the Luo society currently finds itself in. It is hoped that the paper, having shed some light on this practice, shall assist in its re-evaluation and possible refinement because some of its foundations seem to remain relevant even in the current civilisation.

Key Words: Culture, Philosophy, Ethics, Utilitarianism, Widow Inheritance.

INTRODUCTION

This paper intends analyse the traditional practice of inheritance of widows amongst the Luo of Kenya. The Luo is a Nilotic community in Western part of Kenya largely inhabiting the area around Lake Victoria. Amongst their cultural practices is the inheritance of widows (ter or tero in Dholuo) upon the death of their husbands. This is a practice from antiquity in the community based on some philosophy that we wish to examine using contemporary philosophical ethical theories or approaches. In this society, due to reasons that shall be outlined below, upon the death of her husband, a widow was free and even obliged to enter a new union with another man. This union would culminate in the production of offspring where there were none or adoption of the existing ones. According to Luo tradition, children sired by an inheritor are considered those of the dead man and not the inheritor’s (Oluoch 2013). This paper analyses the grounds for this practice and its current status while examining the factors affecting its perception and perpetration in the contemporary society. Finally, an attempt is made to propose new interpretations of these practices that seem to have had a noble basis which have since been corrupted.

Philosophical Ethical Approaches

Some ethical theories try to assess behaviour and states of affairs basing value judgement on their consequences. Secondly, the concept of duty, implied in motive theories, contend that actions or states of affairs derive their value from the principle under which they are carried out or from which they obtain. Finally, those who rely on circumstances argue that since our actions are affected or determined by the situations in which we find ourselves, moral goodness or badness should be judged on the basis of specific circumstances.

The first position, consequentialism, seems to support the philosophy that ends justify means; that whatever we do and however we do it, we stand to be praised or blamed depending on the outcome of that action. The consequentialists, notably John Stuart Mill, believe that any action or state of affairs is good, praiseworthy and can be rewarded if its consequences produce the greatest happiness for the greatest number of people concerned. Mill (1990) argued that although the progress of moral philosophy has been limited by its endless disputes over the reality and nature of the highest good, it is agreeable that the consequences of human actions contribute importantly to their moral value. In this context, whenever we contemplate action we must focus on its good or desirable consequence. The goodness of truth telling for example, derives from what it produces which can be summarised as happiness, development of trust, maintenance of order and so on. The Utilitarian philosophers argue that nature has put man under two forces; pain and
pleasure. Consequently only those actions that produce pleasure or reduce pain can be classified as good.

The second position, duty or obligation, contends that one should do good simply because it is good and not from the point of view of consequences. This implies the application of the principle of Good Will. According to Kant (in Gregor 1998 ed.) having a good will is compatible with having feelings and emotions of various kinds with an intention of cultivating some of them so as to counteract desires and inclinations that lead to immorality. The deontologists argument is supported by the observation that certain actions produce un-intended consequences which could be good or bad. Since we should only praise people or condemn them solely based upon the motives of their actions or the principles upon which they acted, a person who tries to save a drowning child and they both drown is not blamed but praised on account of his motive. In this case the consequence is clearly bad (two deaths instead of one) yet the action is not blamed.

The third position, situationism, contends that the moral worth of an action is to be determined by the circumstances in question. These circumstances could be social, economic or even political. Thus a widow who finds herself in a certain society is bound by the culture of that society whereas a widow who is economically challenged may opt for such an arrangement. Political structures that do not recognise single women in leadership roles would encourage the practice. According to Gunga (2009), widowhood is a process characterised by rituals, remarriages, harassment, rejection, loneliness, poverty, loss of status, fear of the future and depression. This calls for an analysis of the possible advantages of widow inheritance as perceived in the Luo tradition.

THEORETICAL ANALYSIS AND APPLICATION

Widow Inheritance amongst the Luo
What then would be the possible negative and positive consequences of widow inheritance? In the Luo community, positives include that tero ensures provision of material and moral support to the widow. In a way, the practice confirms a father figure in the homestead and guarantees provision of a sense of belonging to children. It also gives assurance of affection and satisfaction of sexual urge to the widow while discouraging sexual promiscuity on the widow’s part. It is also assumed that tero ensures respect for the family of the late husband and the widow and confirms the worldview that wives belong to the community.

Let us examine these positive attributes of widow inheritance in this society. In the traditional set up material wellbeing or generally ownership of property which included tilling of land, grazing of animals, hunting and gathering and so on, were the prerogative of the husband. These and other roles therefore demanded that a woman required a man in her life. This also goes with the question of father figure. It would appear that a home without such a figure was lacking in direction or leadership since no one would for example represent it at a council of elders.

In this society, children were brought up with the conception that there was always a father with whom to identify. In fact one was always expected to introduce himself or herself as the son or daughter of so and so. In the absence of this, there existed a sense of non-belonging which led to offspring being labelled bastards. It does not matter that the children in this arrangement maintained their deceased father’s identity but that there was his representative within the set up to accomplish certain obligations. Some philosophers and psychologists have argued that sexual urges and their fulfilment or lack of, have effects on the mental and physical wellbeing of the individual. Russell (1977) argues that sex is a basic need just like food and drink. It must be fulfilled to avoid undesirable conduct like rape or incest. Oruka (1991) places sex as the third human basic need after food and shelter because of its primary function of procreation for the human race.

Sigmund Freud and Erich Fromm, both psychoanalysts, have analysed the question of sex and concluded that it has a vital role in human conduct and social organisation. Freud (1923) uses his Oedipus complex theory to explain human psychological development. Freud believed that children are born with a libido – a sexual (pleasure) urge. There are a number of stages of childhood, during which the child seeks pleasure from a different ‘object’. To be psychologically healthy, we must successfully complete each stage. Mental abnormality can occur if a stage is not completed successfully and the person becomes ‘fixated’ in a particular stage. This theory shows how adult personality is determined by childhood experiences. This points to the centrality of sex in human relations and wellbeing as has been averred to by Oruka.

Sex is a very sensitive topic which is avoided in many social discussions yet when examined critically it plays an important role in social life. Freud, Oruka, Russell and others may be right in their analyses which underscore the importance of sex. However,
the issue becomes complicated for the widow especially with the existence of children. How to go about its satisfaction without the underlying feeling of betrayal of their father that may arise in the children is an issue. Lurking behind this is the question of sexual promiscuity especially if the widow decides not to identify with one particular man but rather satisfy that need only when the occasion arises.

Fromm (1950) argued that ‘freedom from the traditional bonds of medieval society, though giving the individual a new feeling of independence, at the same time made him feel alone and isolated, filled him with doubt and anxiety, and drove him into new submission and into a compulsive and irrational activity’. This alienation from place and community, and the insecurities and fears entailed, helps to explain how people seek the security and rewards of authoritarian social orders which may be found in customs and rites. With his theory of behaviourism, Fromm explains the role of sex in social organisation. It would seem therefore that widow inheritance, though not likely to have been conceptualised this way in the traditional set up, had a role in fulfilling these aspects of human nature.

In line with this, it was argued within this community that widow inheritance would in a way curtail sexual promiscuity since there would be one partner recognised by society as occupying the position of the deceased husband. This way, even the children would be saved the agony of having to witness different characters associating with their mother occasionally. In a way this would also promote respect for the widow and the family of the deceased. The Luo society had the worldview that a wife was communal in the sense that she was literally owned by the society. This was based on the rites and practices surrounding the whole concept of marriage. For instance negotiations for marriage, and payment of dowry were in many cases a joint effort of members of the bridegroom’s family. Hence in the event of the demise of the husband, a widow was seen as having lost a base and therefore members of the family had to come in to fill this vacuum. Death of a spouse did not dissolve marriage; therefore woman should not remarry but have an inheritor (Oluoch 2013). However, this paper does not envision a difference between remarrying and having an inheritor apart from the fact that certain rites involved in marriage (for example dowry payment) are not performed in the case of inheritance. According to Oluoch the arrangement is the cohabitation of a widow with her brother in law in which the brother in law relates to the widow as a substitute of her deceased husband. ‘Brother’ in this context would be wider in meaning implying either brother of the deceased or a paternal first cousin or a clan cousin. To understand this practice there is need to appreciate the Luo conception of marriage and death. In the Luo culture, marriage is intended to be an everlasting contract whose purpose and function extends beyond the physical death of a spouse. It was a contract between the spouses and their extended families. In the event of death, therefore, the family of the deceased had a responsibility to provide a replacement.

However, these seemingly noble concerns have been challenged by social, economic and politics dynamics. It is no longer the case that women, and by extension widows require a man for their material support. Economic emancipation has seen women capable of having their own income and supporting themselves plus their children. In fact, widows who are better off financially also support other members of the deceased family. Therefore one of the central pillars of widow inheritance has been removed.

Christianity and its concept of salvation has handed a big blow to this practise in the Luo community. In this society there exists a wide range of Christian denominations that have embarked on a serious campaign against this practice. They argue that when one believes in Jesus, issues of the father figure, protection and so on are taken care of and to participate in inheritance is not the way of salvation. Russell (1975) argues that there are a great many ways in which the Church, by its insistence upon what it chooses to call morality, inflicts upon all sorts of people undeserved and unnecessary suffering. According to him, it is a major opponent of progress and of improvement in all the ways that diminish suffering in the world. This is because it has chosen to label as morality a certain narrow set of rules of conduct which have nothing to do with human happiness. Russell was alluding to certain aspects of Christianity like the Catholic opposition to divorce even when it appears the only way to happiness. Perhaps this may also be true concerning widow inheritance (or if we choose to call it remarriage) if indeed it leads to happiness for those who accept it. The contemporary society is characterised by intermarriages between different cultures which has brought to fore the problem of identity. Given that one can marry from other ethnic communities other than the Luo, there arises an identity crisis for the woman and her children. A case in point is the S.M Otieno-Wambui saga which exposed the complications of intermarriage. Wambui a Kikuyu, having lost her husband, a Luo, was faced with the challenge of where to bury her husband. The duo had settled in Ngong, a part of Kenya, as their residence
which the *Umira Kager* clan of Otieno did not recognise as a home befitting the burial of their son. According to Ojwang and Mugambi (1989) this was a test case and exemplar of the debate between customary (indigenous, ethnic, traditional) law against the statutory (common) law that had been imposed in Africa during the colonial period and partially retained after independence. It emerged that ethnic interests still prevailed in Kenyan family and inheritance law. The Court of Appeal ruled that when there was conflict between common law and customary law, the latter is given precedent. Even though the court ruled in favour of the clan, this particular case has been seen as an example of injustice to widows. This exposes the identity crisis that faces widows and their offspring. It is important to note that had the customary law been strictly applied, which would have included widow inheritance, this dispute could have been avoided.

The reality and adversity of HIV and AIDS in the Luo society has greatly undermined this tradition. Whereas it was initially ignored or denied as a non-issue, AIDS has greatly reduced the issue of inheritance especially the one that involves sexual contact. According to a recent study conducted by Elizabeth Glaser Paediatric AIDs Foundation (EGPAF), 19,000 children in the Homa Bay County in Kenya are infected with HIV, with only 8,000 having been identified and introduced to treatment. The county has been ranked as having the highest rate of HIV/AIDS in Kenya, with the prevalence rate of over 25%, that’s 1 in 4 children. HIV is a major problem in Ndhiwa, a constituency of Homa Bay, with adolescent girls often at risk due to a lack of sexual health and hygiene education and widespread sexual abuse and exploitation of girls and women (Team Kenya 2016). This reality has greatly reduced the cultural practice of widow inheritance.

The number of men who have died of HIV-related complications is relatively high as a result of their refusal to stop widow inheritance. As a result, they leave behind young widows a fact that perpetuates the practice and the spread of the disease. The widows were usually not in a position to negotiate whether or not to use protection. Besides, the rate of new of HIV/Aids, infections has remained stubbornly high, despite efforts by the government and private sector to curb the menace. These professional inheritors are actually abusing the whole process of inheritance. In the traditional set up, there existed regulation as to who would inherit who and how it was to be performed. These professional inheritors have hidden intentions especially the desire to benefit from the property of the deceased or a general apathy to work and prefer ready-made wealth. A 2009 study found that the sexual rituals surrounding death have also undergone changes to the point whereby most men are no longer interested in getting married to the spouses of their kin. These professionals are men seeking to exploit women whose spouses have died. They pretend to remarry the woman but their aim is to have access to the resources in the hands of the woman left by her husband, and at the same time have sex with her. The professional *Jater*, is characterized by his lack of material support for the woman cohabit with, yet in the traditional practice of the Luo, *ter* was meant to ensure the woman got material support and her sexual needs were also met (Source watch 2012).

As a response to these and other challenges, organisations such as the National AIDS Control Council (NACC) have come in to intervene. Since its inception, the NACC has had some note able achievements which include the coordinating, development and implementation of the Kenya AIDS Strategic Framework (KASF) and National HIV and AIDS Strategic Plans (KNASP I, KNASP II, KNASP III), the development of policies in key areas including orphans and vulnerable children, mainstreaming gender into the Kenya AIDS Strategic Framework (KASF) and engaging with key sectorial ministries to mainstream HIV and AIDS in the context of the Medium Term Expenditure Framework (MTEF) budget process (NACC 1999). These efforts have in a way taken away some of the traditional responsibilities of the *jater* and made life a bit more tolerable for the widows and their children. The traditional concept of communal ownership of a woman has also been eroded. In the current civilisation, marital arrangements have become private affairs of individuals. Other members of the families and the general society are only asked to witness the union in the form of weddings or the office of the registrar as the case maybe. In fact, many cases have been witnessed where the man and the woman jointly contribute to the cost of their wedding and if need be, the dowry itself. Therefore, it is no longer tenable to argue that the community ‘owns’ the woman and can therefore dictate her operations.

**CONCLUSION**

The issue of widow inheritance seems to have had reasonable grounds supporting it in the Luo tradition. Analysed using the theory of consequences, it seems to have satisfied the utilitarian principle of happiness for the people concerned. If we invoke the Kantian Imperative whereby the concept of duty or motive is concerned, we can conclude that the intent of widow inheritance was based on Good Will. Kant’s
philosophy is based on the assumption that no action can be good in itself except that which is done out of good will. Hence, consequences of an action should be ignored and emphasis placed on its motive to assess its moral worth. The circumstances surrounding the widow may also determine the goodness or badness of inheritance even in the current civilisation. Not all widows have so far overcome the challenges that necessitated inheritance in the first place. Many are still illiterate, poor and tied to custom and tradition which undermines their ability to challenge inheritance. As a point to ponder, maybe the whole issue of widow inheritance needs to be re-addressed and its proper place found in society. Presently, there are many widows who somehow satisfy the various needs that have been mentioned in this paper. Another issue that has escaped focus is the number of widowers who remarry after the death of their partners. In fact in the Luo society, a sister or relative of the deceased woman was recommended to take her place in the belief that the children would be safer or well taken care of. Maybe the whole issue of widow inheritance should be re-focused and even renamed re-marriage to give it a more positive outlook.

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METHODS FOR TRANSLATING ICTS’ SURVEY QUESTIONNAIRE INTO FRENCH AND BAMBARA

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ABSTRACT

Researchers have used many instruments to gather data on the use of Information and Communication Technology to disseminate information on agricultural inputs towards farmers. These instruments are in English and based on some theories. The Technology Acceptance Model (TAM), the Diffusion of Innovation Theory (DOI) and the Unified Theory of Acceptance and Use of Technology (UTAUT) are the three most popular contemporary technology acceptance models. For other speaking languages especially French and Bambara, there is a need to translate. The increasing need for non-English data collection instruments and other survey materials has clearly given recent figures. Despite the availability of tools for translation, the DOI’s instrument has been barely translated into French and Bambara. In this paper, we used an adaptation method to translate the DOI’s instrument into French and Bambara. We produced a method for translating English survey questionnaire into French and Bambara. The method specifies and describes five steps, which are prepare, translate, pretest, revise and document.

Keywords: ICT, Agriculture, Translation, French, Bambara

INTRODUCTION

Information and Communication Technology (ICT)¹ has seen an exponential development in the dissemination of information especially on agriculture. Researchers have used many instruments to gather data on the subject. These instruments are based on some theories. The most technology acceptance models are: Technology Acceptance Model (TAM), Diffusion of Innovation Theory (DOI) and the Unified Theory of Acceptance and Use of Technology (UTAUT) (Woosley & Ashia, 2011). The data collection instrument (questionnaire) of these models is in English. For other speaking languages especially French and Bambara², these instruments need to be translated. The increasing need for non-English language data collection instruments and other survey materials has clearly given recent figures (Pan & de la Puente, 2005). Information on ICTs’ survey translation methods or procedures is limited on the translation process from English to French and Bambara. For instance, developing a guideline for translation from English to Spanish, a study argued that there is limited information on the translation procedure (Pan & de la Puente, 2005). Therefore, there is need to provide a method to translate ICTs’ survey instrument into French and Bambara. Factors affecting the use of ICTs on agricultural input information in developing countries was provided by researchers (Kante, Oboko, & Chepken, 2016). The Diffusion of Innovation Theory was the base of our proposed model. We need to collect data in Sikasso, Mali using the data collection instrument adapted from researchers (Atkinson, 2007; Ventkatesh et al., 2003). Nevertheless, there are two remaining questions namely: a) Can we propose a method for

¹ By ICT, we mean Mobile phone and telecentres
² Bambara is a language spoken in Mali.
translating this questionnaire into French and Bambara?

b) What lessons have we learned?
The literature describes two approaches, which are adoption and adaptation to translate a survey questionnaire. Adoption calls for the direct translation of the data collection instrument from the source language to the target language without regard to linguistic and cultural subtleties that impact the intended meaning of the question (Carrasco, 2003). The second approach, adaptation, uses the existing questionnaire as the basis, but adaptation allows for components of the survey question to be modified or altered (independent of changes made as a result of the translation) in order to make the survey question suitable for fielding in the target language (Hoffmeyer-Zlotnik & Harkness, 2006). Adaptation acknowledges and accounts for semantic, conceptual and other differences that exist across languages.

MATERIALS AND METHOD

We used the adaptation method following the guideline of the Census Bureau guidelines (Pan & de la Puente, 2005). The adaptation allowed us to modify or alter the components of the survey question (independent of changes made because of the translation) in order to make the data collection question suitable for fielding in French and Bambara. The guidelines propose five steps in translating a questionnaire which are: Prepare, Translate, Pretest, Revise and Document (Pan & de la Puente, 2005). But we modified the guidelines to integrate some translating rules from TRAPD (Translation, Review, Adjudication, Pre-testing and Documentation) (Harkness, 2000) and the model ASQ (Ask the Same Question) (Harkness, 2000; Presser et al., 2004).

Prepare
The translation process started by establishing the statement of work, documentation and subject matter contact.

Statement of Work

The purpose of this translation process is to transfer the meaning of a questionnaire of fifty-one items in English into French and Bambara. The translation has to preserve the meaning, style and effect of the source text and at the same time respecting the sentence structure, vocabulary and meaning values of French and Bambara languages.

Documentation
We provided a definition of our keys terms to the translators:

- ICT: This questionnaire refers to ICT as Information Communication Technology such as Mobile phone and telecentres.
- Household head: An individual in one family setting who provides actual support and maintenance to one or more individuals who are related to him or her through adoption, blood, or marriage. In rural areas and to a large extent in the cities in Mali, domestic units are rarely limited to the nuclear family. Indeed, most often they consist of an extended patrilineal family (that is, they consist of a father, his wife (ves), his sons, their wives and children, and unmarried daughters). The household head will be someone who is leading the agricultural activities of the family and therefore using ICTs in this questionnaire. In other words, it is an informant.
- Relative advantage: Relative advantage (or superiority) is the degree to which an innovation is perceived as being better than the idea it supersedes (Rogers, 1983), and is often expressed in this questionnaire in terms of convenience and/ or satisfaction (Adegbidi, Mensah, Vidogbena, & Agossou, 2012).
- Compatibility: It is the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters (Rogers, 1983).
- Complexity/Simplicity: complexity is the degree to which an innovation is perceived as relatively easy to understand and use (Rogers, 1983).
- Observability: Observability, also known as communicability, demonstrability or describability, is the degree to which results of an innovation are visible to others (Adegbidi et al., 2012).
- Social Influence: It is defined as the degree to which an individual perceives that important others believe he or she should use the new system (Ventkatesh et al., 2003).

**Subject-Matter Contact**
Translators had access to one of the author for further explanation.

**Translate**
An approach for survey translation that has recently gained exposure in the literature is the committee or team approach to survey translation (Harkness, 2000; Pan & de la Puente, 2005; Presser et al., 2004). We formed our translation team constituted of two translators for each language. The two translators of each language worked independently to produce the target language translation. The subject-matter contact was the translation coordinator for each one of the languages. The translators documented their work so that we could see their specific challenges and their decisions to deal with these challenges. The two translators and the coordinator reviewed the translation together. Where the translator identified a problem, the coordinator suggested a solution and the three could agree on it or reject it. A first document was then accepted for each language.

**Pretest**
The widely pretesting technique cognitive interview can be applied to the pretesting of non-English language data collection instrument (Pan & de la Puente, 2005). Cognitive interviews are structured, open ended interviews, designed to gather detailed information about the cognitive thought processes respondents use to understand and answer survey questionnaire (Presser et al., 2004). We produced an English language cognitive interview. One respondent, skilled in the field of ICT4D (ICT for Development) studies was selected for each language. He was asked to describe how he understood particular question and response to see if he had difficulty in recalling.

**Revise**
With the cognitive interview pretest, we revised the first document to get a new one. That was the second document for each targeted language.

**Document**
We described all of these steps in a document. The document produced by each of the translators, the team coordinator and the minutes of the meetings.

**RESULTS**
This process led us to produce a questionnaire that could be filled by an English speaker, a French or a Bambara speaker. Our translation process provided some lessons (Table 1).
Table 1: Lessons from the translation process

<table>
<thead>
<tr>
<th>Language</th>
<th>Translation errors</th>
<th>Cultural issues</th>
<th>General problems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>French</strong></td>
<td>We had to decide among two or three French words for one English word. The choice was based on the results of our cognitive interview. For instance, the English word ‘can’ could be translated in French as “can” or “know”. We chose can as “can” in some items and “know” in some others based on the results of the cognitive interview. The sentence structure was also an issue during the process. The sentence was constructed in such a way that it was free of spelling and grammatical errors. Doing so, 10 items structure was changed but with the same meaning.</td>
<td>Issues related to differences in cultural viewpoint were infrequent. Only one item was an exception. The item was “Using ICTs on agricultural input information makes me feel higher in reputation than those who do not use it”. This was not appropriate for the Malian culture. So, we changed it “I feel that using ICTs on agricultural input information gives me a particular status than those who do not use it”.</td>
<td>The main problem came out with choice of “article” such as “the”, “a”; “determiner/pronoun” such as “this”, “those”. We used the grammar and vocabulary as well as the cognitive interview to decide which word to use.</td>
</tr>
<tr>
<td><strong>Bambara (NKO)</strong></td>
<td>The main issue was that e English or even French “word(s)” does not have their equivalent in Bambara. For instance, the abbreviation “ICT” is very hard to translate in Bambara, we therefore decided to use the name of the ICT services in the area as ICT. Thereby, “Senekela” or “Ngasene” meant ICT on agricultural input information as these are the only ICTs operating in the area. As the writing system strongly differs from English or French, the sentence construction also was different. That made all the items sentence structure to change but giving out the meaning intended by the sentence.</td>
<td>The cultural viewpoints were frequent in Bambara. While the future tense appeared in an item, we had to add “By God/Allah willing. For instance the item 46 in English was “I intend to use/continue to use ICTs on agricultural input information” and in Bambara we added “By Allah’s willing, I intend to use/continue to use ICTs on agricultural input information”.</td>
<td>The general issue once again was how to translate the “articles” or “determinant”. There is no “article” in NKO used to write the Bambara language in this instrument. The “noun” is divided into two parts and one of it is the “article” (Davydov, 2005). The main issue coming out from the translators was related to the tense. We adopted wherever needed, the advice from the coordinator.</td>
</tr>
</tbody>
</table>
DISCUSSION AND CONCLUSION

We believe that our methods for translating English survey instrument on ICTs into French and Bambara formed an effective translation. It proposed five steps that are Prepare, Translate, Pretest, Revise and Document. The method was different to that of another research (Forsyth, Kudela, Lawrence, Levin, & Willis, 2006). Although, the cognitive interview and reviews were similar to that research. We have improved the guidelines of the Census Bureau Guidelines (Pan & de la Puente, 2005) by integrating in it the method ASQ (Ask the Same Question (Harkness, 2000) and the TRAPD (Translation, Review, Adjudication, Pre-testing and Documentation) method (Harkness, 2000). Our translated instrument in Bambara is one of the rare translated survey instrument on ICTs. We learned that ICTs’ survey instruments translation should be done in regard to culture of the target population language. In addition, due to absence of some terms in local languages, the term ICT can be replaced by the name of an ICT’s service in the area. We are currently conducting a research in Mali with this instrument. Further line of inquiry could be to test the method or to modify it taking into account some cultural viewpoints of others local languages.

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ACCEPTANCE OF INFORMATION TECHNOLOGY: TOWARD A UNIFIED VIEW. 
STRUCTURE, CONDUCT AND PERFORMANCE OF SMALLHOLDER CEREAL FARMER GROUPS IN THARAKA CONSTITUENCY, KENYA

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ABSTRACT

Collective marketing through farmer groups has increasingly become an important avenue for improving smallholder farmers’ access to better paying markets. However, these groups tend to vary in performance, as well as in internal structure and conduct. Identifying the distinguishing characteristics across farmer groups can help in explaining their diversity and varying levels of performance. However, little is known about specific group attributes that distinguish them. This study used four year (2013-2016) panel data in a structure conduct performance framework to characterize 100 smallholder cereal farmer groups in Tharaka Constituency, Kenya. Principal component analysis and cluster analysis were used to cluster and characterize the farmer groups. Results suggested that farmer groups are rarely specialized in one activity and their activities go beyond collective marketing of cereals. Groups showed significant differences in; membership fees, diversity of group enterprises, level of leadership and marketing training, frequency of elections and market access. Key group similarities included: formation reason, groups’ age, cereals store access, table banking and internal management practices. Across the years, there was a steady rise in groups’ cereals sales though still at relatively low levels for majority of them. Notably, high performing groups took a lead in most of the positive indicators used to characterize the groups. To enhance group performance, diverse management and marketing capacity building activities are still essential. Additionally, bridging social capital in form of linkages with actors supporting these groups can enhance groups’ access to diverse bulk buyers.

Key words: Group characterization, Group structure and conduct, Group performance

INTRODUCTION

Collective marketing through farmers' groups has increasingly become an important avenue for improving smallholder farmers’ access to better paying markets. However, these groups tend to vary in performance, as well as in internal structure and conduct. Ochieng (2014) argues that identifying the distinguishing characteristics across farmer groups can help in explaining their diversity and differential levels of performance. This has attracted different approaches of groupings and characterization of farmer groups in literature.

Organizing observations into sensible groupings is among the fundamental approaches of understanding and learning (Jain, 2010). Cluster analysis is one of the formal study approaches that can be used to group objects based on some intrinsic, observed or measured characteristics or similarity (Jain, 2010; Goswami, Chatterjee and Prasa 2014). This helps to explore and structure data into some meaningful groupings. Goswami et al. (2014) argue that multivariate statistical techniques like Principle Component Analysis (PCA) and cluster analysis can conveniently be adopted for clustering.

Cluster analysis has been widely adopted to characterize different study units. Cluster analysis is a multivariate data analysis approach for dimension reduction, summarizing large data sets and organizing observed data into fewer meaningful structures (Goswami et al., 2014). It is concerned with similarity (homogeneity) of subjects placed in a given group (cluster) and their difference (heterogeneity) to profiles of subjects placed in other groups (Rosie, 2007). Cluster analysis approach is adopted when there is no a priori hypothesis of knowing which clusters different subjects in a dataset fall into (Jamer, 2010). Goswami et al. (2014) argues that it is assumed that subjects fall into distinct groups but there is no prior judgment to partition the subjects into specific clusters hence the need to apply cluster analysis. Rosie (2007) adds that the grouping assumption is based on commonalities between the different sets of selected independent variables. However, the key concern is how to best select the variables to be used in clustering and the number of groupings to be generated.
MATERIALS AND METHODS

Clustering Farmer Groups
Cluster analysis was adopted to group and characterize farmer groups into homogeneous groups. This helped in identifying different farmer group categories, characterized by maximal within-cluster homogeneity and between-cluster heterogeneity (Rosie, 2007). This is an approach for segmenting different types of players in a market that was advocated by (Tuma, Scholz and Decker, 2009), and has been adopted by Petrovic and Gorton (2005); Ochieng (2014). The kernel K-means clustering approach was selected because it allows larger data sets and it shows relations between all variables selected in partitioning the observations into set number of clusters (Goswami et al., 2014).

Minimization of K-means cluster objective function:
$$\min_k \phi (\phi(X)) = \sum_i \left\| \phi(x_i) \right\|^2 - \sum_k \frac{1}{n_k} \sum_{i,j \in C_k} \phi(x_i)^T \phi(x_j).$$

Where: $\phi(\cdot)$ is the first term which is a constant for a given mapping function and it can be ignored, $(x_1, \cdots, x_n) = X$ is the observed variables data matrix, $C_i$ centroid of cluster, $n_k$ is the number of points in $C_i$ and $T$ is the desired transformation.

A sample of 100 farmer groups from Tharaka Constituency, Kenya, was put into three (3) different categories using clusters analysis by K-means. Both quantitative (continuous) and qualitative (categorical) structure and conduct farmer group attributes were used as the clustering variables to generate homogeneous groups in terms of performance. Gower measure of distance in cluster analysis was incorporated to distinctly capture associated mixed effects of quantitative and qualitative variables used to cluster.

Cluster solution differences were further explored using analysis of variance (ANOVA) and Pearson’s Chi square($\chi^2$) for statistically significant difference and association tests respectively. This enabled identification of group characteristics that reliably distinguish the clusters and those that were similar across the clusters. Cluster means, standard deviations and percentages were also computed.

Generating Scores and Indices
Principle Component Analysis (PCA) multivariate statistical techniques were used to reduce the number of variables in likert scales with pre-coded items, and binary response data sets to a lower dimension to reveal simplified structures that underlie them. That is, PCA created uncorrelated indices or components from an initial set of $n$ correlated variables. Each index score was a linear weighted combination of the initial variables. This is demonstrated in a model using a set of variables $X_1$ to $X_n$ in Equation 2(Wu, 2012).

Model specification:
$$PC_1 = b_{11}x_1 + b_{12}x_2 + \cdots + b_{1n}x_n$$
$$PC_n = b_{m1}x_1 + b_{m2}x_2 + \cdots + b_{mn}x_n$$

Where: $b_{mn}$ represents the weight (coefficients for the PCA rotated components) for the $m^{th}$ component and the $n^{th}$ variable.

Measuring Group Performance
Per capita value of cereals sold (PCVCS) by each farmer group for a span of four (4) years from 2013 to 2016 was used as the measure of performance. To generate the value of cereals sold per group, physical quantities of different cereals sold was multiplied by the selling price. To reduce group size bias, yearly value of cereals sold for each group was divided by the number of group members in each year to generate the PCVCS per year.

RESULTS AND DISCUSSION

Clustering of Farmer Groups
Cluster analysis placed the farmer groups into three (3) categories mainly distinguished by performance as shown in Table 1. The first, here in, referred to as the high performing had 31 groups. The second, the average performing had 55 groups, and the lastly, the low performing had 14 groups.

Structure and Conduct Characterization of Cereal Farmer Groups
Structure Differences
The administrative location of a farmer-group had no significance ($\chi^2=8.17$, $p>0.42$) relationship with its performance. However, it was noted that majority of the farmer-groups were located in Mukothima ward, which was the largest ward and home to Tharaka Cereals Growers Association (TCGA) which is the largest and most influential Community Based Organizations (CBO) in Tharaka Constituency. There
was also significant \(\chi^2=31.23, p>0.00\) relationship between performance and the cereals marketing CBOs that a farmer-group belonged to. Majority of high performing groups (87%) were affiliated to TCGA. On the other hand, majority of low performing groups (64%) were not affiliated any CBO. Pairwise correlation test results indicated a strong correlation \((r=0.61)\) between administrative location (ward) of a group and CBO affiliation of the group. This suggests that the ward a group comes from could have significant influence on the CBO a farmer group decided to join. This could be attributed to factors like distance to the CBO’s store location.

Majority (93%) of the farmer groups charged a membership fee. A similar situation is also observed by Ayiek, Bett, and Kabuage (2014) among chicken farmer groups in Makeni, Kenya. The amount charged across groups in Tharaka Constituency ranged from a minimum of KES 50 to a maximum of KES 30,000. The amount was also significantly \((F=3.24, p>0.04)\) different across the groups at 5% significance level. Evidently high performing groups charged a relatively higher membership fee. The high and varying levels of membership fee could be because farmer groups used valuation of group investments as the basis for deciding the membership fee.

**Structure Similarities**

Majority of the farmer groups, 91%, were formed under founder members initiative while Non-Governmental Organizations (NGOs) and government initiatives accounted for 9%. The top three reasons for formation of the groups were table banking (35%), welfare services (13%) and collective cereals marketing (11%). The top three benefits enjoyed by members in majority of the groups were; table banking (37%), agricultural skills (18%) and capacity building and collective cereals marketing (16%). Ayiek, et al. (2014) had similar findings where access to credit from groups was the main economic activity in majority of chicken farmer groups in Makeni, Kenya. This could be because one of smallholder farmers’ main challenge is accessing low interest credit, at favourable terms of payment; a gap farmer groups try to bridge.

Gender heterogeneity was captured by the ratio of male to female members and leaders in the groups. Male to female members were relatively equal across the groups. This shows that both men and women were attracted to being members of collective cereal marketing groups. This could be due to their business orientation unlike pure table banking or merry-go-round groups.

It was also noted that 98% of the farmer groups had a group constitution or by-laws to guide their activities. Majority of the groups (76%) were less than 10 years old, while the overall mean age for all groups was 8.5 years. This could be because farmer group collective action in Tharaka Constituency could have gained popularity in the last 10 years. Overall, 51% of the farmer groups did not have cereal marketing committees. The existing marketing committees had no significant influence on performance which could be because most of the groups’ marketing committees could have been relatively dormant. Most farmer groups (71%) mostly experienced delays in payment of proceeds from cereals sales. The delay in payments could be attributed to the different types of buyers a group sold to.

**Conduct Differences**

On average, majority of the groups (43%) had one other enterprise, apart from collective selling of cereals. The most common enterprises were tree nurseries, poultry and goat keeping. The number of other enterprises was significantly \((F=5.76, p>0.00)\) different across the groups at a 1% significance level. High performing groups had relatively more other enterprises.

To estimate the level of leaders training in a group, important trainings that were considered in scoring were: roles of a leader in a specific leadership position, group dynamics, finance management and record keeping. The level of training was significantly \((F=7.53, p>0.00)\) different at 1% significance level across the farmer groups. To estimate the level of a group’s training in marketing, four important trainings considered were: value addition, post-harvest handling, cereals procurement and tendering process. The level of training in marketing was significantly \((F=2.48, p>0.09)\) different at 10% significance level across the farmer groups. The main trainers were NGOs and government institutions linked to the groups.

Selection of leaders is a necessary activity that any democratic institution has to undertake (Ramdwar, Stoute and Ganpat, 2014). Majority (84%) of farmer groups in Tharaka Constituency held elections at least once every three years while the rest appointed their leaders. There was a statistically significant \((\chi^2=16.51, p>0.09)\) relationship between groups’ frequency leaders selection and performance across the clusters.
About half of high performing groups selected their leaders every three to five years while low performers mostly did it every year to two years. Majority of the groups (59%) do not keep financial records. However, there was evident significant ($\chi^2=9.88, p>0.01$) association between keeping financial records and cluster performance.

Food and Agriculture Organization [FAO](2014) found out that, community cereals stores, commonly referred to as cereal banks in Kenya, boosted collective cereal marketing among smallholder cereal farmers. This study measured access to a group cereals store with whether a group had a common group store or not and the time taken to the store. Majority of the farmer groups (84%) had a common cereals store. Additionally, it took less than one hour to walk from a groups’ meeting point to the store for majority of the farmer groups (76%) which had access to a cereals store. However, the terms of store use: whether on a temporarily lease, long-term lease, temporally owned or permanent owned store had a significant ($\chi^2=10.83, p>0.09$) association with farmer groups’ cluster performance, at 10% significance level. Majority of the farmer groups (30%) owned a permanent store. Most high performing groups had long term lease or owned a permanent store, average groups owned a permanent or temporally store while low performers owned a permanent store or leased temporarily.

There was evident significant ($\chi^2=48.38, p>0.00$) association between the main cereals markets for farmer groups for 2013-2016 and cluster performance, at 1% significant level. Majority of high performing groups sold their cereals to CBOs, middlemen and institutional buyers like WFP and Imara limited. Average groups sold mainly to the CBO, middlemen and local markets, while majority of the low performing groups (71%) sold their cereals in local markets. Majority of the farmer groups (74%) reported not having made any sales under contracts for the four year study period. However, there was a significant ($\chi^2=11.33, p>0.00$) association between contract sales and cluster performance, at 1% significant level. The few that sold through contracts were more concentrated among the high performing groups with 54%. The main contract buyers were East Africa Breweries Limited (EABL) which contracted sorghum farmers through CBOs and World Food Programme (WFP) which entered into buying contracts with CBOs mainly for green grams and sorghum.

The market offering the highest price, immediate payment in cash, and nearest to a farmer groups cereals aggregation point were the major determinants of the preferred market by the groups. These reasons had a statistically significant ($\chi^2=46.87, p>0.00$) association with cluster performance at 1% significant level. The high and average performing groups mainly preferred markets offering the highest price and those paying immediately in cash. The low performing groups’ choice of markets was based on nearness and lack of an alternative market.

**Conduct Similarities**

Table banking was a common practice in most of the farmer groups in Tharaka Constituency. All the 87 groups that practiced table banking offered both saving and interest charged loans services to their members. The average interest rate was at a fixed 10% on borrowed money usually for a short period of time of about 1 to 3 months. The table banking amount in circulation varied from a maximum of KES 800,000 to a minimum of KES 1,000. Majority of the farmer groups made periodic contributions mostly during their meeting days ranging from as low as KES 20 to as high as KES 4,800 per person per month.

Farmer group collective access to high-value inputs namely seed, pesticides and fertilizer from 2013 to 2016 did not vary significantly across the groups with seed being the most accessed input. Farmer groups were also relatively similar in their internal practices measured based on: participation in meetings and decision making; organizational culture like following set rules; and organizational capacity in making future plans. Record keeping was a relatively common practice among the farmer groups. Minutes and members contributions were the most kept records by the groups at 98% and 84% respectively, while activity records were the least kept by only 5% of the groups.

Going for external credit was not a common practice among the farmer. Only 21% of the groups accessed external credit from 2013 - 2016. The low access to external credit could be because table banking services were widely available in the groups. Low access to external credit could also have been amplified by relatively stringent borrowing terms and conditions from formal lending institutions like banks and Savings and Credit Cooperatives (SACCOs).
Table 1: Distribution of farmer groups by distinguishing structure and conduct attributes

<table>
<thead>
<tr>
<th>Variable</th>
<th>Overall N=100</th>
<th>High N=31</th>
<th>Average N=55</th>
<th>Low N=14</th>
<th>ANOVA F-test</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Membership fee amount (KES)</td>
<td>1,715.20</td>
<td>3,189.36</td>
<td>1,203.64</td>
<td>460.71</td>
<td>3.24**</td>
<td>0.04</td>
</tr>
<tr>
<td>No. of other enterprises</td>
<td>1.05 (0.88)</td>
<td>1.45 (0.85)</td>
<td>0.93 (0.88)</td>
<td>0.64 (0.63)</td>
<td>5.76***</td>
<td>0.00</td>
</tr>
<tr>
<td>Leaders training</td>
<td>9.59 (6.12)</td>
<td>12.84 (6.46)</td>
<td>7.84 (5.44)</td>
<td>9.29 (5.22)</td>
<td>7.53***</td>
<td>0.00</td>
</tr>
<tr>
<td>Marketing training</td>
<td>1.82 (1.39)</td>
<td>2.00 (1.24)</td>
<td>1.91 (1.51)</td>
<td>1.07 (1.00)</td>
<td>2.48*</td>
<td>0.09</td>
</tr>
<tr>
<td>Group’s CBO affiliation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>None</td>
<td>24</td>
<td>1</td>
<td>14</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tharaka Cereals Growers A.</td>
<td>55</td>
<td>27</td>
<td>25</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marimanti Cereals Growers</td>
<td>7</td>
<td>2</td>
<td>4</td>
<td>1</td>
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<td></td>
</tr>
<tr>
<td>GAKIUMA Cereals Growers</td>
<td>9</td>
<td>1</td>
<td>8</td>
<td>0</td>
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<td></td>
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<tr>
<td>Kianda Cereals Growers</td>
<td>5</td>
<td>0</td>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency of leaders elections</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16.51*</td>
<td>0.09</td>
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<tr>
<td>Never selected leaders</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Every year</td>
<td>31</td>
<td>6</td>
<td>17</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Every 2 years</td>
<td>35</td>
<td>9</td>
<td>23</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Every 3 years</td>
<td>25</td>
<td>12</td>
<td>11</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Every 4 years</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Every 5 years</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Keeping financial records</td>
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<td></td>
<td></td>
<td></td>
<td>9.88***</td>
<td>0.01</td>
</tr>
<tr>
<td>No</td>
<td>74</td>
<td>17</td>
<td>43</td>
<td>14</td>
<td></td>
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<tr>
<td>Yes</td>
<td>26</td>
<td>14</td>
<td>12</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group main cereals market</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>48.38***</td>
<td>0.00</td>
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<tr>
<td>Local markets</td>
<td>17</td>
<td>1</td>
<td>6</td>
<td>10</td>
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<tr>
<td>CBO</td>
<td>25</td>
<td>6</td>
<td>18</td>
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<td>Middlemen</td>
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<td>14</td>
<td>24</td>
<td>3</td>
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<td>WFP</td>
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<td>0</td>
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<td></td>
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<td>1</td>
<td>0</td>
<td></td>
<td></td>
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<tr>
<td>CGA/SAIOMA</td>
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<td>2</td>
<td>2</td>
<td>0</td>
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<tr>
<td>EABL</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
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<tr>
<td>Imara</td>
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<td>3</td>
<td>4</td>
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<tr>
<td>Main reason for market preference</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>46.87***</td>
<td>0.00</td>
</tr>
<tr>
<td>Easily met conditions</td>
<td>10</td>
<td>0</td>
<td>8</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buys in bulk</td>
<td>11</td>
<td>5</td>
<td>5</td>
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<td></td>
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<tr>
<td>Highest price</td>
<td>31</td>
<td>14</td>
<td>17</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nearest</td>
<td>13</td>
<td>1</td>
<td>6</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No other alternative</td>
<td>10</td>
<td>0</td>
<td>7</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pays immediately in cash</td>
<td>17</td>
<td>9</td>
<td>8</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others (Fixed price, weights)</td>
<td>8</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: *, **, *** significance levels at 10%, 5% and *** 1% respectively; In parenthesis is standard deviation
Source: Dennis Kyalo’s farmer group survey panel data (2013-2016).

Group Performance
All the 100 farmer groups had sold cereals collectively at least once from 2013 to 2016. Only 10% of the groups managed to sell cereals in all the four years while 41% sold only once in the four years. There was a general steady rise in the number of farmer groups that sold their cereals collectively in the four year study period. The average Per Capita Value of Cereals Sold
PCVCS) was statistically different at 1% significance level across the three farmer group clusters for all the four years. There were a relatively wide difference in farmer group cluster performance where high performing group’ had an average PCVCS of KES 22,441 compared to average and low groups which had KES 1,523 and KES 52, respectively.

The average PCVCS for all groups rose from KES 7,046.13 in 2013 to KES 10,239.13 in 2016. The average PCVCS for all the groups for the four years was KES 7,801.39. This means that, if the earning from all the farmer groups sales was to be put in one kitty, each of the 2,480 members would have earned an average of KES 7,801.39 for each of the four years. Though the number of groups that sold had rose, the value of cereals sold in 2014 was relatively low compared to the other years. This could be due to low harvests experienced in Tharaka Constituency that particular year, due to failed rains.

CONCLUSION

In summary, it was observed that farmer groups are rarely specialized in one activity; however, they served diverse purposes to their members other than cereals marketing. This included table banking and welfare functions to members. This suggests that reciprocity motive played a big role in farmer group collective action. The findings concur with those of Fischer and Qaim (2014) who argue that farmer groups’ activities are highly diversified and the groups serve a bigger purpose that goes beyond collective marketing.

Groups had significant differences in; membership fees, affiliation to farmers’ CBOs, diversity of group enterprises, level of leadership and marketing training, frequency of elections and market access. Key group similarities included: formation reason, administrative location (ward), groups’ age, cereals store access, table banking, main benefit to members, having a group constitution and marketing committees, collective access to high-value inputs, and internal management practices. Notably, high performing groups took a lead in most of the positive indicators used to characterize the groups.

Across the years, 2013 to 2016, there was a steady rise in groups’ cereals sales though still at relatively low levels for majority of them. The rise could be due to better prices and more income received when the farmers sold collectively. The higher returns could be attributed to higher bargaining power and economies of scale from selling collectively. Overall, majority of the groups had a weak commercial orientation in relation to cereals marketing. This is depicted by low sales to bulk institutional buyers, limited transaction and financial record keeping and lack of necessary trade licenses and permits.

It is recommended that, bridging social capital in form of linkages with actors supporting these groups can enhance groups’ access to more lucrative markets. This includes linkages to secondary-tier farmer groups (CBOs), credit institutions, input suppliers, bulk buyers and capacity building institutions. Future research can consider comparing farmer groups based on profitability and the transaction costs groups incur during marketing and other activities.

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REFERENCES


ENVIRONMENT AND HEALTH
LABEL-FREE SURFACE ENHANCED RAMAN SPECTROSCOPIC DETECTION HIV-1 INFECTION IN BLOOD AND PLASMA ADSORBED ON CONDUCTIVE SILVER PASTED GLASS SUBSTRATE

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ABSTRACT

We report on application of conductive silver paste smeared glass slides as Raman spectroscopysample substrates for label-free detection of HIV-1 p24 antigen in blood plasma. We also show that the same substrates can be applied in Raman spectroscopic screening of blood plasma for presence of HIV. The characteristic Raman spectrum of HIV-1 p24 antigen displayed prominent bands that were assigned to Ribonucleic acids (RNA) and proteins that constitute the antigen. These spectra can be used as reference during Raman spectroscopic screening for HIV in plasma within the first few days after exposure (<7 days). The Raman spectra obtained from HIV+ plasma displayed unique peaks centered at wavenumbers 1270 and 1446 cm−1 attributed to the Raman active vibrations in the virion proteins. Other bands similar to those reported in literature were also seen and assigned to lipids and carbohydrates. The attachment of the HIV virions to silver nanoparticles via gp120 glycoprotein knobs were thought to be responsible for the enhanced Raman signals of proteins associated with the virus. The principal component analysis (PCA) applied on the combined spectral data showed that HIV- and HIV+ spectra had differing spectral patterns. This indicated the great power of Raman spectroscopy in HIV detection when plasma samples are deposited onto silver paste smeared glass substrates. The Raman peaks responsible for the segregation of the spectral data in PCA were mainly those assigned to the viral proteins. Excellent results were also obtained from Artificial Neural Network (ANN) applied on the HIV+ data with R (coefficient of correlation) and R2 (coefficient of determination) values of 0.9958 and 0.9895 respectively. The method has the potential of being used as quick blood screening for HIV before blood transfusion with the Raman peaks assigned to the virion proteins acting as a reference.

Keywords: Raman spectroscopy, HIV-1 p24 antigen, HIV+, PCA and ANN

INTRODUCTION

In the early years of Acquired Immunodeficiency Syndrome (AIDS) history, Human Immunodeficiency Virus (HIV) was unknown, misunderstood, feared, untreated, fetal, dreaded by many and often linked to traditions (Coffin et al., 1996). With the aim of understanding and eventually developing a cure for AIDS, the HIV became the most intensively studied virus in human history (Zaman et al., 2012). Great progress has been made in obtaining an outline sketch of how genes and proteins in HIV particles operate and in understanding the biochemical specificity of HIV (Greene and Warner, 1993), the factors controlling its replication, the pathology of how it destroys the human immune system and the molecular bases of HIV infection and immunosuppression (Fauci and Anthony, 1993). There have been several attempts of developing new HIV detection techniques and most of them are yet to be available commercially. Some of the methods have aimed at detecting the HIV virus particles and they include nanospectroscopic assays (Block et al., 2012), photonic crystal biosensors (Shafiee et al., 2014), electrical sensors (Shafiee et al., 2015) and surface-enhanced Raman spectroscopy (Lee-Ho et al., 2015 and Lee et al., 2015). Those that were designed to detect the HIV-1 p24 antigen includes electrochemical immunosensors(Ning Gan et al., 2013), electro-chemiluminescence immuno sensor (Zhou et al., 2015), X-Ray Diffraction (XRD) methods (Raymond et al., 2005) and Near Infrared (NIR) spectroscopy (Akikazu et al., 2005; Rahim et al., 2010). According to the UNAIDS 2016 report, by year 2015, 36.7 million people globally were living with the human immuno-
deficiency virus (HIV), 2.1 million new infections and 1.1 million deaths reported (UNAIDS, 2016). To date there is no known cure for HIV but its transmission and progression is checked through administration of highly effective antiretroviral therapy (ART) (Bloch et al., 2012).

The widely used method for the detection of HIV in blood and recommended by World Health Organization (WHO) is based on the presence of specific antibodies associated with the virus (Ezzel, 2002). This method of diagnosis does not detect directly the presence of viral antigen or Ribonucleic acid (RNA) associated with the virus. Further, the method only works about 90 days from initial exposure to the virus since specific antibodies are not produced before then (Moor et al., 2013). Unfortunately, this is the only method accessed by the majority of diagnostic facilities in developing nations. At the early stage of HIV infection, the generic symptoms are often difficult to distinguish from those associated with common ailments such as influenza or fevers. Such symptoms include: sore throat, chronic diarrhoea, skin rushes, swollen glands, sweats especially at night and nausea (Zaman et al., 2012).

There are many advantages of making early HIV detection and includes reducing anxiety of those suspecting to have been exposed, to get a better sense of how and when one got exposed, get early access to support services and prevent new infections. Due to the large extent of the HIV epidemic and the ever high new infections, a number of assays have been developed and new ones explored for detection. The methods in use currently include enzyme-linked immunosorbent assay (ELISA), polymerase chain reaction (PCR) and western blot among others (Shafiee et al., 2015)). These techniques, though reliable and specific, suffer from many disadvantages such as time consuming, expensive and unsuitable for large scale routine screening and cover a narrow range of HIV antigen concentration (Lee et al., 2015). Besides, most of these techniques are unreliable when used within the window period (between 7-90 days after exposure) although a combination of ELISA and PCR has shown to be able to detect HIV-1 p24 antigen as early as 7 days after exposure (Barletta et al., 2004).

Raman spectroscopy is technique based on monochromatic light scattering. It provides key information on the structure of molecules based on the fact that no two molecules can give exactly the same Raman spectrum (Banwell et al., 2007). Different molecules have different vibrations, thus the Raman spectrum of molecules are unique making identification easier (Moor et al., 2013). The position and intensity of features in the Raman shift spectrum is used to study molecular structure and to determine the chemical identity of the sample (Pascut et al., 2011). This technique has been explored as a fast, sensitive, selective, real time detection and reliable screening method for detection of various infections. However, there are still some limitations associated with Bulk Raman Spectroscopic technique that hinders further clinical applications in medical diagnosis. A major limitation being the efficiency of Raman scattering is extremely weak for biological samples (Lin et al., 2011). There is a need to increase the laser power as well as exposure time to acquire good quality spectra, which may change and even damage the biological sample (Dinh-Voet et al., 2005). The development of surface-enhanced Raman spectroscopy (SERS) based on nanotechnology has been used to overcome the drawbacks associated with Bulk Raman Spectroscopy. In addition to signal enhancement, SERS can provide further advantages over other spectroscopic techniques: (1) work well with aqueous solution since it does not suffer from absorption as in the case of IR; (2) no sample preparation; (3) wide concentration ranges; (4) sensitive and specific tool to different molecules; (5) not affected by temperature much and (6) offers non-destructive analysis (Lin et al., 2011).

SERS has recently been employed in detecting blood and plasma fingerprints for gastric cancer (Feng et al., 2011), medical diagnostic and biological imaging (Dinh-Vo et al., 2005), colorectal cancer (Lin et al., 2011), cervical cancer (Feng et al., 2013) and nasopharyngeal cancer (Lin et al., 2014; Feng et al., 2010; Lin et al., 2010). The capability of SERS to discriminate between blood and plasma components from healthy volunteers and patients based on individual blood and plasma components such as DNA/RNA, lipids, carbohydrates and proteins have also been demonstrated with well defined tentative peak assignment (Feng et al., 2011; Lin et al., 2014 and Notigheret al., 2004). Rapid and sensitive determination of HIV-1 based on SERS was first reported by Lee and coworkers (2015), however, in their study measurements were done on HIV-1 virus like particles (HIV-1 VLPs). In this study, blood and plasma characterization is based on real HIV-1 infection.

In this research study, detection of HIV-1 in whole blood and blood plasma pipeted on silver painted microscope glass slide whose nanoparticles is used as a
simple and cheaper SERS substrate. Silver substrate has been used in a number of SERS based research using a complex predetermined mechanism resulting in regular nanoparticle. Through painting a glass slide using silver air dying paint a considerable enhancement was equally able to be achieved in not only a simple but also a cheaper way.

MATERIALS AND METHOD

Sample Collection
Blood and its corresponding plasma samples were obtained from 68 volunteers (40 patients and 28 healthy individuals) after a consented agreement. All volunteers provided written informed consent to participate. This study was approved by the Kenyatta National Hospital-University of Nairobi (KNH-UoN) Ethics and Research Committee (Proposal number: P637/10/2015). Samples were collected after overnight fasting in Ethylene Diamine Tetra Acetic acid (EDTA) collection tubes. After collection of blood, PCR test was performed on the blood samples to classify them as either HIV-1 positive or negative samples. The samples were then temporarily stored in a vertical rest position at -20°C in the laboratories of the University of Nairobi institute of Tropical and Infectious Diseases (UNITID). During this period, blood and plasma were separated based on their densities, with plasma (a pale yellow fluid) occupying the upper part being less dense. The plasma was then pipetted out into a different EDTA container. All samples were then transported to Laser lab for Raman spectral fingerprinting.

SERS Substrates Preparation
The glass slides were cleaned using ethanol and then air dried for about 20 minutes. The silver conductive paste (SPI suppliers, USA) was smeared using a small brush onto a microscope glass slide and air dried for about an hour. The silver paste consisted of mixture of silver metal particles (35-65% of total weight), 1-methoxy-2 propanol acetate (10-30% weight), butyl acetate (10-30% weight) and acrylic resin (5-10% weight). The procedure was repeated till the silver colloids and silver deposition over a deposition surface appeared as nanospheres. This preparation left the glass slide surface with nanoparticles or aggregates of particles that are capable of serving as metal roughness features as shown in fig 1a and fig 1b under x10 objective lens (owing to its spectral lower signal to noise ratio as compared to other objective lenses). On different Raman substrate prepared; HIV-1 p24 antigen stored in Roswell Park Memorial Institute (RPMI) 1640 medium, blood and plasma samples were smeared on the surface and the adsorbate left to dry for about one hour 30 minutes before taking Raman measurements.

SERS Measurement
Raman spectra were obtained using a Laser Confocal Raman microscope (STR Raman Spectrum System, Seki Technotron Corp; Model number RO-110J) with laser excitation wavelength of 785 nm and a laser power of 150 mW. Raman spectra were recorded by focusing the 10% laser power directly on the dried smears of blood and plasma samples on the SERS substrate to reduce photo degradation that may occur when the laser power is higher. The laser was focused on the samples with x10 objective lens. Raman scattered light from the sample was collected using the same objective lens and detected by a Charge Coupled Device (Princeton Instruments; Acton SP2300) equipped with a 256 x 1024 pixel camera cooled at -76°C. The excitation parameters were; diameter of laser spot at the focus point ≈ 71μm, excitation power was 150 mW, exposure time of 15 s and 15 accumulations per spectra. The grating chosen in order to cover a wider spectral range was 600 lines per mm grating. Background spectra were obtained by blocking the laser source from being scattered by the sample. The Raman equipment was calibrated daily using the 520.5 cm⁻¹ band of a silicon wafer. For both the control and the infected samples spectra were recorded from 10 different spot areas. Raman spectra were recorded in the spectral range 157–1800 cm⁻¹ with center wave number of 1100 cm⁻¹. The raw Raman spectral data from each of the samples were first smoothened using Savitzky-Golay filtering function (at 9 points, second derivative) in MATLAB, and autofluorescence background removed using a Vancouver Raman Algorithm based on fifth-order polynomial fitting method developed by Zhao et al. (2015). Multivariate statistical analysis was done using PCAand ANN to
differentiate between Raman spectral data profiles from plasma with HIV-1 from those without.

**SERS RESULTS AND DISCUSSION**

**Characterization of Plasma Samples**
Averaged spectra of HIV- plasma, HIV+ plasma (at selected viral loads; red line - 193, blue – 2753, green – 21771, purple – 37368 and grey – 835020 copies per ml of plasma) and silver paint smeared glass substrate within the spectral fingerprint region 350-1750 cm\(^{-1}\) are displayed in fig 2 and their tentative peak assignment in Table 1. The peaks in the spectra are associated with lipids (713, 928, 1446 cm\(^{-1}\)), proteins (645, 713, 813, 1270, 1446, 1658 cm\(^{-1}\)) and carbohydrates (928, 990 cm\(^{-1}\)) (Virkler and Lednev, 2009; Fenget al., 2010; Feng et al., 2011; Linet al., 2012 and Fenget al., 2013). Most Raman bands in HIV+ plasma were similar to HIV- bands, however, HIV+ displayed unique peaks centered at wavenumbers 1270 and 1446 cm\(^{-1}\). These peaks were assigned to Raman active vibrations in the HIV virion proteins (Virkler and Lednev, 2009; Pavel et al., 2011 and Lee-Ho et al., 2015).

![Figure 2: Raman Spectral Profile of HIV- Plasma (a), HIV+ plasma (b) after baseline correction and Silver substrate (c) –inset. HIV- spectra was vertically shifted for clarity.](image)

The presence of silver nano-particles on the substrate, though sparse (35-65 % per weight in the pastes), are thought to cause the HIV virus particles to get attached to it resulting in the strong Raman signals of associated proteins. Reportedly, the HIV virus has a preferential attachment with the silver nano-particles via gp120 glycoprotein knobs (Jose et al., 2005). The two intense peaks centered at wavenumbers 1270 cm\(^{-1}\) and at 1446 cm\(^{-1}\) were ascribed to vibrational state of amide III of \(\alpha\)-helix and CH\(_2\) bending vibrational mode in proteins and lipids components of plasma respectively (Fenget al., 2010; Feng et al., 2011; Linet al., 2012 and Fenget al., 2013). These results were similar to those reported by Chuanzong and Yiming, (2005) from serum samples (plasma without clotting factor) showing that using the cheaper silver paste smeared glass substrates works equally good.
Table 1: SERS peak positions and vibrational mode assignments (Feng et al., 2010; Feng et al., 2011; Lin et al., 2012 and Feng et al., 2013)

<table>
<thead>
<tr>
<th>HIV- (cm⁻¹)</th>
<th>HIV+ (cm⁻¹)</th>
<th>Band Assignment</th>
<th>Vibrational mode</th>
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</thead>
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<tr>
<td>460</td>
<td>460</td>
<td>unknown</td>
<td>unknown</td>
</tr>
<tr>
<td>556</td>
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<td>Unknown</td>
</tr>
<tr>
<td>638</td>
<td>638</td>
<td>ν(C-S)</td>
<td>L-tyrosine (Protein)</td>
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<td>Proteins; Lipids</td>
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<tr>
<td>725</td>
<td>725</td>
<td>unknown</td>
<td>Adenine (RNA)</td>
</tr>
<tr>
<td>813</td>
<td>813</td>
<td>unknown</td>
<td>RNA; Alanine</td>
</tr>
<tr>
<td>928</td>
<td>928</td>
<td>δ(COH) and ν(C-C)</td>
<td>Carbohydrates; Lipids</td>
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<td>missing</td>
<td>unknown</td>
<td>unknown</td>
</tr>
<tr>
<td>990</td>
<td>990</td>
<td>CH₂ Rocking</td>
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<td>1206</td>
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<td>Amide III (Proteins)</td>
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<td>1446</td>
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<td>ν(C=O)</td>
<td>Amide I</td>
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<tr>
<td>ν -Stretching</td>
<td>Vibration</td>
<td>δ – Bending Vibration</td>
<td>vs - symmetric stretch</td>
</tr>
</tbody>
</table>

**Principal Component Analysis of the HIV-1 p24 contaminated and uncontaminated plasma Raman spectral data**

The great potential of Raman spectroscopy for use in HIV-1 screening within the window period (<14 days after exposure) was demonstrated when used with PCA on the Raman data set obtained from human plasma intentionally contaminated with HIV1-P24 antigen and from uncontaminated plasma (see Figure 3). The first two PCs (PC 1 and PC 2) accounted for 96.69% of the total variance of the original matrix.

Plasma samples contaminated with HIV1-p24 antigen could be clearly distinguished from those without the antigen with sensitivity of 96.5% (28/29) and specificity of 91% (10/11). This indicated that the two Raman spectral datasets had differing spectral patterns thus demonstrating great power of Raman spectroscopy together with PCA in early screening for HIV-1. The samples containing HIV1-p24 antigen had mainly negative PC2 scores while those without the antigen had positive PC 2 scores in the score plot.

**Segregation of HIV- from HIV+ Raman dataset plasma samples using Principal Component Analysis**

PCA algorithm was also run on the data matrix after data preprocessing as shown in figure 4. With PCA, even the subtle spectral differences in the data sets...
were utilized in the differentiation. We found that first two PCs accounted for 99.76% of the total variance with PC 1 (99.03% variance) and PC 2 (0.73% variance) of the original plasma data matrix as shown.

Figure 4: Plots of the first principal component (PC 1) versus the second principal component (PC 2) for healthy group and HIV-1 infected group plasma samples (a), Selected Raman spectrum of HIV- (black line) and HIV+ plasma (red line) (b), Loading plots of PC 1 (c) and Loading plots of PC 2 (d).

Score plots of PC 1 and PC 2 were able to highly discriminate the spectra of plasma from infected group (n=48) and control group (n=28). HIV- plasma samples could be clearly distinguished from those obtained from infected volunteers without using any labeling probe. This was achieved with sensitivity of 100% (48/48) and specificity of 89.28% (25/28).

Principal Component Analysis of blood samples
The potential of chemometric SERS for detection of HIV-1 infection in blood was also demonstrated with the application of PCA on the Raman data set obtained from human blood infected with HIV-1 (n=18) and from healthy blood samples (n=18). PCA algorithm was run on the data matrix after data preprocessing. We found that first two PCs accounted for 99.89% (PC 1 = 99.64% and PC 2 = 0.25%) of the total variance of the original data matrix (see table 5).
Score plots of PC 1 and PC 2 was highly discriminating for the spectra of infected group and control group. As can be seen in Figure 19, blood samples from healthy volunteers could be clearly distinguished from those obtained from infected volunteers without using any labeling probe. This was achieved with sensitivity of 83.3% (15/18) and specificity of 100% (18/18) indicating the applicability of Raman spectroscopy together with PCA in label free detection of HIV-1 infection. Majority of infected samples had mainly positive PC 1 scores while the control samples had mainly negative PC 1 scores in the score plot.

**Prediction of HIV-1 infection using Artificial Neural Network**

An ANN technique was also evaluated to predict HIV-1 infection from SERS dataset of both infected and control whole blood as well as their corresponding plasma Raman datasets. When presented with the testing set, the network generated an output with correlation coefficient value in the range of 0.0 (0%) ≤ R² ≤ 1.0 (100%) reflecting its predictive value for HIV-1 infection. R² can be defined as the ration of explained variation to the total variation of the matrix dataset (Floyd and Tourassi, 1992). 0% indicates that the model explains none of the variability of the response data around its mean while 100% indicates that the model explains all the variability of the response data around its mean. The ANN training and testing model resulted in R² = 0.99994 for HIV+ plasma sample and R² = 0.9601 for HIV+ whole blood samples indicating that the detection achieved clinically relevant precision (see Figure 6 and Figure 7). Generally, R² values higher than 0.9 indicate that the method under investigation is clinically accurate (Annika et al., 2002). Based on this criterion, our method of HIV detection was clinically accurate.
Figure 6: ANN correlation output from HIV+ whole blood Raman dataset. Training and testing dataset from HIV+ whole blood achieved a diagnostic regression $R^2 = 0.9601$ ($R = 0.97986$).

However, when a network trained using infected Raman dataset was used to test a control Raman dataset of the same fluid type as a target, the value of square of correlation coefficient from the trained network was approximately equal to zero. Similarly, when a network trained using control Raman dataset was used to test an infected Raman dataset of the same fluid type as a target, the value of correlation coefficient from the trained network resulted in $R^2 \approx 0$ (see figure 8).

Figure 7: ANN correlation output from HIV+ plasma Raman dataset. Training and testing dataset from HIV+ plasma achieved a diagnostic regression $R^2 = 0.99994$ ($R = 0.99997$).
CONCLUSION

In summary, we applied SERS to determine the effect of HIV-1 infection on blood and plasma components. Raman spectral profile of the infected samples showed specific biomolecular information including reduction in body components especially proteins and lipids as compared to the healthy samples. Therefore, SERS may be a suitable candidate for evaluating HIV-1 infection related changes in blood and plasma samples thus providing useful information that can really help in diagnosis especially at individual level and potentially early screening of the virus.

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IN VITRO ANTIPLASMODIAL ACTIVITIES OF CRUDE EXTRACTS OF CARISSA EDULIS, AZADIRACHTA INDICA, CASSIA SIAMEA AND HARRISONIA ABYSSINICA AGAINST PLASMODIUM FALCIPARUM.

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ABSTRACT

The emerging resistance of Plasmodium falciparum to chloroquine and sulfadoxine pyrimethamine drugs in Kenya has necessitated the need for newer effective antimalarial drugs. The present study investigated the in vitro antiplasmodial activities of methanolic and aqueous crude extracts of Carissa edulis, Azadirachta indica, Cassia siamea and Harrisonia abyssinica on Plasmodium falciparum strains. Drug assays was conducted using SYBR Green I dye. Two Reference Plasmodium falciparum strains, 3D7 and W2 were assayed against two anti-malarial conventional drugs and crude extracts of Carissa edulis, Azadirachta indica, Cassia siamea and Harrisonia abyssinica to generate 50 % inhibitory concentrations of chloroquine, mefloquine, methanolic and aqueous extracts. These extracts have potential for antimalarial activities that can be used to develop pure compounds for prospective antimalarial molecules that can be used to increase therapeutic resources. Methanolic and aqueous extracts of Carissa edulis, Azadirachta indica, Cassia siamea and Harrisonia abyssinica demonstrated in vitro antiplasmodial effect on the two different Plasmodium falciparum strains. The study findings support the hypothesis that Carissa edulis, Azadirachta indica, Cassia siamea and Harrisonia abyssinica have antiplasmodial activities against Plasmodium falciparum strains. The antiplasmodial activities were associated with the variety of the active phytochemicals that are found in these plants. The extracts of these plants have the potential to be harnessed or further study in anti-malarial drug discovery.

Key words: Antiplasmodial, Plasmodium falciparum, Phytochemicals, Methanolic extracts, Aqueous extracts

INTRODUCTION

Malaria is a common tropical disease affecting many people. It is caused by a protozoan parasite of the genus Plasmodium. The parasite is transmitted by Anopheles mosquito as a definitive host from one human - being to another through bite and introduction of the parasite into the human host blood stream. Due to this, five species of mosquito - borne Plasmodium parasites infect humans; these include Plasmodium vivax, Plasmodium ovale, Plasmodium malariae, and Plasmodium knowlesi and Plasmodium falciparum. Among these five, Plasmodium falciparum causes the most virulent form of malaria, and the highest mortality rates and morbidity in children under five years old, pregnant women and old people. More than 2.4 billion people from over 90 countries worldwide have the disease burden experienced in children with the biggest percentage from sub-Saharan African (WHO, 2012). The disease caused by Plasmodium falciparum, if not properly treated and managed in time, always have a high possibility of the parasite developing resistance to the antimalarial drugs (Greenwood et al., 2008). From West Africa and South-east Asia, Plasmodium falciparum revealed an unexpected cluster of clonally propagated parasite subpopulations resistant to artemisinin, which is a key antimalarial drug (Carlton et al., 2008). In Kenya, malaria causes significant morbidity and mortality with a number of parasite resistant to drug cases reported, hence Plasmodium falciparum resistance to chloroquine diphosphate (CQ) and sulfadoxine pyrimethamine (Co EM et al., 2009). The World Health Organization estimates that 80 % of the world’s population depends on medicinal plants for their primary health care (Gurib-Fakim et al., 2007; Mothana et al., 2008; Gupta et al., 2010). In this regard, the use of traditional medicine has been explored globally as folklore medicine among people of developing countries in their health care systems as an alternative where conventional medicine is less available (Gupta et al., 2010; Rates, 2001). Natural products are important source of new antimicrobial agents which are in the form of secondary metabolites (Cowan, 1999). The bioactive of plants have been investigated by a number of researchers worldwide.
were randomly selected and. Thin and thick smears were made by cabinet before they were examined under the, and the flasks labelled. The position in a bio
), 90 % nitrogen (N2) and 5 % oxygen (O2) and then incubated at 37 °C under moisture condition, (Amaratunga, et al., 2013; Akala et
were transferred into bio
., 201
. Caps
. Three fields
. Natural products either as pure compounds or as standardized plants extracts, provides unlimited opportunities for new drug leads because of the unmatched availability of chemical diversity (Parekh and Chanda, 2007). The aim of the study therefore was to investigate the in vitro antiparasmodial activities of methanolic and aqueous crude extracts of the four medicinal plants.

MATERIALS AND METHODS

Plants’ roots, stems and leaves for the study from which the crude extracts were made were collected from Masumbi village, Luo community in Siaya County, Kenya from January to February, 2015 and processed as described by Oduor et al., (2016).

Preparation of Plasmodium falciparum Culture Medium
The in vitro Plasmodium falciparum culture was done under sterile condition. A 10.4 g packet of powdered Roswell Park of Memorial Institute (RPMI 1640) medium was weighed and added to the cylinder containing 960 ml of phosphate buffer solution. Another 5.94 g of HEPES was weighed into a clean boat and poured into a cylinder containing 960 ml of phosphate buffer solution. A magnetic stirrer was put in the cylinder, covered it with a clean Parafilm paper, and stirred using the magnetic stirrer until the components were completely mixed and dissolved. The volume of the content was topped up to one litre. The preparation was filtered using 0.2µm filter unit, and labelled with the expiry date, (Trager and Jensen, 1976).

Activation of Plasmodium falciparum Strains from Liquid Nitrogen
Reference Plasmodium falciparum strains in liquid nitrogen were stored for future use. For the revival, they were located in the storage and pulled out for processing. They were transferred into bio-safety cabinet and thawed over water bath at 37 °C. The amount thawed was transferred into 15 ml centrifuge tube, and the volume marked. The amount thawed was picked and divided by 5. A volume of 12 percent (%) sodium chloride (NaCl) was picked and mixed with the sample. The content was then left to stand at room temperature for 5 minutes. This was followed by 0.2 % and 0.9 % NaCl respectively. About 9 volumes of 1.6 % sodium chloride (NaCl) was added and centrifuged at 1500 rpm for 3 minutes. The supernatant was removed, and 9 volumes of 0.9 % NaCl plus 0.2 % glucose were added and centrifuged at 1500 rpm for 3 minutes to enhance parasite adaptation. The supernatant was removed and the flasks labelled. The pellet was mixed with 4.5 ml of 20 % complete medium with serum (CMS) and 0.5 ml of washed zero positives (0+) red blood cells (RBCs) to homogeneity then transferred to 25 cubic centimeters (cc) culture flasks. Components of the flasks were then gassed with 5 % carbon dioxide (CO2), 90 % nitrogen (N2) and 5 % oxygen (O2) and then incubated at 37 °C under moisture condition, (Amaratunga, et al., 2013; Akala et al., 2011).

Maintaining Plasmodium falciparum Strains in Roswell Park Memorial Institute (RPMI- 1640) Culture
Media was changed by removing flasks containing complete medium with serum (CMS) 10 % from the refrigerator and warmed in 37 °C in an incubator for 10 minutes and then placed in a bio-safety cabinet. Caps were subsequently removed from culture flasks. The culture flasks were held at 45 degrees or tilted to allow the media to flow towards the corner to be aspirated until 0.5 ml of medium and red blood cell was left. Clean and sterile microscopic glass slide were removed from the slide packet and placed on the working biosafety cabinet. Thin and thick smears were made by expressing 10 µl of blood on the slide, and use another clean slide held at 45 degrees to make thin films. The slides were left to air dry in the bio-safety cabinet, fixed with methanol for 5 minutes and stained with Giemsa stain 1 in 10 dilutions for 20 minutes. The smears were left to dry in an upright position in a biosafety cabinet before they were examined under the compound microscope using ×100 objective lens to confirm the presence of the Plasmodium falciparum parasites. Caps were then removed from the flask containing medium, and 4.5 ml of medium was aspirated into the serological pipette and expelled into the 25 cc culture flasks. The red cells were re-suspended and the bottles gently agitated in a circular motion. The flasks were flushed with 5 % CO2, 90 % N2 and 5 % O2 gas mixture and then placed at 37 °C in an incubator under moisture condition.

Plasmodium falciparum Parasitemia in Thin Blood Smear
A volume of 10 µl of blood was obtained by micropipette and transferred onto clean, sterile glass slides. Thin smears were made, air dried and fixed with 70 % methanol underflow laminarcabinet. The slides were stained using 1 in 10 dilutions of Giemsa stain for 20 minutes. Three fields were randomly selected and
observed using ×100 objective lens. and on each field count, the number of red blood cells and the number of parasites were counted up to 2,000. Parasitaemia was calculated as the number of parasites divided by the total number of red blood cells.

Preparation of the Splits (Drugs, Medium and Culture)
Determination of necessary volume of culture was done, and 50 % fresh red blood cell (RBC) and medium needed for 5 ml, 6 % haematocrit was done. The required volumes of 50 % red blood cells and medium in 25 cc culture flasks were mixed. The containers were placed in 37 °C dry incubator for 5-10 minutes. Warmed flasks plus old cultures were diluted in the laminar flow cabinet before new bottles were labeled. The desired volume of old culture was added into the corresponding flasks containing fresh red blood cells and medium mixed and placed horizontally on a working surface. Flasks were flushed with 5 % CO₂, 90 % N₂ and 5 % O₂. The new cultures were again mixed in a circular motion and placed horizontally in the 37 °C incubator.

Preparation of Standard Drugs (Chloroquine and Mefloquine)
This was done under a bio-safety cabinet. Stock solutions of 5 mg/ml were prepared in 5 ml of 100 % dimethyl sulfoxide (DMSO) for chloroquine (CQ) and mefloquine (MQ) respectively. CQ = 5 mg/ml × 1,000,000 = 5,000,000 ng/ml. Starting concentration on the plate was reduced to 2000 ng/ml. Therefore 5,000,000 ÷ 2,000 = (1: 2,500) × 9 = 9 µl in 2,500 µl, hence 4 × (9 × 2,500) = 36 µl in 10,000 µl divided by 1,000, hence chloroquine 36 µl in 10 ml medium. Approximately 300 µl of CQ was picked and transferred into the 1st well of the 1st column of 96 well microtiter plates. The same procedure was repeated with MQ with the starting concentration of the plate = 500 ng/ml. 5,000,000 ÷ 500 = 10,000 hence 9 × (1 µl in 10 ml) = 9 µl in 10 ml. About 300 µl of MQ was picked and transferred into the 2nd well of the 1st column of the 384 microtiter plate. Further dilutions were done in complete medium with serum (150 µl) to reach the desired starting concentration of 2000 ng/ml and 500 ng/ml for CQ and MQ respectively. A serial 2-fold dilution followed to generate 10 concentrations for IC₅₀ testing. Concentrations range from the highest to lowest were 2000 ng/ml to 1.977 and 500 ng/ml to 0.488 ng/ml for CQ and MQ respectively.

Preparation of Test Drugs (Methanolic and Aqueous Extracts)
Both extracted sample with methanol and aqueous were weighed using electronic analytical balance. The various weights obtained were dissolved in 100 % dimethyl sulfoxide (DMSO) and vortexed under laminar flow cabinet using Barnstead Lab-Line shaker / Thermolyne 2555 Bonlevald made in the USA. The amount of DMSO was weight dependent. Starting concentration 10,000,000 ng/ml was reduced to 50,000 ng/ml. 10,000,000 ng/ml was divided by 50,000 ng/ml to obtain a ratio of 1: 200. Both sides of the ratio were multiplied by 10 to obtain a ratio of 10 µl of cpd: 2000 µl of complete medium with serum and cpd, 10 µl in 2 ml.

Preparation of Primary Culture (Mother) Plates
Approximately 300 µl of each reference and test drugs was added manually to the first well of column 1, 2, up to 8 of the 384 microtiter plates. Complete RPMI 1640 medium, 150 µl was added to a well 2 of each column through 12. Biomek 2000 was used to perform two-fold serial dilutions by carrying 150 µl from first well of each column through 12.

Preparation of Secondary Culture (Daughter) Plates
Daughter plates were placed in the same orientation with the mother plate. Volume of 12.5 µl of each dilution per well was transferred from mother plate to daughter plate. Changing tips after every dispensation. The mother and daughter plates were kept at -80 °C for one day. The plates were thawed at 37 °C in a culture incubator for 1-2 hours before used for drug screening.

In vitro Antiplasmodial Activity Assay
Antiplasmodial activities of methanolic and aqueous crude extracts and reference drugs were assayed against chloroquine-sensitive, (3D7) and chloroquine-resistant Indochina 1 (W2) Plasmodium falciparum strains using a non-radioactive assay technique. The technique uses deoxyribonucleic acid (DNA) dye that accurately depicts in vitro parasite technique. This fluorochrome is known as SYBR Green 1, an non-radioactive DNA dye (Wanyama et al., 2011). Laboratory cloned parasites were obtained from liquid nitrogen, thawed at 37 °C and cultured as described by Akala et al., (2011) to establish replication robustness of 3 - 6 % parasitemia. Briefly stock solutions 5 mg/ml were prepared in 5 ml of 100 % dimethyl sulfoxide (DMSO) for chloroquine (CQ) and mefloquine (MQ). Concurrently a total of 45 mg of methanolic and aqueous extracts were weighed using analytical
RESULTS AND DISCUSSIONS

Chloroquine, mefloquine, methanolic and aqueous extracts of the four plants was assayed against Plasmodium falciparum 3D7 and W2 strains and the comparison of the mean IC_{50} values against relative fluorescence units (RFUs) demonstrated. See figs. 1, 2, 3, 4, 5, and 6.

In the study in vitro anti-plasmodial activities, showed that the active constituents in all the methanolic and aqueous extracts had antiplasmodial activities against Plasmodium falciparum 3D7 and W2 strains. The following extracts showed similar 50 % Inhibitory concentration (IC_{50}) to that of chloroquine (CQ) assayed against 3D7 strain: methanolic extracts of Cassia siamea stem bark, Harrisonia abyssinica root bark and aqueous extract of Harrisonia abyssinica root bark. Similar IC_{50} to that of CQ assayed against W2 strain was observed in methanolic extracts of Azadirachta indica leaves, Harrisonia abyssinica root bark and aqueous extract of Azadirachta indica leaves.

In the current study, methanolic extracts of Cassia siamea stem bark, Azadirachta indica leaves, Carissa edulis root bark, aqueous extracts of Harrisonia abyssinica root bark and Carissa edulis root bark showed similar IC_{50} to that of MQ assayed against 3D7 strain. Similarly, methanolic extracts of Azadirachta indica leaves, Cassia siamea stem bark and aqueous extract Azadirachta indica leaves showed IC_{50} similar to that of MQ assayed against W2 strain.

In this study methanolic extracts of Harrisonia abyssinica root bark, Azadirachta indica leaves and aqueous extract of Harrisonia abyssinica root bark showed similar IC_{50} to CQ and MQ assayed against 3D7. This was similarly observed with methanolic extracts of Azadirachta indica leaves, Cassia siamea stem bark and aqueous extract of Azadirachta indica leaves assayed against W2 strain.

Previous study on antiplasmodial activity of Azadirachta indica had been reported, (Ahmed et al., 1999) on selected Sudanese medicinal plants with emphasis on Maytenus senegalenis (Lam.). In this study, findings of in vitro anti-plasmodial activities of the methanolic and aqueous extracts are comparable with, (Mohammed et al., 2009) whose study was on assessment of antimalarial activity against Plasmodium falciparum and phytochemical screening of some Yemen medicinal plants. In this study, in vitro antiplasmodial activities of the four methanolic and aqueous extracts active constituents, (e.g., flavonoids, and terpenoids of methanolic extracts concurred with, (Dhar et al., 1998) in which extracts of Azadirachta indica were suggested to contain active constituents which might target specific metabolically active processes at the parasitic schizont stage. In a comparative study of acetone/water and aqueous extracts of Azadirachta indica leaves; they manifested inhibitory effect on a chloroquine-sensitive Plasmodium falciparum at a concentration value of 20 μg/ml (Iroka, 1993). In this study, antiplasmodial activities of methanolic extracts of Azadirachta indica showed IC_{50} values of 11.76μM while aqueous extracts of A. indica gave IC_{50} values of 3.42 μM on sensitive strain of Plasmodium falciparum, (e.g., 3D7 chloroquine sensitive strain). However, earlier findings had shown that Azadirachitin of A. indica was able to block the development of motile malaria gametes in vitro and raised the possibility of developing Azadirachitin-based compounds as antimalarial agents with transmission-blocking potential (Jones et al., 1994).

In vitro antiplasmodial activities in this study concurred with, (Kebenei et al., 2011) whose findings on Carissa edulis showed IC_{50} value of 1.95 μg/ml.
Although the methanolic and aqueous extracts of *Carissa edulis* showed IC$_{50}$ values of 20.2 µM and 2.48 µM, for chloroquine sensitive strain was 16.12 µM and 12.7 µM for chloroquine resistant strain in this study, *Carissa edulis* showed good antiplasmodial activities on both chloroquine sensitive resistant strain.

*In vitro* antiplasmodial activities of this study is in agreement with, (Al-Youssef and Hassan, 2014) who demonstrated different constituent’s sesquiterpenes which were a class of compounds found in *Carissa edulis* possessing antimicrobial, antimalarial, anticancer and anti-inflammatory effects. Although nine eudesmane-type sesquiterpenes were isolated from the methanolic extract of *Carissa edulis* root, these were carissone, cryptomeridiol, β-eudesmol, 6α-carissanol, 6β-carissanol, 2α-carissanol, 4-Epi-Aubergerone, and dehydrocarissone. The same plant extract a germacrane-type sesquiterpene, germacrenol, were also obtained, methanolic extract of *Carissa edulis* in this study demonstrated only trace compounds e.g., steroids, saponsin, tannins, flavonoids and terpenoids which have similar effects, (Sofowora, 1986; Achenbach, 1985).

In the study, *in vitro* antiplasmodial activities of methanolic and aqueous extracts of *Cassia siamea* showed IC$_{50}$ values of 3.08 µM and 5.19 µM for *P. falciparum* 3D7 strain and 11.35 µM and 12.85 µM for *P. falciparum* W2 strain. *In vitro* antiplasmodial activities of methanolic and aqueous extracts of *Cassia siamea* therefore concurred with (Bero et al., 2009) whose identified 5-Acetonyl-7-hydroxy-2-methylchromone with IC$_{50}$ value of 19.4 µM on *P. falciparum* 3D7 strain and Anhydrobarakol with IC$_{50}$ value of 36.4 µM on *P. falciparum* 3D7 strain, (Pillay et al., 2007). The *in vitro* antiplasmodial activities in the methanolic and aqueous extracts of *Harrisonia abyssinica* demonstrated good antiplasmodial activities on 3D7 and W2 strains of *P. falciparum* while aqueous extracts of *H. abyssinica* root bark showed good antimalarial activities on 3D7 and moderate antimalarial activities on *P. falciparum* W2 strain.

**CONCLUSIONS AND RECOMMENDATIONS**

The *in vitro* anti-plasmodial activities of the four medicinal plants were determined. This study supports that *Carissa edulis*, *Azadirachta indica*, *Cassia siamea* and *Harrisonia abyssinica* have antiplasmodial activities to different *Plasmodium falciparum* strains. The antiplasmodial activities were associated with the variety of the active phytochemicals that are found in these plants. These plants have the potential to be harnessed or further study in anti-malarial drug discovery and especially the ones that have shown IC50 similar to chloroquin and mefloquine.

**ACKNOWLEDGEMENTS**

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Figure 1: $IC_{50}$ plots for chloroquine, methanolic and aqueous extracts against *Plasmodium falciparum* 3D7 strain RFUs.

CQ is chloroquine and C.a, C.m, A.m, A.a, H.a, and H.m are methanolic and aqueous extracts of the four plants.

Figure 2: $IC_{50}$ plots for mefloquine, methanolic and aqueous extracts against *Plasmodium falciparum* 3D7 strain RFUs.

Figure 3: $IC_{50}$ Plots for chloroquine and mefloquine, methanolic and aqueous extracts against *Plasmodium falciparum* 3D7 strain RFUs.
4: IC$_{50}$ plots for chloroquine, methanolic and aqueous extracts against *Plasmodium falciparum* W2 strain.

Figure 5:
IC$_{50}$ plots for mefloquine, methanolic and aqueous extracts against *Plasmodium falciparum* W2 strain RFUs

Figure 6: IC$_{50}$ plots for chloroquine, mefloquine, methanolic and aqueous extracts against *Plasmodium falciparum* W2 RFUs.
EDUCATION AND CAPACITY BUILDING
ABSTRACT

Every year, when the Kenya Certificate of Primary Education (KCPE) examination results are released, the same story of mass failure in rural schools is repeated. Academic performance prediction modelling could provide an opportunity for learners' outcomes to be known early, before they sit for final examinations. This would be particularly useful for education stakeholders to initiate intervention measures to help students who require high intervention to pass final examinations. This study proposed that an academic performance prediction model could be built using Logistic Regression to classify students into two categories, those that will pass and those that will need intervention to pass. A six-step Cross-Industry Standard Process for Data Mining (CRISP-DM) theoretical framework was used to support the modelling process. Modelling was conducted using two datasets collected in Kwale and Mombasa County respectively. The first dataset had 2426 records having 22 features, collected from 54 rural primary schools. The second dataset had 1105 records with 19 features, collected from 11 peri-urban primary schools. Evaluation was conducted to investigate: (i) the prediction performance of Logistic Regression on the two datasets with all the features and; (ii) the prediction performance with an optimal subset of features. Two common performance measures were adopted, ROC area and F-Measure. It was found that the model achieved a ROC area measure of 88.7% with all features and 88.5% with the optimal feature dataset. Similarly the F-Measure rate was 89.7% for all the features and 89.6% for the optimal feature subset. Further, a mobile application was implemented to facilitate the model use in rural areas where desktops cannot be used. Teachers in 15 schools used the model for two weeks to classify their Class Six and Class Seven students. Results show that nearly 80% of the students requiring high intervention could be determined. This high prediction performance means that the students who need high intervention could be determined early enough before the final examination. Further, this accuracy of prediction is good enough to motivate stakeholders to initiate strategic intervention measures.

Keywords: Prediction Modelling, Academic Performance, Rural Schools, Prediction Performance

INTRODUCTION

Education is very important; it prepares the human resource that is necessary for economic development of a country (Munyi & Orodho, 2015). Kenya, like any developing country has faced challenges to ensure quality education, especially in rural public schools. Most students in these schools perform below the national average marks required for progression to secondary schools. Therefore, they drop out of the school system and end up as unskilled labourers. The problem of mass failure in rural public schools may have been catalysed by the free primary education policy. The initiative caused increased enrolment with the same limited resources (Somerset, 2009). Somerset argues that this increased enrolment is what has affected the quality of education. The increased access is a good thing as long as the required resources are made available. Munyi and Orodho associates the problem with: over stretched facilities, overcrowding in schools, high teacher-pupil ratio, over-age children, insufficient textbooks, poverty, culture that impedes education, and limited support from the community.

Kwale is one of the counties in Kenya that has many rural schools. Similar counties face the problem of mass failure. A problem that is likely to remain or worsen unless intervention measures are put in place. The strategies through which mass failure in primary schools can be reduced have received much attention from researchers. Studies have attempted to identify the causes for mass failure in rural public schools and proposed recommendations for the government to act on (Mweki, 2016). However, many such studies have not suggested ways that could be used in solving the problem. The government of Kenya has attempted to enforce policies for managing education in order to improve quality (Lucas, McEwan, Ngware, & Oketch,
A drawback to this is that this is only possible at macro-level. The government approach lacks effectiveness because the policies are general (Achola & Pillai, 2016). The problem is caused by many and varied reasons, hence the need for a specific strategies to assist individual students.

This study proposes to use Machine Learning. A technique that has been used successfully in developed countries to predict students at-risk of failing long before they sit for final examinations (Tamhane, Ikbal, Sengupta, Duggirala, & Appleton, 2014; Thai-Nghe et al., 2011). Techniques for determining the attributes that are most indicative of the target have also been used in a number of areas to reduce the size of the dataset used (Tang, Alelyani, & Liu, 2014). This approach was used in this study. The focus is identifying the causes of poor performance in academic work, and to use these causes or attributes, to classify students into two categories, high-intervention and low-intervention cases. High-intervention stands for the students that need strategic measures for them to get above average marks. Low-intervention stands for the students that are above average, those that may not need any strategic measure to achieve above average marks. The model predicts the students that require high intervention as early as one or two years before they sit for Kenya Certificate of Primary Education (KCPE). The high accuracy of prediction by the model is what motivates strategic intervention.

The paper is extracted from a bigger study; it is guided by the following questions:
(i) What is the prediction performance of Logistic Regression on the two datasets when the complete datasets are used?
(ii) What is the prediction performance of the two datasets using the optimal subset of features?

The rest of this paper is organised in the following four sections. Section 1 has been the introduction, Section 2 describes the adopted methodological approach. Section 3 presents the results of prediction performance and a discussion of the results. Section 4 concludes the paper with a summary of achievements of further research.

METHODS

This study used the Cross-Industry Standard Process for Data Mining (CRISP-DM) (Kurgan & Musilek, 2006). CRISP-DM is a six-step process that include domain understanding, data understanding, data preparation, data mining, evaluation, and using discovered knowledge. These steps are illustrated in Figure 2.1.

![Figure 2.1 CRISP-DM Processes (Mgala, 2016; Kurgan & Musilek, 2006)](image)

**Problem Domain Understanding**

Problem domain understanding focuses at the area of interest in the problem solving process (Asamoah & Sharda, 2015). In this study, a preliminary survey with 7 education officers, 14 head teachers and 124 teachers in Kwale County was used to achieve this. Findings revealed that poor academic performance exists in the County, and that nearly 70% of the students who sit for KCPE do not score more than 250 marks out of 500 total marks.

**Data Understanding**

In data understanding, data is examined closely to determine its quality and usefulness for the mining process (Asamoah & Sharda, 2015). This was achieved by scrutinising the collected 2426 student records consisting of 22 fields from rural schools, and the 1105 student records of 19 fields from peri-urban schools. The examination entailed: a consideration for the tools to be used for the type of data; the fields that need conversion to make them usable in WEKA; and the records that needed data to be either filled or deleted.

**Data Preparation**

Data preparation entails combining tables from different sources and pre-processing the data. It entails solving data problems such as missing data that may hinder effective analysis (Sattler & Schallehn, 2001). Data preparation was achieved by: typing the manual records into excel, determining the validity of the typed data, cleaning the data by replacing missing values and deleting the records that did not have the target,
discretising some of the data, and selecting the most predictive features.

Data Mining
Data mining is the process of analysing data in order to extract meaningful patterns from it (Shafique & Qaiser, 2014). Logistic regression modelling technique was used to build the models using WEKA machine learning environment (Hall et al., 2009). The rural dataset was divided into 70% training data and 30% test data. The peri-urban data was divided into 60% training data and 40% test data, this was done to increase the number of test data for the peri-urban data. Using a 10-fold cross validation method (Refaelzadeh, Tang, & Liu, 2009), the modelling and evaluation was achieved as shown in the results section.

Evaluation, Discovered Knowledge
Evaluation focuses at interpreting the model performance to determine whether it achieves a reasonable performance or not (Shafique & Qaiser, 2014). A comparison of the prediction performance for logistic regression on the different datasets was carried out. Two metric measures were used for the evaluation process, F-Measure and ROC area.

Using the Discovered Knowledge
This stage explains how the discovered knowledge or results are to be used. The prediction results obtained using logistic regression were compiled into a report that was presented in conferences or presented to education stakeholders. The aim is to motivate initiation of strategic intervention among the stakeholders.

RESULTS AND DISCUSSION

The results of modelling and testing using the 10-fold cross validation method are presented in Table 3.1. Two metrics were selected to compare the model prediction performance with the different datasets, Receiver Operation Characteristic (ROC) Area and F-Measure. ROC Area is a metric curve generated by plotting sensitivity against specificity; it is a preferred measure because of its stability even in imbalanced classes (Jiménez-Valverde, 2012). F-Measure is the other preferred metric because it combines precision and recall to obtain an average value (Shaikh, Mahoto, Khuhawar, & Memon, 2015).

### Table 3.1 Results obtained using 10-fold cross validation with logistic regression

<table>
<thead>
<tr>
<th>Metric</th>
<th>Full-rural dataset (22 features)</th>
<th>Optimal rural dataset (7 features)</th>
<th>Peri-urban dataset (19 features)</th>
<th>Peri-urban dataset (7 features)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROC Area</td>
<td>88.7%</td>
<td>88.5%</td>
<td>89.7%</td>
<td>90.2%</td>
</tr>
<tr>
<td>F-Measure</td>
<td>89.7%</td>
<td>89.6%</td>
<td>78.4%</td>
<td>79.9%</td>
</tr>
</tbody>
</table>

Discussion
The aim of this research was to develop a model that could predict the students that require high intervention. The high prediction performance of the model is what would motivate strategic intervention among education stakeholders. Detailed results on feature selection and implementation of the model in a mobile form together with evaluation process results are presented in my thesis (Mgala, 2016). The results presented here show that the model prediction performance for the rural dataset was nearly the same for both the complete dataset and the optimal 7 feature dataset. This means, the seven features could be the most indicative of the problem of poor performance in Kwale County. These features are: test-marks, gender, family-income, student-age, teacher-shortage, student motivation, and study-time. Importantly, the high metric values indicate that students requiring high intervention can be classified early before they sit for KCPE, and that the stakeholders will be motivated to initiate strategic intervention. On the other hand, the peri-urban data show slightly higher performance with the ROC Area metric. It also shows a noticeably lower performance for the F-Measure value. This shows that the model is sensitive to the type of data used. In the work by Mgala (2016), the optimal features picked were: test-marks, parent-education-level, student-age, teacher-absenteeism, student-discipline, gender, and family income. Four features are similar in both datasets while three are different, which explains the slight difference in performance.

CONCLUSIONS

This paper presents the CRISP-DM process for data mining and extends its application in educational data from rural schools in Kwale County, Kenya. The process was used to model logistic regression. Results show that a high accuracy was obtained in predicting the students that require high intervention before they sit for KCPE. Using the cross validation method in the
two datasets, and using preferred metrics, ROC Area and F-Measure, high values of over 88% were obtained with the rural dataset. This is the focus of the study. The peri-urban dataset showed a noticeable variation but also attained nearly 80% with optimal dataset. These results are high enough to motivate initiation of strategic measures for the students that are classified as requiring high intervention.

Future work will be in extending the study to other counties with which have rural schools to validate the model. It is also intended to further refine the model by using more data collected from the other counties. The mobile tool will also be refined so that it could be adopted in the Kenyan education system and beyond.

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EDUCATIONAL TECHNOLOGY AND HIGHER LEARNING

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ABSTRACT

There has been an increased interest in applying technology with the objective of improving teaching. Research indicates that though there has been the use of technology in teaching, it has been on a lower scale compared to other sectors. The purpose of this theoretical review was to analyze how education technology influences the quality of education delivery in institutions of higher learning. The study looked at how Active Theory and behavioral learning theory have been employed in studies on how technology can be incorporated into higher education, and how it affects quality of content delivery. The study employed the use of secondary data from other studies conducted in the field of higher learning. For this study, peer reviewed articles in the field of higher education were accessed from online databases. Findings from the secondary data showed that these theories have been significantly used in studies concerning improving quality of learning in higher education using educational technology. This study shows however that theories used to explain educational technology need to be contextualized to fit into the African educational systems. It further shows that there is need for more research on how academic staff adopt and adapt to educational technology.

Key Words: Educational technology, higher education, quality of education, academic staff

INTRODUCTION

Reiser (2012) noted that educational technology was viewed as instructional media where instruction is presented to learners through physical medium. In American schools Educational Technology can be traced back to the first two decades of twentieth century when educational technology was being introduced into the field of education. Educational Technology is the organization of any learning system adapting or adopting methods, processes, and products to meet specified educational goals. This involves systematic identification of the goals of education, recognition of the diversity of learners’ needs, the contexts in which learning will take place, and the range of provisions needed for each of these (Reiser, 2001). In India educational technology was devised to suit the needs and abilities of the pupils and suit the societal needs as expressed in identified learning goals (UNDP, 1976).

Radio and television marked a landmark in the development of educational technology worldwide. Prior to this, the scope of education was quite limited and very narrow. The invention of computer and the use of internet has changed the educational practice the world over. This has brought about the information age (Aniemeka, 2002).

There has been an increased interest of applying technology to improve learning and teaching (Spector, 2012). Application of technology in education has led to the evolution of educational technology, which is defined as “the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources” (Januszewski & Molenda, 2008). It also refers to the transformative movement in learning and teaching that exploits technological advances for offering learning experiences which are not possible to be organized in current formal educational settings (Haythornthwaite & Andrews, 2011). The significance of technology in higher education institutions cannot be overemphasized. The Economist Intelligence Unit (2008) stated that students and the corporate sector are drawn to institutions that have embraced educational technology in their curricula and management.

Technology has become an important aspect of students’ lives. Jhurree (2005) asserted that technology has the potential to drive economic, social, political, and educational transformations. Developing countries could not ignore technology if they were to remain competitive and relevant within the globalization trend (ibid). McGregor (2002) and Dodds (2007) note that technology contributes to strengthening higher education institutions and promotes innovations. Technology has emancipative power, which is able to
assist institutions to move from the status quo and perform their functions in an improved way. In institutions of higher learning, technology contributes in building communities of innovators radically changing institutional processes and practices, and implementing infrastructure and tools that enable people to excel (ibid).

Studies related to educational technologies have focused on its implications to students and the institutions. There is a gap in focusing on how lecturers are adapting to educational technology to improve their teaching and research. Although, technology cannot be viewed as a panacea for all educational challenges faced especially in developing countries, it has the potential to impact on learning outcomes. (Jaffer, Ng’ambi, & Czerniewicz, 2007).

THEORETICAL PERSPECTIVES

Researchers (Barab, Barnett, Yamagata-Lynch, Squire, & Keating, 2004; Blin, 2004, 2005; Brine & Franken, 2006; Issroff & Scanlon, 2002) have used Activity Theory to study the design and implementation of learning supported by technology in various communities of. In this study, Activity theory is used to explain how technology and innovation in education is as a result of social interaction and change brought about by human interactions in institutions.

Studies that applied activity theory as their theoretical and analytical processes examined: the academic application of gaming using computers (Amory, 2010; Ang, Zaphiris & Wilson, 2010), computer supported collaborative learning (Collis & Margaryan, 2004; Lipponen, Hakkaraainen & Paavola, 2004), mobile learning (Uden, 2007; Sharples, Taylor & Vavoulou, 2007) and explicit and tacit knowledge sharing by teaching communities (Baran & Cagiltay, 2010). These studies have focused on technology’s mediation of emergence of reflective and expansive learning, construction of new knowledge, the need for theoretical framework that unifies technology and education, but fails to bring out how educational technology can be integrated in teaching and learning to improve on service delivery in higher education.

Studies that employ activity theory to examine the outcomes of constructivist learning environments have focused on the needs of the students and failed to mention the role lecturers play in the use of educational technology (Jonassen & Rohrer-Murphy, 1999; Jenlink, 2008; Fullick, 2005). Jonassen & Rohrer-Murphy (1999) used activity theory to show how human consciousness emerges from socio-cultural contexts and transforms through their engagement in activity systems.

Activity theory takes its origins from both Leontev’s notion of activity and Vygotsky’s idea about the tool mediation. Activity theory emphasises on social factors and interaction between agents and their environments. It explains how cultural development is a process of both social exchange and externalization of human reflection. (Daniel, 2001). Tools shape the way human beings interact with reality.

Social learning perspective indicates that learning occurs as a result of interactions with the human and objects (Driscoll, 2005; Vygotsky, 1978). According to Vygotsky, social interaction and cultural context have an effect on cognition and learning. Likewise, activity theory explains that learning emerges from human activity in a complex activity with interaction among subjects, objects, and tools (Engeström, 1987; Jonassen & Rohrer-Murphy, 1999). For understanding and analyzing complex human learning activities in a context, Activity theory may be an analytical framework for analyzing the system (Yamagata-Lynch, 2013).

Activity theory, also known as Cultural Historical theory, is a social psychological framework that grew out of two theoretical pillars of Soviet psychological thought in the 1920s and 1930s: Vygotskian cultural – historical psychology and praxis-focussed Marxist materialism. It seeks to create an account of human cognition in which people, their intentions, tools, culture, and their encompassing structures are all considered as inherently inseparable components of human activity which constitute thought (Lemke, 1990). It is used as a guiding framework to understand how technologies are adopted, adapted, and configured through use in complex social situations. It also links behavioral theory as a cause for motivation for use of educational technology in higher learning.

Engeström’s activity theory, situated within socio-cultural theory, was used to analyze complexities within and surrounding academic activities, such as writing assignments or using online resources by students (Engeström, 2001). Engeström used this theory to provide a tool to analyze how individual or groups use mediating artifacts (online writing resources) to achieve a specific object and outcome (Williams et al., 2007). According to Barab, (2004) this theory also provides a framework to
analyze socio-cultural influences of rules and norms, community and division of labor in the same activity system. This theory highlights how we learn through social interaction and thus learning is most powerful when people are engaged in joint activities with peers (Leander & Lovvorn, 2006). It also looks at how technology has brought change to education through historical analyses in the context it has been applied (Engeström, 1993).

This theory is grounded in the intellectual tradition of dialectical materialism which are principles shared by Hegel and Marx. Innovation, change, and development are brought about by contradictions (Engeström, 2001). Researchers have focused on examining active theory on how it applies to systems and systems and the socio-cultural influences it has on educational technology little is said on how active theory applies to academic staff adapting, adopting, improving educational technology in teaching.

**LITERATURE REVIEW**

The main goal of higher institutions of learning is to produce skills through provision of education. A university, for example, builds a good reputation and becomes popular due to the quality of education it provides. For example, Egerton University was ranked the second best university in Kenya, according to the latest webometrics ranking done by 4 International Colleges and universities (4ICU, 2016). It is natural that when discussing ICTs and Higher Education Institutions, the focus should be on supporting this main goal.

Dodds (2007) argued that integrating technology in education could ensure constant access to education by transcending time and space; access to remote learning resources; improvement of the quality of education and training even with the availability of education to more people; improved learner motivation to learn; and enhanced teacher training. The major benefits of computers and computerization could be argued as providing speed and reliability. Dodds (2007) noted that technology introduces simple time saving tools and reliable infrastructure. The author further observed that contemporary research has moved away from individualistic approaches to research to international multidisciplinary research (Balasubramanian2009).

Through educational technology therefore, a university can tap into the research prowess of a myriad studies of a multidisciplinary nature drawn from elsewhere in the region, the continent, and the globe.

In Sub-Saharan Africa, mobile phones have become more common than computers (Aker & Mbiti, 2010). Ale and Chib (2011) argue that apart from enhancing technology literacy and familiarity, computer-based teaching could enhance research, innovation and encourage multidisciplinary teaching, which will in turn enhance levels of motivation in creation of new knowledge. Innovation is defined as the planned process of introducing change, intended to bring about improvements, solve, or alleviate some perceived problem (Klein & Knight, 2005). Chigona and Licker (2008), defined innovation as the effective implementation of a new or significantly improved idea, service, process, or practice that is intended to be useful. Christensen, (2011), defines innovation as a process, system, or modification that improves an existing product or system. It may make it better, bigger, more efficient, and/or more beneficial to the end user.

Kenya’s Vision 2030 recognized science, technology, and innovation as one of the drivers of socio-economic transformation. It specifically underscored the need to move to a knowledge-led economy (Republic of Kenya, 2007). Under the strategies for promoting science, technology and innovation, the blueprint, recognized the role of institutions of higher learning and the importance of their collaboration with industry. It also noted that indigenous technology remains unmapped and untapped. The failure to tap into our local capability including academic staff or innovation has seen most companies in Kenya importing software from Finland and other developed and developing countries, thus losing a lot of revenue to foreign firms. It further stated that in order to encourage innovation and scientific endeavors, a system of national recognition should be established to honor innovators (Republic of Kenya, 2007). The blueprint therefore clearly acknowledged the role of innovation and tapping into our local talents not just the youth but also the academic staff in achieving national development.

**Training and Support in Using Educational Technology and Resources for Teaching and Learning**

Training and support for use of educational technology in teaching and learning improves the confidence, effectiveness, and capabilities of academic staff. This would also provoke them to adopt better methods of teaching and learning using new technology. According to a survey done by Teaching and Learning International Survey (OECD 2015), approximately 60% of academic staff report moderate or high
development needs in Information and Communication Technology for teaching. A lack of initial teacher and learner training on how to use technology can lead to feeling unprepared on how to use it effectively in their teaching and learning practices. This also affects how they carry research in different fields, as they are not exposed to the diverse knowledge in their fields (Blackwall, 2013).

Evidence shows that the use of blended learning (online and face to face) in initial teaching and learning can lead to increased use of technology in the classroom (Foster, 2012). Masters et al (2012) found that online training for academic staff brought about better outcomes in the classroom for the learners they subsequently taught compared to other approaches. Urban-Woldron (2013) saw that prolonged use of blended learning for academic staff is more effective than one-off face to face teaching sessions at nurturing academic staff’ ability to integrate technology into research, and classroom. Abar and Barbesa (2001) asserts that use of educational technology enables academic staff to solve issues such as reviewing publications, papers, assignments, school organization and support material, which are essential in building new knowledge and giving quality services in an institution. Harris (2006) suggests that use of technology in teaching enables academic staff to plan their schedule well and network with both their colleagues and students faster and easier, which lessens their workload.

Overcoming Academic Staff Anxieties of Digital Teaching and Learner Centered Pedagogies
Characteristics of academic staff (anxiety, attitude and self-efficacy) are closely linked to academic staff’ satisfaction and engagement with technology. Organizational support such as training, technical and management are all important factors necessary in initiating academic staff into adopting innovation (Cheok & Wong 2015).

For effective and efficient use of digital tools and resources (including sharing knowledge across educational institutions), academic staff need to adapt their attitude to include the role of innovation and that to do so, they need guidance, space, and time to adapt to new methods. Reimann, et al., (2009) and Petko (2012) observed that computer and Internet applications are more often used by academic staff in the classroom when they consider themselves to be more competent in using Information Communications and Technology for teaching. Goodwyn (2009) supports this observation by arguing that academic staff that have a capacity to integrate educational technology into everyday learning, have a strong motivation to connect with their learners’ lives and have normalized digital technology in the classroom. However, for the most part they are self-taught. Those academic staff provide excellent role models for colleagues to adopt the use of education technology. Parette et al (2009) suggests that institutions need to provide more support by showing academic staff how they can integrate technology into the curriculum if it is to be used effectively.

Maintaining and Upgrading Compatible Equipment across many Systems
Financial resources can be a barrier to effective implementation and maintenance of technology infrastructure to support teaching and learning. Fredricksson (2009) and Goodwyn (2011) state that for sustainability to be seen, there is need for budgetary allocation for purchase of modern technologies and the maintenance of the existing infrastructure and upgrading both hardware and software.

CONCLUSIONS
A lot of focus in research has been in how students and institutions use technology to create new knowledge and innovation. Little has been done on how academic staff can adopt and adapt educational technology in research, development of new knowledge encouraging multidisciplinary approach to academic research improving teaching experience for the academic staff. There is also the need to understand theories that explain technology adoption in the African context as Active theory was more centered on dialectical materialism and socio-cultural influences in adopting educational technology. A limitation of the active theory in studying educational technology in the African context was that it employed a more aggregated approach whereas it focused on the larger systems more than the components that made up the system.

In order to realize effective implementation of technological innovations in a challenged and challenging environment such as the higher education institutions, there is need to address technology transfer. Institutional absorptive capacity, innovation framing, and the need for higher education institutions to move from a culture of technology adopting to one of technology generating would also be another issue. These concerns need to be addressed both internally
and externally by higher education institutions, donors, and the governments. On technology transfer, the higher educational institutions should be able to tap the capacity of the donors. The traditional perception was that higher educational institutions did the invention through their research and development initiatives and transferred the invention to industry. There is a need, however, for higher educational institutions to recognize that they could be recipients of their own inventions and innovations. This could reduce their dependency on external donors on new technology as they will be able to harness the untapped potential of their students and encourage innovation in different fields not just science technology engineering and mathematics. This will also enable high educational institutions to contribute in the achievement of the sustainable development goals.

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www.4icu.org/ke/
Environmental education continues to be a crucial component of curricula at all levels of education. Waste management remains a serious challenge in our communities and schools, which must be addressed in school and in extra curricula activities in order to reduce waste accumulation and its undesirable effect on human life. This paper describes a study that tested a model to stimulate the teaching and learning of Environmental Education (EE) in primary schools through development and trial of Pupil-Centred Approach Mind Map Exemplary Lesson Materials (PCAMM-ELM) focusing on waste management. The Wastes topic received diverse understandings among teachers. As a result, the teaching of waste management topics faces complex problems including poor waste knowledge among teachers, lack of relevant and stimulating learning materials and use of conventional teaching approaches. The three aspects are addressed intensively in this paper. The study adopted a quasi-experimental research design. The respondents were standard seven geography teachers and learners from two primary schools in Dodoma Municipality. The results disclose that the material and approach applied in intervention school influenced performance, motivation and interests of teachers and pupils. Secondly, there was a reasonable change in pre-test and posttest performance of learners between the control and treatment schools, whereby in treatment school mean score was significantly different when compared to the control school. The study concludes that learners and teachers’ motivation, performance and interests on practices of teaching and learning EE may be enhanced and adopted through use of the designed PCAMM-ELM accordingly. The study recommends further design, validation and development of local procedural EE lesson materials based on developing competences that update primary teachers’ pedagogical knowledge in order to build a user friendly community practices for sustainable environment.

The environment is continually experiencing challenges and problems which in turn affect the health of living things over the earth (Kimaryo, 2011; UNESCO, 1978 & Nordstrom, 2008). Studies show that despite natural calamities such as earthquakes, human beings of all ages play the largest role in bringing about problems and challenges, either knowingly or unknowingly. These problems are at local, national, regional and global levels (UNESCO, 1978). This situation makes environmental education (EE) to be a crucial curriculum component at all levels of education (Kashaigili, 2012; MoEC, 1995; Osaki, 1995 & Kimaryo, 2011). EE is an educative process that enhances peoples’ knowledge about their environment to develop responsible environmental behavior and skills for the purpose of improving the quality of the environment (UNESCO, 1978 & Nordstrom, 2008). For many years now, EE has been considered a cross-cutting issue in education in many countries (Kashaigili, 2012; MoEC, 1995 & Mtaita, 2007).

As it is in most local community primary schools, Tanzania experiences similar challenges like in other countries (Kashaigili, 2012; Kimaryo, 2011; Osaki, 1995 & OUT, 1998). Large class sizes and poor classroom evaluation systems are also observed to be the weaknesses in past Tanzanian studies. Daily activities such as sweeping of school surroundings and smoke from burning waste subject school environment to soil erosion, air pollution, degradation of the beauty of the environment endangering of human health (Kashaigili, 2012).
Waste is scattered everywhere we live, but the community pays little attention to it. Generally, we are the victims of our own unfriendly practices to the environment. Waste management (WM) remains a serious challenge in our community. Intentional efforts are needed to address it in school and in extra curricula activities in order to reduce waste accumulation, and its undesirable effects on the environment and human life. This research gap necessitated developing and testing a model to encourage teaching and learning of EE in primary schools through development of PCAMM-ELM; as a way to intervene pedagogically. Four research questions guided this study, namely:

1) How can exemplary EE lesson materials on waste management be organized to support the sequential teaching and learning of EE among learners in primary level Geography?
2) What form of waste management materials are practically feasible in normal primary school setting?
3) What change in learners’ performance is possible after learning by using the new WM material and approach?
4) How effective would the designed materials and approach be in enhancing learning and attitude change?

MATERIALS AND METHODS

This was a developmental research study (van den Akker, 1999) in which the pretest-posttest non-equivalent control group design (Wiersma, 2004) was used to compare outcomes of both the treatment school (school I) and the control school (school C) during implementation. The study had three stages namely: needs assessment, design and appraisal of the lesson material, piloting the material in semi controlled conditions and major field testing. The major field testing process included pretesting, implementation of PCAMM-ELM, and administration of posttest. Participants included 165; 2 standard seven teachers and 163 pupils who were purposely selected because it was a standard seven geography topic (MoEVT, 2005). Data collection was done through interviews to teachers and students, administering a questionnaire, observation of teaching and learning process, Test administration and reviewing relevant curriculum documents including the schemes of work, lesson plans and lesson notes with a focus on objectives, teaching methods and activities, teaching resources and assessment practices to determine if they reflected actual understanding, interpretation and EE practices of teachers were also done. The semi-structured interview process collected opinions, feelings, attitudes and implementation practices in the trial school. The observation protocol generated classroom interaction data from all lesson development stages. A pre-retest and posttest was administered to both the intervention and control schools in order to determine whether there was a change in pupils’ learning. The test comprised of six multiple choice items, six matching items and six short answer items. A semi-structured Likert scale questionnaire with six items and six open ended questions collected perceptions data from pupils in treatment school. Practicality of the designed material was determined by use of pictures. The data from questionnaire and the test were analyzed using descriptive statistics and independent sample t-test for significance of the means (pretest and posttest) between the school I and C. Qualitative data from semi-structured interviews were thematically analyzed. The permission to conduct the study was sought from responsible authorities and oral consent from parents whose pupils participated in the study via the office of the head teacher. The goal of the study was communicated to teachers in order to allow their willingness to take part in this study.

FINDINGS AND DISCUSSION

Question 1: How EE exemplary lesson materials on waste management for primary schools should be organized to support the sequential teaching and learning in Tanzanian primary level?

The findings are drawn from the context analysis and the design of the exemplary lesson materials. Using the interview with primary teachers, the results showed that teachers lacked EE knowledge and skills, procedural materials, insufficient time, pre-service and in-service training, and motivation. One teacher said,

“I fail to get EE message to communicate to my students from the syllabus; . . . there are no books. This makes it difficult in designing effective EE learning activities”.

Osaki (1995) and Kimaryo (2011) revealed similar situation to teachers. These results together with review of literature enabled us to formulate seven specifications and guidelines for the design of
PCAMM-ELM and formative evaluation of lesson prototypes in this study. The design guidelines were: EE learning objectives, learners’ active learning, content and pedagogical support, flexible and active learning environment, fit with the school timetable, alignment with the current curriculum and inquiry thinking. Design specifications focused on: lesson overview, intended learning objectives, preparation of the lesson, readings, subject matter, teaching strategies and learning assessment mode. Similarly, various studies design and use guidelines and specification in the design of educative exemplary materials (Kamugisha, 2013; Mafumiko, 2006 & Tilya, 2003). Design guidelines and specifications shaped the designing, development and implementation of PCAMM-ELM, the learning anticipated, and formative evaluation of lesson prototypes. According to Mutebi (2000), design guidelines and specifications are identified as the teaching practices and perform similar roles.

**Question 2:** Are the waste management materials practical in normal primary school setting?

This part evaluated practicality of PCAMM-ELM implementation in the classroom settings. It included study appraisals from the piloting, iteration and major field implementation. Through observation and interviewing teacher and pupils, the piloting results of five lessons indicated that lesson one and four spent extra time and lesson one was less interactive. This feedback enabled to reorganize by splitting lesson one and four into two, hence seven lessons as a way to maximize the lesson time. Seven lessons included:

- the conception of wastes, types of wastes, sources of wastes, effects of wastes, conception of WM, waste separation and its importance and strategic techniques of WM (4Rs).

Pupils were observed to enjoy the lessons, showed competence, were interactive and presented well in group activities as they moved experience from lesson one to five. Teaching and learning based on PCAMM-ELM integrated teachers and pupils prior EE experiences that among them developed discussions, curiosity, hands-on activities, motivation, collaboration in learning, link of community/school WM practices and the theory. These indicators made teachers and pupils like the material and approach. All the changes were accommodated in order to allow the iteration process. The iteration of PCAMM-ELM aimed to settle challenges likely to hinder the implementation including ownership issues. After a week of iteration exercise, the teacher and some pupils were interviewed. Both the teacher and pupils said that the material has reasonable coverage of content, clear layout, enough learning activities, helpful to teachers and pupils, and environmentally friendly lessons. The teacher claimed that time allocated in project work was short and suggested use of questions and answers to replace school surrounding visits due to limited time. The teacher said:

‘I suggest using question and answers in place of a visit around the school and group presentation. If changes accepted, lesson coverage will comply with the time’.

The PCAMM-ELM was validated by incorporating inputs from the iteration in order to get the final prototype for the major field.

The major field implementation engaged the treatment school (school I) and control school (school C) distanced from each other for about thirty kilometers. The PCAMM-ELM was implemented in school I, and school C carried normal teaching in the same topic. The sequence started with the pretest, then PCAMM-ELM implementation, and lastly posttest administration.

**Pre-test in School I and C: Administration and Results**

Administration of pretest was conducted by the researcher, research assistant and classroom teachers in the same day in order to get the comparable pupils’ entry abilities in the aspect of WM. The pretest mean scores results of between school I and C were M=29.09 (SD= 11.27; N=102) and M=27.23 (SD=12.66; N=61) respectively and statistical testing at t (95) was 0.973, p-value of 0.332. Having slight difference in mean scores and p-value of 0.332 >0.05 level of significance implied that the effect was not statistically significant. The results concur with the argument of Wiserma & Jurs (2004) that p> 0.05 level of significance indicates that the effect obtained is not statistically significant, therefore similar pupils’ entry abilities. Likewise, procedural and results in this study correspond with that employed in studies by Mpama (2011) and William (2006), and results disagree with Kamugisha (2010).
Classroom implementation of PCAMM-ELM sequentially started lesson one to seven. Lessons included a range of WM engaging activities that gave pupils opportunities to integrate their experiences, make presentations, project work, small groups and visiting the school to record focused things. The results from observation and interview to pupils and teachers revealed a diverse interactive learning that pupils felt free learn, sought EE first-hand information, developed critics and sharing of ideas or experiences (see plate 1). Pupils' increased interest on lessons, built cooperating spirit and analytical and problem-solving skills to act ethically to the environment.

Plate 1: Pupils are discussing in their groups

These findings concur with those of Kamugisha (2010), Mafumiko (2006) and William (2009) who argue that use of learner centered approach greater roles to learners than the teacher. Similarly, Tilya and Mafumiko (2010) advocate that learner centered approach help pupils learn how to learn and opportunities to work together in constructing knowledge. Kyriacou (2009) argues effective small group work creates a reasonable climate for a sense of security and self-confidence; and an optimum opportunity for learners to talk reflectively with each other. However, in lesson seven the pupils felt that there was insufficient time for discussions; an aspect that also was experienced in studies by Kamugisha (2010) and William (2009) who claim it when new teaching approach is used for the first time and in discussions of group work activities.

Following use of learner centred approach, pupils’ freedom and integration of their experiences; two innovations emerged: making charcoal out of waste paper and welcome of waste collector.

Making of charcoal emerged from the pupil’s response as a way of recycling waste paper scattered in the local environment. The researcher’s question wanted pupils to mention types of waste likely to be recycled or recovered from our environment. As the slogan that learning has no end, the pupil had to present how waste paper results into charcoal. The pupil demonstrated competence, confidence, courage and preciseness in presenting, answering questions and elaborating the process. Plate 2, 3, and 4 show the pupil’s presentation.

Plate 2: Pupil presentation. Plate 3: Drying charcoal Plate 4: Burning the charcoal

The presentation addressed the required resources, procedures, precautions and advantages. Resources included waste papers, buckets/tins/dishes, water and socks. Procedures: 1) collect waste paper; 2) tear waste papers into small pieces; 3) put small pieced papers in the bucket/dish/tin; 4) wet pieced papers in the dish of water (wait for three days), 5) scratch watered pieced papers until it turns into porridge like; 6) squeeze the porridge-like papers into socks; 7) take out oval shape squeezed papers in any dry surface; 8) wait for at least 4 days to dry and 9) start using the ‘charcoal’. Precautions: 1) the place must be free from water and/or humidity, 2) if bags like open cement are used to dry oval shaped papers, leave them open, and 3) the finest porridge-like produces high quality charcoal and the vice versa is true. Advantages: 1) It saves the cost of buying kerosene or making charcoal from trees 2) It
is environmental friendly-no smokes that pollute the environment; 3) too economical as it generates money by selling the product; 4) the charcoals burn slowly and therefore saves energy where a slow cooking food stuff is on the cooker, 5) they are waste paper produced products from in our surrounding that dirty the environment, and 6) the process is so easy to manage.

Teachers and pupils were involved in touching and smelling the charcoal, asking questions and elaboration, observing the process as well as watching the burning of charcoal that also revealed their inquisitiveness. Two questions among many asked by teachers were: ‘Is this type of charcoal able to cook food for a long time? Can it be extinguished by using water?’ The pupil responded that the charcoal burns slowly, is good for cooking foods that required longer time to cook and once extinguished by water it cannot be used again. This innovation left the teachers blaming traditional teaching and that most things are unfolded by thinking that pupils are not innovative.

These are some quotes:
‘…our pupils know things we don’t know. I could not expect a pupil in our school and my class who are knowledgeable as I saw one girl demonstrating…teachers think pupils are unable’ [Interview (20/4/2012, Teacher B)].

Another teacher said;
‘…I did not expect to see oval made charcoal burning but I have witnessed it…I have learnt a new thing and experience in my life from one of my pupil I teach’ [Interview, (20/4/2012, Teacher C)].

The results corroborate those of Evans, et al (1996) and Palmberg (1996) that pupils’ knowledge influence positively parent environmental performance. Likewise the school is part of the community (Kimaryo, 2011), therefore primary pupils can act as social change agents in the home and in community (Uzzell, et al., 1994).

In lesson six ‘waste separation’, the researcher welcomed a guest ‘waste collector’ in order to share experiences. Through the guest presentation, an average of 40 kilograms of disposed plastic and metal materials is collected every a day. A kilogram of plastic bottles in the factory costs Tsh 300 and the metal materials cost Tsh 400. Plate 4 shows the presentation of the guest.

Plate 4: Guest presentation

Both the pupils and subject teacher appreciated the presentation and noted various strategies of sustaining the environment. However, the pupils found that the guest earns Tsh 360,000 per month (for plastic bottles) and tsh 480,000 (for metal materials); the entrepreneurship skills in activities that conserve the environment.

Pupils’ Project Presentations
Five groups of pupils presented projects precisely sourced from the market, shops, bus stand, hospital and school. The project work aimed to develop skills such as observation, investigation, interview, recording and report writing, problem solving and analysis of EE issues at their early age. The results revealed that project reports were logical and argumentative, high pupils’ participation irrespective of gender and the spirit of collaboration in a friendly way. Kimaryo (2011) asserts that pupils generate knowledge and various skills when they are exposed into carrying out investigations, which are important in the sustenance of the environment. Plate 5 shows a pupil presenting a project.

Question 3: Is there any change in learner’s performance after learning by PCAMM-ELM?
The results revealed that the mean scores of pre-test between school I and C were M=29.09 (SD= 11.27; N=102) and M=27.23 (SD=12.66; N=61) respectively and statistical testing using an independent sample test at t (95) was 0.973, p-value of 0.332. When the posttest was administered, the mean score results of school I became M=58.41 (SD=17.52; N=102) and school C was M=40.79 (SD=11.11; N=61). The results indicated both
schools increased the mean scores in a varied
deviation when posttest was compared to pretest.
An independent sample test was applied. At the
significance test, the t(95) was 0, p value of 0.332
which implied the significance difference. The
results concur with that of previous researchers,
namely Kamugisha (2010), Mpama (2011) who
found tremendous rise in mean scores and
significance difference between the treatment and
control schools.

**Question 4: What are learners' perceptions on the
effectiveness of the PCAMM-ELM?**
The results on the participants’ perceptions with
PCAMM-ELM indicated that almost all aspects
were rated positively. Some of these aspects
included the logical approach, linkage of theory
with practice; integrating local environmental
experiences in learning and teaching curiosity under
the new approach. Others were freedom of sharing
and participating in discussions. The results concur
with those of Kafanabo (2006) and William (2009)
that students became interested and the learning
was made easy due to activity-based materials. The
questionnaire showed that learning through small
groups, project activities, and presentation of
group’s ideas before the class, activity-work based
such as transforming waste paper into charcoals,
freedom in classroom lesson activities, close and
collaborative interaction among themselves was
very promising. This agrees with Osaki (1999; 2000), Oser (1986) and several others who
discourage use of traditional teaching because it
involves pupils less and is less stimulating and
motivating.

**CONCLUSION**

This study demonstrates that exposing pupils to
new ideas, procedural resources, appropriate
teaching methods and opportunities not only
updates their understanding but also broadens
responsiveness for them and encourages change of
behavior and attitudes. Adherence to these aspects
leads to freedom in learning; interactivity develops
thinking and skills of conserving the environment.
With PCAMM-ELM, teachers and pupils became
empowered to change their practices of teaching
and learning in their classrooms and social agent of
EE issues in the community. The study recommends encouragement of more primary
teachers to try out this approach in EE related
topics. It also encourages curriculum developers to
design, validate and develop procedural lesson
materials and update teachers’ pedagogical
knowledge through in-service and pre-service
training. It also suggests that similar studies
involving several intervention and control schools
(urban, rural, religious, private, government) can be
conducted to determine whether they would get
results comparable to the present study.

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however, those of the researcher.

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IMPACT OF TECHNOLOGICALLY ENHANCED LANGUAGE LEARNING ON LEARNER ACHIEVEMENT IN WRITING SKILLS-A CASE STUDY OF NAKURU COUNTY

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ABSTRACT

The use of ICT in learning language has been observed to have positive impact on learner performance in language skills, as well as enhanced learner retention capabilities. Consequently, there has been a global trend geared towards introducing this technology in classrooms. In this regard, the Kenya Institute of Curriculum Development has developed English classroom technology material with the aim of improving learner outcomes. However, the impact of this material on learner outcomes has not been determined. The purpose of this study, therefore, was to determine impact of introduction of ICT on learner achievement in English language writing in Kenyan secondary schools. The study was conducted among Form 2 students in four selected secondary schools in Nakuru County through administering writing tests. The study used Randomized Control Trial (RCT) approach, through the pre-test-post-test method. The impact of ICT on students’ achievement was estimated using Difference in Differences (DD) technique, t-tests and effect size to test for differences in the means of the scores of the two groups. The DD resulted in a value of 12.45% in favour of the experimental schools, with a t-test score of 2.86 and a p-value of 0.05. Effect size was estimated at 0.36. The results showed that the use of technology has a positive impact on enhancing learner language writing skills. It is, therefore, recommended that the government significantly improves the current classroom ICT situation in Kenyan classrooms in order that learners may fully benefit from the education they receive.

Key words: education, classroom technology, impact evaluation, achievement, Randomised Control Trials.

INTRODUCTION

The government of Kenya, in its Jubilee Party Manifesto, and in The National ICT Master-plan introduced in 2014, focused on improving the learning experiences of both primary and secondary school students through the introduction of laptops in two stages; first at the primary level, then the secondary level. This move has been informed by global trends, government policy and the Vision 2030 development plan.

Global trends include the Millennium Development Goals (MDGs), among which is a provision for universal achievement of primary education; the Education For All (EFA) project, which is focused on the provision of quality education for all; and the United Nations Literacy Decade (UNLD), which also places emphasis on the quality of learning, both what students learn and how they learn it (UNESCO, 2008).

In policy implementation, one issue that was highlighted on the agenda on the manifesto of the current government was the implementation of a new technologically-enhanced learning programme through the introduction of laptops for primary schools. While the programme is yet to fully take off at the time of the study, it is still high on the government’s agenda, and has been piloted (Gacicio, 2014).

This is also supported by the enactment of the Kenya Institute of Curriculum Development (KICD) Act of 2013; and the adoption of the Vision 2030 development plan. The KICD was mandated with the responsibility of being in charge of curriculum development. One of its key responsibilities, as stated in the act, is to ‘develop, disseminate and transmit programmes and curriculum support materials through mass media, electronic learning, distance learning and any other mode of delivering education and training programmes and materials’.

The Vision 2030 is a development plan that is set to transform Kenya into a middle-income country with a high quality of life by the year 2030. To this end, the government identified three key pillars; social,
Technologically enhanced learning has been greatly employed in other countries. In Asia, for example, the use of technology in teaching and learning has been of great importance, specifically in the teaching of foreign languages such as English in China (Hu, 2002). Hussain et al. (2010) conducted a study on the impact of ICT in English language learning in Pakistan and found that the learners performed better when they were instructed in a technology based learning environment, and that technology was central to the learners’ development of their abilities of knowledge, comprehension and application. In the United States, studies have shown that the role of technology in learning has also been directly linked to learner achievement.

In Africa, and more specifically in Kenya, the use of such technology has not been fully embraced, as a result of various challenges that face implementation of such programmes (Evoh, 2007). This has contributed to a lack of information on what impact technologically enhanced learning could have on learner achievement, and specifically, technologically enhanced language learning (TELL) in English language writing skills. This, therefore, creates a need to fill this knowledge gap.

The history of TELL has grown from the 1960s and 1970s with the use of language labs, in which there were booths, each providing a cassette deck, and accompanying microphone and headphone. Teachers monitored their students' interactions by using a central control panel (Zamani, 2014). The basic premise behind this technology was that if verbal behaviour was modelled, and then reinforced, students would quickly learn the language in question (Alexander, 2007). Presently, there are a variety of computer applications available including vocabulary, grammar, and pronunciation tutors, spell checkers, electronic workbooks, writing and reading programs, as well as various authoring packages to allow instructors to create their own exercises to supplement existing language courses (Gündüz, 2005).

As concerning the effectiveness of TELL on learner achievement, multiple studies have confirmed that TELL indeed enhances learner achievement in language skills, both input and output language skills. Mdlongwa (2009) lists the perceived benefits for the student as: increased motivation; increased active participation and creativity; improvement in knowledge and skills; increased responsibility and self-esteem; and increased collaboration. Carr et al., (2011) found that increased use of TELL in language learning was helpful in increasing the students’ confidence in acquiring speaking skills for the new language, through increased interactive speaking and writing exercises that the introduction of ICT offered. Balanskat and Blamire (2006) point out that there was significant evidence of the benefits and advantages that the use of TELL had on students as; increased student motivation and therefore, enhancement of the student’s personal commitment and engagement; enhanced independent learning. Ramirez (2012) also notes that the use of TELL contributes to enhanced collaboration and communication among the students, through the use of communication technologies; and lastly, there would be an improvement in student attainment and outcomes.

**PURPOSE OF THE STUDY**

The purpose of this study was to conduct a prospective impact evaluation of the implementation of technologically enhanced learning on learner achievement in English language writing skills.

**METHODOLOGY**

The study used the mixed method approach, as it employed a combination of a case study and an experimental template. An experimental template design refers to how participants are allocated to the different conditions in an experiment (McLeod, 2007). For this study, the type of experimental template used was the Randomized Control Trial (RCT), specifically through the use of pre-test-post-test method. It was appropriate because the aim was to compare the achievements of the experimental groups with those of the control groups. The research design specifically employed the dynamic comparison.

Data collection was through the use of pre-test-post-test method. This was through giving English language writing tests to both the test and control groups before and after the intervention, to determine the impact of the intervention on learner writing skills. A
questionnaire was administered at the end of the study to determine the impact of technologically enhanced language learning on learner motivation.

The data were analysed using both quantitative and qualitative methods. Quantitative data collected from the tests involved the use of Difference-in-difference (DD) technique, to determine the effect of the use of technology in language learning. The data analysis also used t-tests, an inferential statistical procedure used to determine if there was any significant difference between the means of the two groups, the test group and the control group. Hypotheses were tested at 5% level of significance using the SPSS software. The measure of in the difference between the effects of the two independent variables on learner achievement was determined through computation of the effect size, using the Cohen’s d formula.

RESULTS AND DISCUSSION

Difference in Difference Analysis of Impact of ICT on Learner Achievement in Writing Skills

The study first undertook a difference in difference analysis to determine the prospective impact of ICT on learner achievement in writing skills. This was done through giving a similar writing test to both the experimental and control groups at the beginning of the study, known as the pre-test. After giving the test, the scores achieved by the learners were recorded in both the test and control schools, and the average scores for each group determined. The two groups were then re-tested with the same concepts on writing skills as they had been tested before, with a similar writing test given to both the test and control groups, known as the post-test. The average difference-in-difference score was calculated by finding the difference in performance in the experimental group, and subtracting the difference in performance in the control group school. This meant subtracting each group’s average pre-test score from its average post-test score, and finding the difference between the two differences attained. The procedure was as indicated in the Table 1.

<table>
<thead>
<tr>
<th></th>
<th>experimental School Group</th>
<th>Control Group</th>
<th>School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Post-test writing score (%)</td>
<td>48.0741</td>
<td>44.0756</td>
<td></td>
</tr>
</tbody>
</table>

The experimental school group attained a pre-post difference of 16.9630%, while the control school group attained a pre-post difference of 4.5042%. With both differences attained, it was now possible to determine the average difference-in-differences score, which was done by subtracting the pre-post difference of the control group from the pre-post difference of the test group. The result was an average difference-in-differences value of 12.4588%.

This result pointed to the fact that the experimental group performed better than the control group. The difference-in-differences analysis performed above indicated that there was a significant positive difference in impact of ICT on writing skills in favour of those who used ICT in learning when compared to those who only used the traditional textbook method. However, this did not give the significance of the difference, which was therefore determined by use of the independent t-test.

Independent T-Test Analysis of Significance in Difference in Achievement in Writing Skills

In order to determine the significance of the difference in achievement of both the test school groups and the control groups, an independent t-test was carried out on the hypothesis; There is no statistically significant difference in achievement in English language writing skills between students taught using ICT and those not taught using ICT. The independent t-test is a statistical procedure that is carried out with the aim of finding the significance in difference between the average scores of two groups.

The hypothesis, There is no statistically significant difference in achievement in English language writing skills between students taught using ICT and those not taught using ICT, was tested for significance at 0.05 level of significance.

The values attained after the independent t-test procedure are as shown in the table2 below:
Table 2: Output of Independent t-test for measuring significance in difference in achievement in writing skills

<table>
<thead>
<tr>
<th>Equal variances</th>
<th>F</th>
<th>Sig.</th>
<th>T</th>
<th>Df</th>
<th>Sig. (2-tailed)</th>
<th>Mean Difference</th>
<th>Std. Error Difference</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>posttest writing</td>
<td>Assumed</td>
<td>.223</td>
<td>.637</td>
<td>2.86</td>
<td>252</td>
<td>.005</td>
<td>3.9984</td>
<td>1.3959</td>
</tr>
<tr>
<td></td>
<td>not assumed</td>
<td>2.86</td>
<td>249</td>
<td>4</td>
<td>.004</td>
<td>3.9984</td>
<td>1.3940</td>
<td>1.2527</td>
</tr>
</tbody>
</table>

Table 2 provides the results of the actual t-test, with the values of significance.

The independent t-test produced a value of t=2.864 with a p-value of p= 0.05; which indicated that there was a significance in difference in performance between the students who used TELL in learning writing skills and those who did not use TELL, as indicated by the p value. It also indicated that there was a positive difference in achievement between them, as shown by the positive t-value, in that those who used TELL in acquiring writing skills performed better than those who did not use it.

The score of the p-value was at p= 0.05, which was at the hypothesis testing threshold of0.05. There was, therefore, sufficient evidence to reject the null hypothesis that; there is no statistically significant difference in achievement in English language writing skills between students taught using TELL and those not taught using TELL; and accept the alternate hypothesis that, there is a statistically significant difference in achievement in English language writing skills between students taught using TELL and those not taught using TELL. Even though the t-test gave the measure of significance of the difference in learner achievement in reading skills between the two groups, it did not give a measure of the size of the effect of the impact of TELL-enhanced language learning on learner achievement in writing skills. To determine this, the calculation of the Cohen’s d value for effect size was employed.

Effect Size Analysis of Significance of Prospective Impact of Technologically Enhanced Language Learning on Writing Skills

While the difference-in-differences provided a reliable estimate of the impact of technologically enhanced language learning on writing skills, and the t-test measured the significance, the effect size was used to determine how much on an effect technologically enhanced language learning had on writing skills. This was determined by calculating the Cohen’s d value based on the respective average post-test writing skills scores for both the test and control groups.

This resulted in an effect size value of d =0.36, which was classified as an large effect, as it was above the Cohen’s effect size arbitrary value of 0.2 to 0.5 for a large effect. With this result, it was necessary to reject the null hypothesis for the study that stated “there is no statistically significant difference in achievement in English language writing skills between students taught using ICT and those not taught using ICT”, and accept the alternate hypothesis that “there is a statistically significant difference in achievement in English language writing skills between students taught using ICT and those not taught using ICT”.

These study findings are in agreement with various other study findings that have been conducted before to determine whether the use of technology in language learning results in significant differences between learners who learnt writing skills using technology and those that did not. For instance, a study conducted by Tri and Nguyen (2014) observed that the use of classroom technology in learning resulted in a
significant increase in performance in writing skills tests over those that did not. Spieza (2010) also found that the use of technology improved student achievement in the classroom; in that the frequency of exposure to classroom technology was directly proportional to the learners’ level of achievement. While achievement was significant for those in technologically improved environments, it was also noted that the use of such classroom technology improved the learners’ retention capabilities (Ramirez, 2012). Sandolo (2010) also found that, through the use of technology in learning English language skills, learners were more motivated to learn, and that proficiency in writing was developed through technology because of instant feedback.

These study findings, taken into consideration alongside the study findings of the current study, work towards supporting the adoption of the alternate hypothesis for this study, that there is a significant difference in achievement in writing skills between learners taught using technologically enhanced language learning and those not taught using technologically enhanced language learning.

CONCLUSIONS

The objective of this study was to determine the prospective impact of technologically enhanced language learning on learner achievement in writing skills. The study therefore tested the null hypothesis that, there is no significant difference in achievement in English writing skills between learners taught using technologically enhanced language learning and those not taught with technologically enhanced language learning. The hypothesis was tested among secondary school English language learners in Nakuru County in four schools. The first measure used was the difference-in-differences, which was used to determine the reliable measure of difference between learners who learnt writing skills using technologically enhanced language learning and those who did not. This determined the difference in differences score at 0.7082, which indicated that the experiment group performed better than the control group. The study also used the independent t-test, which was used to determine the measure of the significance of the difference in performance between the experimental and the control groups.

This resulted in a t value of t=12.807, which also resulted in a p value of p=.000, which was less than the 0.05 threshold for accepting the null hypothesis. The t-test, therefore, indicated that there was sufficient evidence to reject the null hypothesis, H0, that there is no significant difference in achievement in English writing skills between learners taught using technologically enhanced language learning and those not taught with technologically enhanced language learning; and accept the alternate hypothesis, H1, that there was a significant difference in achievement in English writing skills between learners taught using technologically enhanced language learning and those not taught with technologically enhanced language learning.

In order to also determine the magnitude of the impact that technologically enhanced language learning had on learner achievement in English language writing skills, the study made use of the effect size, using the Cohen’s d method. This resulted in a value of 1.60, which, according to Cohen’s criteria, is quantified as a large effect.

With these statistical procedures, the null hypothesis, H0, that there is no significant difference in achievement in English writing skills between learners taught using technologically enhanced language learning and those not taught with technologically enhanced language learning; was rejected. Instead, the alternate hypothesis, H1, that there was a significant difference in achievement in English writing skills between learners taught using technologically enhanced language learning and those not taught with technologically enhanced language learning, was accepted.

From this study, it was concluded that the use of TELL in learning English language writing skills led to better performance in the writing skills than learning English language writing skills without the use of TELL. This implied that, in order to improve learners’ English language writing skills, the use of TELL in teaching will be more beneficial to the learners’ achievement than the sole use of traditional textbook met

RECOMMENDATIONS

Based on the results of this study, the following recommendations are therefore proposed:

i. The government of Kenya should ensure that schools have achieved threshold minimum ICT infrastructure capabilities before the introduction of technologically enhanced learning. This will involve conducting an ICT-preparedness in the schools to determine the ICT infrastructure
capability levels of Kenyan secondary schools. It will also be helpful in determining the level of ICT preparedness of Kenyan teachers for ICT-based learning. This will ensure that technologically enhanced learning has a stable and reliable platform from which it can be efficiently implemented, in order to achieve optimum effectiveness.

ii. The government should also ensure that teacher training significantly involves educational and classroom ICT training. This will be essential in helping teachers employ classroom ICT infrastructure effectively, as well as enabling them to prepare adequately for their classes.

iii. The government, in conjunction with educational content developers, educational ICT experts and teachers, should work towards developing learner-relevant classroom ICT content for subjects taught in schools. This will work towards increasing the uptake and interest of ICT-based learning among learners, with the main objective of enhancing motivation to learn, and therefore increasing effectiveness of technologically enhanced learning.

iv. As key stakeholders in education, guardians of the learners should be sensitised on the features and importance of technologically enhanced learning, that they may have an understanding of what the learners are exposed to in the learning process.

v. It is also imperative that the learners, who are the main raison d’être for technologically enhanced learning, be sensitised on the potential introduction of technologically enhanced learning, and also be sufficiently prepared for it. This will be essential in helping them fully understand what is expected of them with the introduction of technologically enhanced learning.

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EDUCATIONAL PLANNING AND PRACTICES IN KENYA

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ABSTRACT

Education plays a key role in reducing poverty and enhancing life choices. Therefore provision of increased education and training opportunities has been a long-standing objective of the Government of Kenya. Since Independence, the Government has sought to address the challenges facing the education sector through a range of policy initiatives. Nevertheless, a major focus has been the attainment of Universal Primary Education and the need for achieving greater access, participation, equity, quality and relevance. However, at the beginning of the 21st century, the country has been faced with new challenges for educational policy, which incorporate both the right to universal access to education, and the need to enhance rapidly the development of skilled human resources. This is despite the government efforts to bring in major transformations with more than ten reviews by special education commissions and working parties having been established since independence. Moreover, increased public demand for education and training over the years has strained the government efforts in achieving its goal, and in response partnerships have been intensified with parents and communities, individual investors, civil society and donors so as to salvage the emerging challenges facing the education sector as it grows. On the contrary, there is continued evidence of disarray of business in the education system in Kenya today and so, at all levels the pressing challenge of how to improve quality, enhance efficiency and at the same time reduce unit costs must be addressed. This paper therefore seeks to explore and address the constraints facing educational planning right from basic to higher education, and how these constraints can be resolved so as to create a long-term solution to the problems that are putting education for the Kenyan child at stake.

Key Words: Educational planning, Practices, Challenges, Constraints, Way forward, Kenya, Universal Primary Education, Education Commission.

INTRODUCTION

Educational planning, in its sense, is the application of rational and systematic analysis to the process of educational development with the aim of making education more effective and efficient in responding to the needs and goals of its students and society (Coombs, 1970). Educational planning involves a qualitative and quantitative continuous process, concerned not only with where to go but with how to get there and by what means. It deals with the future outlook basing on the past. Its work does not cease when a plan gets on paper and has won approval, but continues until it is fully implemented. For planning to be effective, it must be concerned with its own implementation, progress made and unforeseen obstacles that may arise and how to overcome them. The planning process includes not only a projection of the development of the economy over the next few years, but also resource plans for the spending departments and the costing and revision of plans (Atkinson 1983). Planning is therefore an integral part of the whole process of educational management, defined in the broadest sense. It can help the decision-makers at all levels; from classroom teachers to national ministers and parliaments to make well informed decisions. It can do this by helping them see more clearly the specific objectives in question, the various options that are available for pursuing these objectives, and the likely implications of each. Planning can help to attain larger and better aggregate results within the limits of available resources. To achieve such benefits, however, planning must use a wide spectrum through which many interacting variables can be put in focus and all of them seen as part of the plan. Therefore it is important that before recommending any one course of action, planners must first see what room the decision-makers have as part of their plan. They must look, for instance, at the state of the society, where it wants to go, and what it will require to get there, the nature of the students, their needs and aspirations.
In most developing countries like Kenya, education planners experience challenges derived from the rapid expansion of the education system such as over enrolment, low quality education, inadequate funding and other resources due to either parents’ unwillingness to cooperate or the fact that they are too poor to raise money (Republic of Kenya, 2005). One of the central tasks of educational planning therefore is to try to keep the internal and external forces in the educational system at balance under dynamically changing circumstances and with assistance from all education stakeholders. That is, the process of planning, organizing, directing and controlling needs to be considered and executed expeditiously, if at all long term plans are formulated for future development. Otherwise, planning may not result into the expected results. This paper therefore seeks to explore the challenges that education planners face in the course of planning for the needs and requirements of the education system in the developing world.

BACKGROUND OF EDUCATIONAL PLANNING
Educational planning has its origins to ancient times. Here are some of the examples of early educational planning in linking a society’s educational system to its goals. Spartans for instance, 2,500 years ago, planned their education to fit their well defined military needs, social and economic objectives. Plato during his reign in Athens, planned education that would suit the political and leadership needs. In China during the Han Dynasties and Peru of the Incas planned their education to fit their particular public purposes. Planning has been modified over time so as to fit in changing goals and expectations of the society (Coombs, 1970). These historical examples of educational planning cited above however differed in the extent, objectives and complexity. Some were applicable to entire nations, others to individual institutions; some undoubtedly were far more effective than others; some were fragmented, others involved a continuous process over a long period; some were in a highly strict settings, others in a more democratic environments. They all had something to teach, but did not have all the features that could be seen in a modern educational planning. For instance due to existence of more educational institutions following increased enrolment, planners have had to estimate how many students there would be, how many classrooms, teachers, desks and books would be needed to serve them adequately, the curriculum needs and methods of instruction as well as the appropriate examination system, how much money all this would require, where the money would come from, and how and when it would be spent. These various projections led to budgetary proposals for future academic calendars and eventually ended in a chain of decisions and actions. This is educational planning that needed efforts of competent planners. As educational institutions and systems grew larger and multifaceted, and as the budgetary proposals became more official, planning processes also had to acquire formality so as to provide for the stability and feasibility of established educational policies which would lead to further improvement in education. Therefore the main focus of planning was not only based on the technicalities and logistics of education, but on the needs of the students and society, as is currently evident in the goals and aims of an education system.

Educational Planning in Kenya
The kind of educational planning that was done in Kenya prior to independence had these four key features:
(a) It was short-term, except when new programs had to be incorporated so that facilities had to be expanded in which case the planning had to be projected further. (b) It was fragmented in that various parts of the education system were planned independently of one another.
(c) It did not integrate the evolving needs and trends of the society.
(d) It was not dynamic to changing educational forms.

But since independence up to date, planning has been done with incorporation of various education review commissions such as the Ominde Commission in (1964), Gachathi Commission (1976), Mackay Commission (1981) and the later Koech Commission. The government also launched the Kenya Education Sector Support Program (KESSP) in 2005 which advocated for a shift from project planning of education to program planning and implementation. The plan describes how education provision across all sectors and nationwide would be planned, financed, managed, implemented and evaluated over the five years (KESSP 2005). The Ministry of Education, Science and Technology’s strategic plan for 2005 to 2010 is among other economic strategies put in place by the government so as to help in implementing the education policies put under plan.

Challenges in Planning Supply of Teachers
Experience in the 1950s and 1960s showed how critically the teacher supply planning was at mercy of changes which likely occurred in the rate at which teachers left the profession and future wastage rates which were powerfully influenced by demographic or economic factors and could not be predicted but had immediate effects on education sector. The wastage rates were further influenced by unpredicted retirement rates and high rate of teachers leaving school due to ill health or death. Moreover, teacher planning is affected by the time lags in training and absorbing teachers at various levels in the developing countries. In Kenya for instance, primary school teachers take a minimum of two years to be trained and upon completion, they take some time before they are employed by the government. This is unfairly in line with the increasing enrollments and student needs, hence putting the quality of education at stake. But if the time lags for training were reduced, then it would make work easier for education planners in terms of planning for the teacher capacity versus the enrollment over a long period of time (Zabalza et al 1979). Moreover, the teacher-student ratio in special units and schools which have adopted inclusive education is often too high, while the dropout rate for children with disabilities is high just because there are inadequate teachers and even the few who are available are not sensitive to the needs of this kind of learners. Sometimes it is a common feature that teachers and other staff within the school, ignorantly use inappropriate language in reference to disability and this erode self esteem and a sense of worth in students with special disabilities. What does this imply for an education planner? Those teachers are not adequately trained to handle the various kinds of learners in a school learning environment (Republic of Kenya, 2005).

Crowther, (1976), in his studies further found that since the variation in birth rate is obvious especially in developing countries, this leads to population movement between areas, especially to urban areas, and hence more teachers would be required in towns while in declining areas there may be a surplus. Some teachers just like other workers may not find it easy to move, this results into regional variations, thus causing considerable problems both to planners and teachers. Studies highlight a number of challenges facing teacher recruitment and retention in schools across developing countries, which include inadequacies in teacher preparation programs, high teacher attrition rates, difficulties in training teachers in some areas and lack of adequate teachers in specified subjects such as Mathematics and Sciences (World Bank, 2007). It is important to note that the achievement of Millennium Development Goals and Education for All goals in education cannot be realized without numbers of properly trained, qualified and motivated teachers. The quality of trained teachers both in the developing and developed world are becoming the hardest segment of the teaching segment of the teaching profession to attract and retain and is most expensive to achieve (World Bank 2005). Research also indicates that there is extensive employment of under qualified teachers and also teachers on contract in most developing countries (United Nation Educational, Scientific and Cultural Organizations, UNESCO 2006). This is further clarified by the current employment of teachers on contract in Kenyan secondary and primary schools, at the expense of over enrolment of students. This has put the quality of education output at stake. In most developing countries, the governments are providing teachers for adult education and continuing schools and are trying to boost post literacy curriculum for those who wish to re-enter the formal system of education. This is in an effort to enhance adult literacy. In Kenya such efforts have brought the current literacy level to about 74%. However, according to the recent National Adult Literacy Survey, about 7.8 million adults are still illiterate, due to low participation and access to adult education programs, attributed to inadequate number of trained teachers, lack of teaching and learning materials, gender inappropriate teaching methods and poverty related issues (Republic of Kenya, 2011).

Unjust Education Policies
Gender mainstreaming and special education has not been properly addressed in most developing countries. Issues such as gender insensitive school learning environment, sexual harassment and gender biasness have been reported in most cases. Inadequate school infrastructure such as water and sanitation, lack of sanitary towels for girls, lack of positive role models especially women teachers in Science, Mathematics and Technical subjects and demand for primary, secondary and tertiary education which is high especially since the adoption of Education for All goals, Free Primary Education and Free Secondary Education, against the existing facilities and resources, result in issues of quality that affect girls much more than boys (Republic of Kenya, 2007). Despite the efforts by education stakeholders in most developing countries to enhance growth in special education sub-sector, this expansion has been limited in most cases. This clearly demonstrates that special education has
not received special attention in most countries. This is coupled up with negative attitude from the communities and societies, and the cultural disadvantage and societal stigmatization suffered by people with special needs. In addition, career stereotyping restricts people with disabilities to traditional oriented careers, discouraging them from venturing into more lucrative professional fields like engineering, architecture and medicine (Summers, 1992).

**Curriculum Development**

Most text books and other teaching and learning materials used in schools do not address the plight of learners with special needs, especially in illustrations and contextual representations. This has an effect not only by making this category of learners feel excluded but it also leaves them with no role model to emulate (Republic of Kenya, 2005). Such learners are often left out of very crucial part of curricula such as sex education, Human Immuno-deficiency Virus and Acquired Immune Deficiency Syndrome, HIV/AIDS and life skills education programs since people believe that children with disabilities have limited mental capabilities, and do not often engage in social activities including sex and sports and thus even no special sporting facilities are allocated for them. Concerning adult education, due to inadequate trained teachers in this sub-sector, the adult education curriculum does not adequately provide the functional literacy needs of the adults. This is majorly due to lack of a policy framework, which makes provision of adult education by various stakeholders to be uncoordinated.

**Challenges on Quality of Higher Education**

The manner of management of education institutions right from those of basic to higher education is a drawback to quality assurance in most developing countries. The World Bank (2007) expresses its concern on management and institutional leadership which usually determine good governance and achievement of institutional objectives. The quality of university graduates according to Uvah, 2005 could be measured by how well they have been prepared for life and service to the society in various spheres of human endeavor. This quality may also be measured by how good and efficient the teachers are, how adequate and accessible the facilities and materials needed for effective teaching and learning are and how well prepared the graduates are for meeting the challenges in life and solving societal problems. Education stakeholders including the government, labour market (employers), students, parents and the society at large complain about the output of the Kenyan universities and that graduates from public universities are poorly prepared for work challenges. Recently, the Kenya Commission for Higher Education Secretary directed all public and private universities to continuously review their training programs to suit the changing market demands, since most employers have had to retrain graduates from institutions of higher learning, yet this is a waste of money and time. “It is our duty as major stakeholders in the education sector to re-align our programs with expectation of vision 2030”, the secretary noted, adding that among some of the major challenges facing many universities today is inadequate qualified members of the academic staff (Makabila, 2011). Many graduates are hence being viewed as half-baked. The big question is that, what could be the major contributing factors against the quality assurance in Kenyan universities? Among them are:

- Rationale of student admission into the university i.e. some students cheat their way into the university through national examinations cheating, and these deficiencies will persist and eventually manifest in them as low quality products. In Kenya for instance, cheating in Kenya Certificate of Secondary Education examinations is rampant and especially in Mathematics and Sciences, since it has been easier to detect as students make similar mistakes in certain questions. According to studies by Onderi (2011a), grading of Kenya’s national examinations based on compulsory subjects fails many students who would have otherwise passed genuinely. This is why in some instances; some stakeholders find no logic in making Mathematics and Science subjects compulsory for all students irrespective of their desired careers, so that equity in all subjects is provided. Moreover, admission to the private universities has contributed to lowered standards of education since students who did not qualify for regular intake can still be admitted for a competitive course in private university just on the basis of ability to pay for the expensive course training.

- The projected accelerated intake of form four leavers to the public universities this year will definitely have pressure on the existing physical infrastructure and human labor, evident by a lot of part timers in the university academic teaching staff, rather than adequate full time employees.
These challenges among others if not addressed properly, are expected to contribute to strain on available physical and human resources, and this will in turn lower the quality of education in Kenya.

In Kenya for instance, schools and higher institutions of learning, appointment of lecturers to administrative posts without prior training on management and more often there is no one to direct them on what is expected of them, to expose them to management. Past researches show that there is government interference in appointment of chief executives, weak institutional structures for governance and infringement of academic freedom (Mwiria, 2007). Moreover, it is a common feature in most developing countries that post graduate students at the universities almost double the time taken by students in developed countries such as American or European universities. In Kenya, PhD and Masters Students take a long time to complete their research, and this leaves the education planners in a state of confusion especially in having to plan for extra cost for supervision manpower and facility usage against the rising number of post graduate students admitted every year. The question is why do students not complete their degrees on time, especially at postgraduate level? The reasons include:

- Lack of adequate qualified manpower to supervise the post graduate students;
- Lazy supervisors or supervisors too committed to their own private businesses;
- Lazy students and some normally relax after completing their course work;
- Lack of incentives for lecturers who supervise post graduate students;
- Poor schools’ management hence poor mechanisms to identify poor supervisors;
- Some universities have over enrolled Masters and PhD students, against a very small pool of qualified teaching staff. There are cases where some lecturers have as many as 20 Masters and 10 PhD students, a number that is too high; whereas the agreed global rate should be about 10: 1 for Masters and 5: 1 for PhD.
- The old school professors are in many cases responsible for a high dropout rate of post graduate students, mainly because of their negative attitude. Since they took many years working on their Masters and PhD, they don’t see why their supervisees should take shorter periods.
- Cost of research, whereby many students cannot go beyond course work because they lack funds, yet in Kenya for instance there is no university which spends more than 10% of its revenue on research.
- Many university libraries do not have enough materials. Graduate students are therefore unable to access important information and this drags behind their progress. This is a common feature in public universities unlike private universities where at least the stock in the library is of recent books and journals, and even the internet services are available for research by the post graduate students (Amutabi, 2011).

Fear of Technological Advancement
Technology is a critical form of wealth to a nation. Therefore, innovation, research, development, information and communication and science and technology are among the key pillars of education and training. To enhance teaching and learning in secondary schools, the MOE has disbursed a total of 4 million per constituency for 5 secondary schools. Currently, the form one integrated syllabus for Information and Communication Technology, ICT has been developed in all the subjects for the same. Teachers are now required to be ICT compliant in order to enhance their teaching pedagogies (ROK 2005). In Kenya, media has significantly played a recognized and powerful role in disseminating educational information to its large population as well, as its prominent role in the molding of public opinion. The advancement of technological development in Kenya has made it easier for accessing information through various gadgets such as the internet, television, radio, calculators and mobile phones. The print media for example is attributed to vigorous advocacy campaign against HIV/AIDS especially since it was declared a national disaster in 1999. This has been done through featuring articles and other information related to the disease (Africa Regional Sexuality Resource Centre, ARSRC 2006). More so, education has been made much easier with type advancement of technology especially the invention of the internet. For instance, information can be obtained in a matter of seconds from the web, other than seeking for it through long procedures in the libraries. Communication has also been made easier since the invention of mobile phones, internet and telex. Unfortunately, technology has come with its shortfalls. For example, use of mobile phones has made it possible for candidates to cheat in exams (Nation team 2010). The invention of
computers has replaced human planner and human resource in education sector. This is evident by increased number of e-learning centers in various institutions of learning. In focus to attainment of vision 2030, ICT is among the key pillars for industrialization in Kenya. This has therefore called for equipment of Information and Technology, IT among people. However, the entrepreneurs have found it viable to put up IT training centers of their own, even behind shops as private businesses yet the skills they impart in learners are inadequate with needs of the competitive job market. The trainees therefore end up desperate and this has led to dilution of the essence of ICT standards (Hernes 2005). ICT has also contributed to the rampant moral decay amongst the youth. There are sites on the web which propagate pornography and are most popular with the learners. Some television programs especially the ‘soap operas’ have not impacted well in the learners. In fact this is among the prevalence causes of mobile phones in schools. The essence of this therefore is that the education planners still have to put in place stringent measures so as to deal with this culture that is out to erode the quality of education. Due to technological advancement, machines are replacing human labour, hence a threat to planning.

Rationale of Teacher Pedagogy and National Examinations
National examination results in most developing countries leave education stakeholders with a lot of question marks. In Kenya for instance, during schools’ prize giving days, the celebrants are the individuals who have scored grades A. They are celebrated because of the great roles that they will hopefully play in the economy as doctors, pilots, engineers, lawyers, corporate managers and planners. However, the awarded individuals are in the minority. There is a majority of high school graduates who obtain grades D+ and below, that we need to think about. In Kenya for instance, take Gatundu district in Kiambu County, data shows that out of 117 district schools with 9, 013 candidates who sat for KCSE examinations in 2010, 31% (3, 198) obtained a grade D+ and below (Kinyanjui, 2011).

What is the essence of this? At the age of 18, high school graduates with grades D are sent out into the world, inadequately prepared for the competitive labour market. This in fact erodes their confidence since they are viewed as examination failures. They lack analytical skills of good citizenship required for societal transformation especially in a developing nation. The society is actually committing a crime against this generation of the youth by condemning them to hopelessness, yet there are no adequate village polytechnics to absorb and train the so called ‘examination failures’ on hands-on kind of jobs. Worth noting is that the ‘D’ culture is later exhibited in the manner of parenting their children. It produces irresponsible parents especially when it comes to their children’s education; their children go to school unkempt, and are not motivated to learn, and as a result, they score grades that are no better than those of their parents: the D grade reproduces itself. Education planners are therefore left with a gap to fill, so as to make education a vital tool that meets its societal expectations.

Political Influence in Education System
Despite the government’s intervention to transform the education system geared towards achievement of the Millennium Development Goals, (MDGs), political interference in the allocation of resources has been skewed towards the politically sound regions. This is evident by the parity in the distribution of higher learning institutions. Moreover, despite the planning for fairness in education funds allocation in the constituencies, the decision on how to carry out this allocation lies majorly on the area member of parliament. In realization of this challenge, the government initiated Economic Stimulus Programs (ESP), in order to stimulate the economy. Each constituency was allocated 30 million in order to modernize their school infrastructure to be at par with the rest of the well established schools. The Ministry of Education has also formulated intervention of measures through provision of funds to schools in order to raise their general infrastructure. With enactment of the Constituency Development Fund Act in 2003, there has been a tremendous growth in school’s expansion and hence this has brought the need to review the teacher distribution in Kenya. Political influence eventually leads to decline in donor contributions like the International Monetary Fund, World Health Organization and the World Bank.

Lack of Proper Planning Techniques

11th Egerton University International Conference and Innovation Week
This is evident in most developing countries. Sometimes the government sends few teachers to schools against rising enrollments and this forces the school committees and boards to employ teachers at their expense. This results in impulse spending and unexpected deficiencies in resources. Planners have little time dedicated to their task due to other commitments and this leads to haphazard planning which later do not meet their expected objectives. This improper planning is also many a times caused by poor economic status of most of these countries so that lack of adequate finances leads to insufficient monetary allocation to various sub-sectors of education leading to low productivity.

**Recommendations for Possible Solutions to the Challenges**

For a nation to develop, we need to work towards inculcating a positive self image in the young citizens by ensuring that we give them quality education. We need to create a critical mass of self assured individuals. This will help in improving the quality of education offered in learning institutions. But from the aforementioned discussion, it is evident that education planners need to re-engineer their planning processes in order to curb the issues discussed. The following are some of the recommendations and the proposed possible solutions to the challenges facing education planners in Kenya:

(i) More teachers to be trained in all sub-sectors of education so as to cater for the rising demand hence enrolments at these levels.

(ii) To ensure quality in student output by the universities, primary and tertiary levels of the education system must also ensure quality in their productivity. Examination malpractices at these levels which have a great challenge to the validity of the scores attained by candidates must be fought. Disciplinary measures should be put in place by the examining bodies and schools should develop policies in regard to cheating so as to eliminate the cheating culture, and inculcate a culture of learning, necessary for imparting appropriate skills for future careers.

(iii) To ensure that long term plans are formulated properly for future development, the process of planning, organizing, directing and controlling in education need to be considered and executed expeditiously; teachers should be involved in decision making so as to promote their morale hence their support for the school administration.

(iv) Head teachers should have the ability to measure and correct performance and should ensure that school events conform to plans so as to achieve the set goals.

(v) Community participation should be encouraged so as to take in to account their views concerning how they want the schools to be managed; this will boost their support for the school management and administration.

(vi) A lot of sensitization workshops should be mounted to all the education stakeholders especially the management boards in order to impact the necessary skills to them so as to be able to deal with the day to day emergent issues in education.

(vii) Quality Assurance needs to be vigilant on teacher and supervision at all levels of learning so as to check on whether the teachers are implementing the practical teaching methods which are normally advocated for in the in-service training, INSET programs such as SMASSE (Strengthening of Mathematics and Science in Secondary Education).

(viii) Like in North America and in Europe, there should be proper institutional mechanisms at the universities so as to identify poor supervisors; those with poor track records. I.e. the new post graduate students should be given supervision records for lecturers so that they are free to make their choice of supervisors.

(ix) The lecturers should get incentives in terms of lowered teaching loads, especially when they have more than the average number of supervisees. I.e. supervision should be regarded by the universities as part of normal teaching. This will boost their teaching motivation

(x) The education systems should continue to mainstream children with special needs in the national education system and they should develop guidelines for gender responsive interventions to enhance participation and gender equity in the education.

(xi) Appropriate gender responsive curriculum and co-curricular activities, sporting facilities, sex education, life skills, ICT and assessment of teacher education and learning activities for children with special needs should be designed and implemented.

(xii) Affirmative action for admission of female learners and learners with special needs in secondary and tertiary institutions should be strengthened with a view to increase enrolment
and enhance gender equity and equality at these levels of learning.

(xiii) Regular review of adult literacy rates and continuing adult education with a view of incorporating emerging issues in this sub-sector and mainstreaming them in the curriculum.

NOTE: If the above recommendations are rigorously put in place by all the educational planners involved, then Kenya will be able to sustain the policies made in the education sector, for achievement of its long-term goals.

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ABSTRACT

Education is central to development as it empowers people and strengthens nations and hence it is critical to Kenya’s attainment of Vision 2030. Investment in education benefits the individual, society and the world as a whole. Teenage pregnancies have become more rampant among technical training institutes student in Kenya. This study highlights the challenges, coping mechanism and support accorded to student mothers in technical training institutes in Baringo County. The study used the ex-post facto research design. The target and accessible population constituted of student leaders, peer counselors, guidance and counseling officers in the office of dean of students and student mothers in Emining and Baringo technical training institutes. Purposive sampling technique was used to select a sample size of 64 respondents for the study. The study established that student mothers face various challenges that require urgent attention. The major challenges highlighted by student mothers were 93.6% economic and socio-psychological problems that include; stigma and discrimination 90.6%, low self-esteem and guilt 84.1% among others. This study concludes that there were a number of challenges student-mothers went through within the school environment. Because of these challenges student-mothers have opted to use various coping mechanisms to complement the support that they receive from their parents, relatives, friends, lecturers, and school administrators to manage their conflicting. Also the study recommends that lecturers need guidance with respect to how student-mothers can be encouraged and supported academically so that they do not make these students’ lives worse because of insensitivity. This is necessary because the study found out that most lecturers did not know how to handle and offer advice to student-mothers.

Key Words: Challenges, Student Mothers, Coping Mechanism, Support Accorded

INTRODUCTION

Teenage pregnancy is a global problem with U.S.A., UK and Australia leading in rates of teenage pregnancies in the developed world (Quinlivan, 2006). In 2005, Pennsylvania had 26,047 teenage girls who faced the challenges of being young mothers. In the United States nearly one million female adolescents become pregnant each year (Banda, 2015). This is twice the rate found in Great Britain and nearly ten times the rate in Japan. The rate of adolescent child bearing in the United States has fallen since the late 1950s from 96 births per 1000 women aged between 15 to 19 in 1957 to 49 births in 2000 (Mangino, 2008).

In Kenya, national figures on teenage pregnancy stand at 23% with an estimated 5.5 million girls between the ages of 15 to 19 giving birth annually. In Kenya as in others African countries, childbearing trends vary based on regional and socio-economic status. Teenage pregnancy is highest in Nyanza Province where it stands at 29% compared to all provinces (CSA Report, 2008). In Kenya, just like it is in most Sub-Saharan Africa (SSA) countries, teenage pregnancy is a major contributor to school dropout among girls (Bunyi, 2008). Pregnancy at a young age is likely to curtail a young woman’s schooling and thus her economic potential (Okoth, 2015). Mpesh (2010) says that the Kenyan issue of school dropout because of pregnancy is as old as the school system itself. Despite the introduction of free primary education fewer girls are joining technical training institutes due to teenage pregnancy.

At a time when more money and time is being spent on education than ever before students’ drop out due to
pregnancy and has become an issue of great concern to the nation. When a girl drops out of technical training institute level, the cost is often higher than when she drops out in secondary school level due to the cumulative expenditure over the years and the fact that the student leaves without a certificate unless they return to complete training after delivery. Based on the per capita expenditure of Ksh 70,000 in technical training institute level, the government stands to lose up to 40 million annually due to pregnancy related dropout in Kenyan technical training institutes. This is because the recurrent expenditure once invested cannot be recovered if a girl leaves school half way through the school year (CSA Report, 2008).

The Ministry of Education, on recognizing the negative impact of teenage pregnancy on girl child education have put in place the return to school policy guidelines in the mid 1990s to ensure that girls who became pregnant while still in school get a second chance (Mpesha, 2000 & CSA Report, 2008). This has been emphasized because education is considered a basic right in our society and world-wide to enhance productivity across sectors, increase economic growth and provides citizens with basic life skills. However, these students go through a lot of challenges in combining responsibility of being mothers and students at the same time. A recent research done by Centre for the Study of Adolescence (CSA) on teenage pregnancy revealed that despite the existence of return to school policy at least 10,000 girls drop out of school every year due to pregnancy and only a few resume studies (Onyando & Omondi, 2008). Where the policy is implemented, it has had positive effects, with some girls proceeding to universities and other institutions of higher learning (CSA Report, 2008). However, student mothers face various challenges on resuming studies, one of which is to be a mother and a student at the same time. Fulfilling the challenging and sometimes demanding roles of being a mother and student concurrently can contribute to role overload and conflict, which can have a negative impact on her schooling as well as her overall wellbeing.

Stress arises when the goal structures that an individual holds have the potential for conflict, especially when an individual is committed to two or more goals that cannot be easily attained at the same time. Thus, devoting efforts to attaining one goal can impede the attainment of another goal. This role conflict contributes to stress being experienced by the individual (Carver & Scheier, 2009). Stress is a particular class of experience and coping is the response that follows from these experiences (Carver, Scheier & Pozo, 2012). Coping is an effort to create conditions that permit the individual to continue moving towards a desired goal (or away from anti-goals) or an effort to disengage oneself from goals that are no longer seen as attainable (Carver & Scheier, 2009). The implementation of the return to school policy has enabled a significant number of student-mothers to get back to school with the aim of completing their technical training institute’s school education. Despite the existence of the re-entry policy, most student-mothers still find it difficult to fit back into the school system after delivery. However, some resume but they face numerous challenges as they try to fit back into the schooling environment. This situation makes it necessary for them to adapt certain coping strategies. The coping mechanisms employed by student-mothers when they resume studies have a great impact on how well they do and how far they will progress in the academic field.

LITERATURE REVIEW

The paper reviews literature related to return to school policy in Kenya which highlights issues associated with pregnancy and schooling.

Return to School Policy in Kenya

Pregnancy has led to many girls dropping out of school in Kenya. A number of studies suggest that student pregnancy is associated with disruption of schooling, social disadvantage and an on-going cycle of poverty (Kaufman, C. (2011; Maekke, 2013 and Okoth, 2005). Despite world-wide acknowledgement of the value of female education, a large number of girls in SSA continue to have their school careers cut short by unwanted pregnancies and as a result suffer the negative social and psychological consequences that are derived from this situation (Bayona & Murangi, 2012). The Kenyan government therefore put in place a strategy to help curb this situation by giving the young mothers a second chance to pursue their education through the inception and implementation of
return to school policy. The government introduced the re-entry policy because technical training institutes are not able to give new teenage mothers appropriate facilities to care for their children while they continue with their studies. The policy permits girls to go home to deliver and nurse their children and thereafter they are free to rejoin their former technical training institutes without hindrance from school administration, parents or society (Oyaro, 2008).

Until 1990s the trend in Kenyan technical training institutes was to carry out clinical check-up on school girls and eliminate pregnant ones. Things have since changed and the practice now is to allow the victim maternity leave and then allow her back to continue with school (Okoth, 2015). It has been held over the years by various communities and individuals that continuity in education for a girl terminates at the altar of pregnancy (Oyaro, 2008). Today, there is hope that such girls can continue with education after delivering. However, their dreams may be cut short if they fail to receive care and support to enable them handle their new situation with ease. Further, where ad hoc policies such as re-entry policy to enable girls who become pregnant while in school to re-enter the system upon delivery are articulated, they have not been followed by strict implementation. More often than not the implementation of such policy is not monitored. The lack of monitoring and follow-up procedures is making implementation of return to school policy difficult. The situation is made worse by the absence of penalties for non-compliances (Onyando & Omond, 2008). Consequently, the policies have not addressed the relevant issues effectively (Bunyi, 2008).

In some situations the re-entry into school policy is considered a reactive rather than a preventive strategy for it does not spell out any measure or programmes for preventing technical training institute girls’ pregnancies. In fact, arguments have been advanced that the practice may be indirectly encouraging rather than discouraging school girls’ pregnancies because assured that they can have a second chance after discontinuing due to pregnancies, girls may be inclined to undermine the consequences of irresponsible behaviours like sexual activities (Bayona&Murangi, 2012 & CSA, 2008). This view is true especially if the student-mother herself, her peers and the rest of the school community is not guided on the benefits of implementing such a policy through sensitization.

METHODOLOGY

The study employed ex post facto correlation research design. The research design is appropriate to behavioral science as independent variable cannot be manipulated. It attempts to investigate the causes or consequences of differences that exist between or among groups of individuals (Orodho, 2003). This is to say independent variable has already occurred (socio-psychological challenges) and the study examined the existing state of affairs (coping mechanism and support that student mothers receive). The study was carried out in Baringo and Emining technical training institutes in Baringo County. The institution were selected as they had high cases of student mothers and lack mechanisms of dealing with this challenge. According to Chigona & Chetty (2007) the current situation of student mothers in the tertiary institutions of learning is a crisis not only due to degradation of the societies morals but also as a result of poor parenting and lack of guidance of the youth in Kenya. Purposive and stratified random sampling procedures were used. Purposive sampling procedure was used to select 120 registered student mothers in both institutions. To ensure equal representation of each category of student mothers in terms of level of studies (first year, second year and third year) stratified random sampling using the lottery technique was used to select 64 respondents for the study. From the 64 respondents all the respondents complied with the study and gave their responses. 4 trained Peer counselors were involved in the study. Data was collected using interview schedule for the trained Peer counselors and questionnaires for the respondents which were developed by the researcher. Data was analyzed using statistical package for social science and presented using frequency distribution tables.

STUDY RESULTS AND DISCUSSIONS

Challenges of Student Mothers

Several challenges were highlighted by respondents which included socio-psychological and economic.
These challenges have affected their desire to complete their technical training education despite the government’s attempt to reduce waste age as a result of dropout rates among student mothers.

**Socio-psychological Challenges**
The researcher sought to find out the socio-psychological challenges faced by student mothers and the results summarized. From the study several challenges were highlighted by the participants and the results summarized in table 4.1

<table>
<thead>
<tr>
<th>Socio-psychological challenges</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of concentration</td>
<td>48</td>
<td>75%</td>
</tr>
<tr>
<td>Worries over marriage</td>
<td>13</td>
<td>20.3%</td>
</tr>
<tr>
<td>Lack of Professional Counselling</td>
<td>34</td>
<td>53.1%</td>
</tr>
<tr>
<td>Stigma and discrimination</td>
<td>58</td>
<td>90.6%</td>
</tr>
<tr>
<td>Fear and loneliness at school</td>
<td>42</td>
<td>65.6%</td>
</tr>
<tr>
<td>Low self-esteem and guilt</td>
<td>54</td>
<td>84.1%</td>
</tr>
<tr>
<td>Lack of skills to handle student-mothers’ situation by lecturers</td>
<td>46</td>
<td>71.9%</td>
</tr>
</tbody>
</table>

Source: Field study 2016

From the study results the respondents highlighted several challenges that mainly touched on social and psychological life which makes student mothers attempt to pursue their technical education to completion a challenge they included; Stigma and discrimination was also highlighted as the highest challenge to student-mothers. The respondents reported that they experienced stigma from various sources. The student mothers stigmatized themselves, and also they were teased by fellow students, some parents and some lecturers. Boys and girls often verbally abused these girls, making their participation in class to seem unwelcome. Teenage mothers were sometimes ridiculed in front of classmates by both lecturers and fellow students whenever they did not satisfy the class requirements making them suffer from low self-esteem, fear and loneliness at school. Low self-esteem and guilt was also noted as a challenge since these girls had become mothers whilst young and still in school they were stigmatized and so they tended to have low self-esteem. Low self-esteem made them feel out of place especially when other students felt that they were not fit to be within the school system. Lack of skills to handle student-mothers’ situation by lecturers was also highlighted as a challenge whereby teenage mothers were disadvantaged at school because their lecturers did not know how to handle them and their situation when they were at school. Lecturers had difficult time handling the student-mothers because they did not know how to treat such students. They were left in a state of dilemma, to advocate for or not advocate for the use of contraceptives by such girls. Lecturers had challenges addressing emerging issues or even teaching certain units like social psychology and reproductive health that deal with aspects that the student mothers had or were going through to have the others informed and at the same time keep the image of the student-mothers in their midst (FAWE, 2015).

Lack of concentration whereby student-mothers were normally not fully settled while at school and this adversely affected their social and academic life. They lacked a great level of concentration in their academic work due to lack of ability to adequately manage parenting and schooling successfully at the same time. A worry over marriage was another challenge whereby the society does not appreciate teenage pregnancy and children born out of wedlock. Considering that these students were already in that state, most of them looked worried over their future life for they were not sure about their fate in marriage. Lack of Professional Counselling was another challenge whereby student-mothers were counselled as they returned to school and even when they were in school to prepare them on how to deal with their challenges like stigma, balancing their time to attend to schooling and parenting demands. However, the counselling services that they received were not very adequate since the counsellors lacked proper training in counselling. The consequence is that student-mothers got overwhelmed with their situation making many of them not cope resulting in their poor performance. Fear and loneliness at school was also noted as a challenge where most of the student-mothers were shy to approach lecturers for consultation, the reason was not wellknown, it was not clear if they feared going to lecturers in the staffroom or not. Sometimes teenage mothers had fear participating in class discussions. For example, whenever topics like ‘teenage pregnancy’ and
other socially related subjects were being taught the teenage mothers became particularly not interested and uncomfortable that everybody was talking about their situation.

**Economic Challenges**

The respondents reported that they faced economic challenge whereby 93.4% of the respondents stated that they faced economic challenge, while 6.6% of the respondents reported that they did not face economic challenge. This indicates that majority of the student mothers had economic challenges.

From the study results majority of the student mothers faced economic challenges which affected their desire to complete their studies and care for their siblings as most of them were not married. A few reported that they do not have economic challenge as they were married and their husbands were able to meet the financial obligations. Their husbands have enabled them achieve their dreams of attaining higher education in-order to acquire employment and improve their families economic status. According to Chigona & Chetty (2007) greater percentage of student-mothers were daughters of parents who had nothing at all to do to feed for the new sibling and their daughter’s lives and fully depended on informal employment and sustenance farming. This great level of dependency on their parents may have made the girls be at risk of dropping out of school due to lack of finances to see them through their education. Sometimes student-mothers had to do household chores when they returned from school and the only time they could do their homework was at night. Unfortunately, most of them came from families where the lighting system in the house was just hurricane lamps making it difficult for the girls to study or do their homework at night, as they could not have the lamps on due to inadequate supply of paraffin. Additionally, after their delivery most of their parents became reluctant to pay their daughters’ school fees compared to the period before they conceived and resumed studies.

**Support Student Mothers Received**

The researcher sought to investigate the type of support the student mothers received while in the technical training institutes and the responses summarized in Table 4.2.

**Table 4.2: Support Student Mothers Received**

<table>
<thead>
<tr>
<th>Support received</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spiritual support</td>
<td>55</td>
<td>85.9%</td>
</tr>
<tr>
<td>Social support</td>
<td>43</td>
<td>67.2%</td>
</tr>
<tr>
<td>Instrumental support</td>
<td>24</td>
<td>37.5%</td>
</tr>
<tr>
<td>Emotional support</td>
<td>46</td>
<td>71.9%</td>
</tr>
<tr>
<td>Informative support</td>
<td>37</td>
<td>57.8%</td>
</tr>
<tr>
<td>Appraisal support</td>
<td>42</td>
<td>65.6%</td>
</tr>
</tbody>
</table>

From the study the success of a student mother was contingent upon active contributions of all stakeholders in supporting them through their education process alongside motherhood demands. From the responses spiritual support was mostly highlighted as the major support received by the respondents. This is the kind of support that is concerned with sacred or religious matters like prayer and meditation. The study established that student-mothers were supported by their parents and technical training institutes to get access to spiritual support that was also very necessary and important to them in handling their situations. Emotional support was the second highlighted support received by student mothers which reflects the individual’s experience of receiving care, encouragement of the sense of personal value and the perception of confidence and trust from family, friends, neighbours and colleagues. Parents were very supportive in assisting student-mothers to make them feel cared for by taking care of their young ones as the girls went to school. Lecturers and other students also provided care and encouragement to the student-mothers making them have confidence and trust as this
encouraged their sense of personal value. They also took part in providing encouragement and ensuring that student-mothers’ learning environment was conducive. According to Bunyi (2008) parental education is a strong contributor to female student’s education. The education level of the student-mothers’ parents had a great impact on the girls and their education. Mothers with higher education background were better placed to guide their daughters against early pregnancies, thereby making the number of those who became pregnant to such mothers fewer compared to girls from families where their mothers had a lower education background (Bunyi, 2008). The educational background of the fathers also determined the ability of the girls getting a second chance to pursue their education even after delivering. Student-mothers from families where fathers had a higher education background got a greater percentage for a second opportunity to get educated compared to those from families where fathers had a lower level of education (Oyaro, 2008).

Social support was also highlighted as the support received which entails student-mothers getting financial support, encouragements and pieces of advice alongside appreciation of their abilities. Appraisal support was also reported whereby technical training institutes tried their best to make student-mothers comfortable upon returning to school by communicating to them information that was relevant to self evaluation rather than problem solving with the intention of boosting their self esteem. According to Mpesha (2010) student-mothers at times are motivated to carry on with their studies as they were given examples of successful student-mothers. At times they were asked about their babies’ welfare to make them feel cared for despite what they had gone through. However, there were certain times when the needs of student-mothers were not adequately met due to financial difficulties or even not knowing that the students were in specific needs. In as much as the parents, lecturers and peers tried to support the student mothers they too faced various challenges that hindered their full support. Parents tried to provide their daughters with school requirements but at times it was a challenge. Some student-mothers were also never free to express some of their needs, they were so reserved and this meant that their parents and guardians were to guess what they required and provide to them (Okoth, 2015).

Instrumental support was also highlighted as support received whereby student mothers received access to practical service and/or financial assistance. Practical support is support that is inclined to action rather than speculation. It involved individuals taking action to ensure that the expected is done by taking steps and beginning to act without much ado. Parents often provided the basic needs to both the student mother and her baby (their grand child) and took full responsibility of bringing up the child and also supported the girl in school. Wanting the best for their children the parents always did for them all that they could to enable these children attain their set goals. Lecturers too played a significant role in the provision of material support to the student mothers. Considering the needs and situation of student-mothers, lecturers were sometimes obliged to support them in various ways to help them cope with their situation by assisting them in their academic work to enable them catch up with ease. The fathers of the babies made some impact in supporting the student-mothers’ education since they were positive about their academics but were not involved in provision of financial support. They were only mentioned by the student-mothers as being supportive in academic matters as they encouraged the girls to continue with their education and showed interest in their schooling experiences. According to Onyando and Omondi (2012) other organizations are not left out in the support of student-mothers as they actively take part in empowering the girls and also supporting them financially by paying their fees with the intervention of school principals in most cases. Like the Baringo Take off Programme, Higher Education Loans Board, World Vision and the Constituency Development Fund office.

Informative support was also reported as one of the supports received by student mothers which involves appropriate advice and assistance in coping and solving problems. Guidance and counselling was the most critical form of support student-mothers were accorded by lecturers, peers, parents and other relatives both at school and at home to help them cope with their situations. According to Quinlivan (2016) most student-mothers received counselling services from
their parents as compared to other sources. This is an indication that in as much as the students spent more time with lecturers at school than being with their parents, lecturers did not actively offer them counselling services that they needed. This also illustrated that the counselling services that the student-mothers got from their parents were not very adequate considering the time shared together making the students’ access to counseling services marginal.

Coping Strategies of Student Mothers
Student-mothers were different and distinct in all components of psychological adjustment processes and varied in the way they responded to challenges. Psychologists like Di Vesta (1970) and Mouly (1973) identify coping mechanism as a compulsory strategy in dealing with challenges and difficulties in our daily life experiences. Student-mothers got actively involved in trying to cope with their double role of being a mother and a student concurrently. They reverted to coping strategies, harmful (such as avoidance and emotion focused) as well as constructive

Table 4.3 Coping Strategies by Student Mothers

<table>
<thead>
<tr>
<th>Coping strategies</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Problem focused coping strategies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Financial matters</td>
<td>61</td>
<td>95.3%</td>
</tr>
<tr>
<td>Time management</td>
<td>58</td>
<td>90.6%</td>
</tr>
<tr>
<td>Make ups for the missed lessons</td>
<td>34</td>
<td>53.1%</td>
</tr>
<tr>
<td>Self drive</td>
<td>45</td>
<td>70.3%</td>
</tr>
<tr>
<td>Spiritual support</td>
<td>38</td>
<td>59.4%</td>
</tr>
<tr>
<td>2. Avoidance coping strategies</td>
<td>52</td>
<td>81.3%</td>
</tr>
<tr>
<td>3. Emotion focused coping strategies</td>
<td>56</td>
<td>87.5%</td>
</tr>
</tbody>
</table>

Source: Field Study, 2016

Problem Focused Coping Strategies
Financial Matters
The study established that student-mothers got actively involved in having their challenges addressed if not solved. To make them overcome their financial difficulties student-mothers were forced to look for finances to cater for their needs (personal and school) alongside the needs of their babies by getting involved in various activities and ways. They got involved in some economic activities like selling firewood, vegetables or even working for others at home or in farms at their free time over the weekend and holidays. Sometimes they requested for financial assistance from parents, lecturers and other relatives.

Time Management
Student-mothers tried their level best to fully utilize any free time that they could find to catch up with other learners in terms of syllabus coverage and also to do their personal study while at home or even in school. Sometimes the student-mothers went to school very early and stayed behind in the evening as others left for home to fully utilize their time at school to enable them get enough time to finish assignments and also study. When they missed lessons they consulted their lecturers and fellow students for assistance.

Make Ups for the Missed Lessons
At times student-mothers also explored the field of education by consulting lecturers for remedial services and also other students to know what was covered in their absence and to borrow notes from them to enable them be at per with their counterparts who were regular at school.

Self Drive
Student-mothers had their own initiated drive to make them cope with their situations to better their academic abilities and had some role models whom they strived to emulate. They also read story books to keep their minds occupied and sometimes went through articles that talked about the challenges they were going through to guide them on how to deal with their situation.

Spiritual Support
When situations become tough people turn to God for support by seeking God’s intervention to deal with their social and emotional challenges. Student-mothers too used this strategy to help them go through some of their life challenges.

Avoidance Coping Strategies
Denial is a defence mechanism proposed by Sigmund Freud, in which a person faced with a fact that is too uncomfortable to accept rejects it, insisting that it is not true even though there might be overwhelming
evidence (Okoth, 2015). This explains the reason why teen parents who are faced with serious social problems deny it. They might possibly admit the fact but deny its seriousness, or admit both the fact and the seriousness but not want to take responsibility for their social problems. This strategy was able to work for those who used it to cope with their new situations as they also went ahead to ignore and assume all that others said about them. In some cases student-mothers felt overwhelmed by their situations to the point of lacking what to do to improve on their condition, they therefore accepted whatever came their way.

Emotion Focused Coping Strategies
Some of the teen mothers just decided to be bold enough to take the insults from their surrounding and just develop their own psychological shock absorbers but for those who were not able to be strong and forge ahead shied away from school because of too much pressure piling on them at school. Student-mothers tried their best to make full use of the three identified coping mechanisms to help them cope with their situations. However, they (student-mothers) did not succeed fully in overcoming their challenges to make them more comfortable as they doubled up as mothers and students. Strategies like avoidance and emotion focused coping styles were in several occasions used by some student-mothers. In as much as this strategy served them well at times, it negatively impacted on them psychologically (Mangino, 2008).

CONCLUSIONS
The study established that there were a number of challenges student-mothers went through within the school environment and sometimes at home. Because of these challenges they go through student-mothers opted to use various coping mechanisms to complement the support that they received from their parents, relatives, friends, lecturers, and school administrators to manage their conflicting roles with the support from different individuals like parents, peers and lecturers. In as much as parents, relatives, peers, lecturers and technical training institutes administrators tried their best to support these needy students their efforts were also curtailed by other factors like financial constraint, time limit, lack of set up programmes and means to be followed and individual desire to set aside more time for personal and private study. This therefore left the student-mothers to come up with their own ways to come out of their difficulties. The study also established that student-mothers thereby resorted to make use of coping mechanisms that could be of benefit to them as per the situation at hand and their general capability. Some in most cases had also lost interest in education in most cases and were confused about their abilities the reason as to why a majority of them did not do well academically on resuming studies. The return to school policy is a noble idea to help girls who would have otherwise dropped out of school because of pregnancy get a second chance to education. These girls need adequate support if they are to complete their technical training institutes education and get access to higher education.

RECOMMENDATIONS
The following recommendations could be considered for adoption and put into practice so as to support student-mothers go through their technical training institutes school education successfully:

1. Lecturers need guidance with respect to how student-mothers can be encouraged and supported academically so that they do not make these students’ lives worse because of insensitivity. This is necessary because the study found out that most lecturers did not know how to handle and offer advice to student-mothers.

2. There is need for technical training institutes to motivate guidance and counselling lecturers by sending them for seminars and workshops to help them sharpen their skills.

3. There is great need to have the student-mothers transferred to other technical training institutes to avoid stigmatization. This should however be done only after conducting a series of counselling services both at the current school before exit and the new school on readmission.

4. Encourage parents who can afford to take their daughters to boarding technical training institutes to enable the students have ample time to study while at school without much difficulty. However, for parents who may not afford boarding fees they should have their daughters
readmitted in preferably different day technical training institutes from their previous technical training institutes and they be given ample time to study while at home.

5. Technical training institutes, communities and individuals need to be sensitised on the return to school policy to make them aware about its existence and thereby appreciate it.

REFERENCES


ALTERNATIVE STRATEGIES AGAINST MAL-FUNCTIONING CRIMINAL JUSTICE SYSTEM IN ENSURING SECURITY IN KENYA

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ABSTRACT

Crime control in any country though primarily a mandate of the government should be a responsibility for all people, and an engagement of several agencies. This is because crime which is the main source of insecurity has many negative impacts. At the individual, family and neighbourhood levels, effective crime control lies in ensuring that one does not become a victim. However, in some countries like Kenya, provision of security has been left mainly to the traditional government institutions such as the police who have not succeeded because of a plethora of weaknesses in and mal-functioning of the criminal justice system in general. The aim of this paper is to explore these limitations against the fulfillment of deterrence, incapacitation, reformation and rehabilitation theories of punishment by the Criminal Justice System in Kenya. The methodology involved elaborate review of the findings of other scholars such as Omuya (2015), Omeje et al. (2010), Nyongesa (2013) and Gathu (2014) among others on the factors responsible for the mal-functions of the Criminal Justice System in Kenya. The paper concludes by making a case for the use of environmental, situational and social strategies based on the theories of public security as a mechanism of ensuring security in the country instead of relying heavily on the criminal justice agencies.

Key words: Criminal Justice System, Theories of punishment, Theories of public security, Crime control Strategies, Kenya.

INTRODUCTION

The Criminal Justice Institutions; namely the police, judiciary and corrections should in synergy ensure that the suspected offenders are arrested, tried and ultimately punished so that they never commit crimes again. These efforts are meant to reduce criminal activities thus ensuring public safety and security. To achieve this noble goal, the whole process should ensure that punishment is able to deter, incapacitate, reform and rehabilitate the convicts (Tewkbury 1997, Birzer et al 2004 and Adler, et al, 1996). However in Kenya, evidence abounds on the inability of the Criminal Justice Institutions to realize effective security due to several weaknesses.

LITERATURE REVIEW

Challenges Facing Enhancement of Security by Criminal Justice Institutions in Kenya

The success or otherwise of a criminal justice system can be measured by among others the extent to which its’ institutions in their respective functions enables the attainment of safety and security in the society. In Kenya however, several factors have negatively affected these key institutions in their work.

To begin with, among the main duties of the police in relation to public security in Kenya like in other countries, are investigation of cases, arrest of the offenders and presentation of evidences in courts of law during trial. However, it has been observed that there are several weaknesses in the police service and other ills that have had negative consequences on the court decisions, and penalties awarded to the offenders which in the end may lead to perpetuation of crimes and recidivism by the offenders to the detriment of public safety and security. For instance, some police officers are not professional enough in their work particularly when it comes to handling gender based crimes, and respect for human rights. For instance, female rape victims have complained that their plight have been made fun of by male police officers at the report desks when they go to report rape crimes. As concerns human right abuses, rampant complaints have consistently emerged against police torture and extra-judicial killing. (Omuya, 2015, Omeje, et al 2010 & Omboto, 2015). Limited resources are another hindrance to the police operations. This includes lack of necessary apparatus (Mageka, 2015). The police in Kenya also suffer from external meddling in their work, particularly from the political class (Kivoi, et al 2013, Nyongesa, 2013).
Corruption in Kenya police which in the year 2014 made Amnesty International to describe the service as a bribe factory is another anathema (Mageka, 2015). This implies that the law is enforced with partiality which in the end denies justice to the public and spurs crime levels. This means that people who commit crime may evade arrest by bribing the police or if arrested, compromise the investigating officers thus evade punishment. This acerbates insecurity as the undeterred offenders continue with crimes. In the end, based on the foregoing, the police in Kenya are not very effective in ensuring security.

Similarly, the Judiciary has several weaknesses. For instance, Gathu, 2014 observed that one of the greatest causes of biases in the Kenyan judiciary is corruption which takes the form of judges and magistrates being bought or bribed to enter favourable rulings and give judgments which lead to miscarriage of justice. This results into failure to punish guilty offenders who would continue with criminal activities due to lack of deterrence. The other prominent factor among others which affect the delivery of justice is delays in determination of cases (Infotrak, 2012). These factors among others encumber the effectiveness of the judiciary therefore leads to higher insecurity rates. They are responsible for poor rulings, convictions and wrong or ineffective punishments which make the unfairly convicted and punished offenders to become bitter thus turn into vicious criminals, while the guilty but unjustly acquitted continue with crime.

The correction institutions which in Kenya are mainly prisons and probation centers are no better. It has been established that there are a myriad of problems that have made it near impossible for prison institutions to achieve any meaningful goals of punishment, rehabilitation and reintegration. For instance, the capacity of prisons personnel to rehabilitate the offender has been questioned against their level of education, training and integrity. The academic and training levels of the majority of prisons staff has been established to be lower for the delicate work of rehabilitation, while in terms of integrity; several prison officers have been caught smuggling drugs and phones into prison institutions thus negating on the achievement of the prisons mandates (Omboto, 2013). There have also been complaints about deplorable prison conditions and the hostile treatment of offenders there in by the prisons staff; under such circumstances no reformation can be attained (Odera-Oruka, 1985). The end results of all these have been high rates of recidivism among prisoners (KNBS, 2014), which raises crime rate and level of insecurity in the country.

Whereas Probation and After Care Services is the only government agency charged with the responsibility of reformation and rehabilitation of offenders in the community in Kenya, it also suffers from several factors that interfere with its’ work. These include huge caseloads, poor supervision, lack of co-operation from the offenders and limited resources (Hannah, 2012, Okech, 2015, Aben, 2011). Given these challenges in the criminal justice system institutions, there is need for utilization of different approaches that focus on the risk factors responsible for crime. The strategies are more cost effective and have greater social benefits than the reactive responses of criminal justice agencies because they prevent social, economic, political and psychological effects of crime.

THEORETICAL ANALYSIS

The paper uses theories of punishment to analyze effectiveness of criminal justice institutions in controlling crime and theories of public security in arguing for application of environmental, situational and social strategies in enhancement of public safety.

Theories of Punishment
The theories of punishment posit that by having in place effective punishment, criminal justice institutions should be able to guarantee public safety by minimizing cases of insecurity through criminal activities. For example, based on deterrence theory, the already punished convicts and others should prefer to abide by the laws due to fear of punishment. However, the number of recidivists in Kenyan prisons which according to KNBS, (2014) increased by 76.9% in 2013 indicate that punishment and by extension criminal justice institutions have not been successful in deterring crime. This is caused by the fact that in some cases punishment awarded by the courts are not parsimonious to the severity of the crimes. Also at some times due to corruption, preferential treatments among others some of offenders are not punished thus continue to commit crimes un-deterred.

According to incapacitation theory, punishment should also make it impossible for the offenders to commit crimes. Based on this philosophy offenders are normally removed from the community into prison institutions to protect the society from their criminal activities. This implies that prisoners under incarceration should not continue with crimes in
prisons and against the society from which they have been removed. However in Kenya, this is not the case given that the cases of convicts extorting money from the public through threats and conmanship by use of mobile phones are rife. In addition, reformation and rehabilitation theories expect that through punishment the character and personality of the convicts should be transformed for them to live in the society as law abiding citizens; in a nutshell be rehabilitated. This has also not been achieved as indicated by the recidivism rates.

**Theories of Public Security**

These are theories which argue that enhancement of public security lies on community and environment oriented approaches. For example, according to Poyner, (1983) Brocken Window theory developed by Wilson and Kelling in 1982 posits that images of disorder promote crime. The theory argues that if disorder were eliminated then serious crimes would be prevented. It further postulates that a continuation of disorder in the end weakens social control by making people to disengage with their community thus giving criminals room. Disorderliness in the community causes crime, and crime causes further disorder and crime. Simply put, this theory of public security argues that if a broken window is not replaced it encourages vandals to continue with the damage thus perpetuating insecurity. In a nutshell for insecurity to be minimized, disorder should be eliminated.

Routine activity theorists on their part postulate that crime is as a result of a convergence of three elements. These are a motivated offender, suitable target and absence of a suitable guardian. Thus the daily routine activities of individuals strongly influence when and where criminals attack them. This theory has practical implications for prevention of crime and insecurity; it has guided prevention strategies such as mounting of surveillance cameras which deters possible criminals. Defensible space theory developed by Oscar Newman in 1970 (Poyner, 1983) opines that the building design and the physical layout of a community determine a crime occurrence. It argues that a good design that gives residents ownership and responsibility over their surrounding gives them the chance to control and defend it which bars potential criminals. For instance, neighbourhoods must not have so many exist and entries. Additionally, they must not depend on the police for their security but have a sense of ownership and security for themselves. This theory gave birth to the UK police’s program ‘Secured by Design’ in 1988 which has benefited many homes. However, the effectiveness of defensible space rests on the willingness and the ability of the people concerned to police themselves. This theory is linked to personal space theory.

Situational crime prevention theory which is another public security theory postulates that insecurity can be reduced by minimizing opportunities for crime. This involves putting up measures that reduces the ease to commit crimes by threat agents. The guidelines provided on how to reduce opportunities for offenders to commit crime thus enhancing public security are: removing excuses that facilitate crimes; for instance, it calls for instituting laws at national and organization levels on crime which people are expected to obey. Also calls for the increase in the risks for committing crime; for example, by increasing chances of arrests and punishment and also making it difficult to commit crimes.

Finally, Social contract theory which originated from the work of Thomas Hobbes should guide state authorities to provide for the populace needs which if neglected compel them to commit crime. This is more relevant given that the threats to human life and national security in the contemporary nations has taken new dimensions which include poverty, unemployment, famine, droughts, diseases, corruption, dictatorship, mismanagement, nuclear threats, pollutions, desertification, wars, internal conflicts, drug trafficking, drug abuse, human trafficking, poor leadership and administration, terrorism among others.

**CONCLUSION**

**Utilization of Non- Criminal Justice Oriented Strategies to Enhance Security**

Given the failure and weaknesses of punishment based security enhancement measures, the paper recommends that security management in Kenya should be achieved through the use of environmental, situational and social strategies.

**The Environmental and Situational Security Management Strategies**

According to Poyner, (1983) measures helpful in prevention of crimes through environmental designs include surveillance, control of movements, activity support and motivational reinforcement. Surveillance on crime targets which involve among other measures installation of CCTVs in homes and business premises, proper lighting of areas at night, use of supervisory personnel, guards or vigilante groups is key in
deterring potential of offenders who would fear being caught in crimes. Related to this, movement controls which involves any procedures that limit the movement of potential offenders into areas where they are most likely to commit crimes is also an effective crime prevention mechanism. The measures which assist in controlling movements include the use of security locks on gates and doors, minimizing entry points, closure of streets, and controlled access to particular areas among others.

Having activities around possible criminal target properties such as banks which increases the presence of many people around the properties most of the time also serves a surveillance function thus scares potential criminals who may target a property. Motivational reinforcement is also vital. It is about encouraging people to engage in crime prevention activities which involve encouragement of personalized environments, having in place well kept public areas, ensuring cooperation between business entities, and community policing.

Situational Crime Prevention approaches seek to reduce the opportunities of committing crimes, increase the risks of committing crimes and decrease the benefits of crime. Poyner, (1983) posit that effective situational crime prevention strategies involve target hardening, target removal, removing the means to crime and reducing pay-off among others. Target hardening is a common approach to security which entails the use of stronger locks and burglar proof installations on doors and windows. This assists in barring away potentials criminals from such properties. Target removal is about putting away the properties or resources that are desired by the criminals. For instance to prevent thefts and robberies of money, cash payment is always replaced by other forms of payment to reduce the risk, this can be use of cheques, electronic money transfer etc.

Concerning removal of the means to crime as a strategy, it involves eliminating access to the items that facilitate commission of criminal activities. Common methods in this strategy include gun control in public places where people may fight, the use of plastic containers instead of bottles, providing prisoners with paper or plastic cutleries among many others. Reducing pay-off involve devaluing properties in case they are stolen or taken away by criminals. The strategy includes marking properties with distinct permanent marks which will discourage theft. For example, window curtains, cups and cutleries are commonly marked with logos of organizations which will make them distasteful to use outside those organizations. Another measure against theft of money on transit has been installing in the safes chemicals which deface the money notes if broken into. Finally, formal surveillance by the police or employing private security personnel to patrol or guard properties is also a useful situational measure which deters potential offenders.

Social Interventions in Crime Prevention
One of the most effective mechanisms of reducing crime rates in a society is provision of opportunities for honest and legitimate living to the citizens. According to Robert K. Merton when the society fail to provide some individuals with opportunities to meet the desired goals such as accumulation of material wealth, attaining higher education and training, better housing, clothing, and food among others; crime will most likely arise as a consequence of this conflict between the goals and their attainment through legitimate means. Crime and deviance, therefore is high among the lower class because opportunities to meet the society’s desired goals by legitimate means such as employment are fewer for them (Bohm and Halley 1997). That there are individuals who commit crime as a means of survival due to poverty and unemployment must be awake up call to the governments to do everything possible to empower their citizens by creating gainful employment opportunities in both formal and informal sectors to diffuse huge economic inequalities currently experienced. When our youth are trained in various professions but are not guaranteed of employment, as is the case in Kenya then they only turn out to be educated criminals who are very difficult to deal with due to their knowledge and exposure.

The Kenya government should for instance build decent and affordable houses for the poor to replace slums that host millions in urban centers. Soft loans should be offered to the small scale farmers and other people in the lower economic bracket to enable them start gainful businesses that will create wealth, and unnecessary restrictions to the legal business opportunities that the poor can operate must be removed. The poor must be offered free medical care and free education. The government must control prices of essential commodities because inflation and drastic increase in the cost of living only make the crime rate worse.

Similarly, taxes on essential commodities like food stuffs and fuel used by the lower class should be
removed and the tax bracket level should be raised so that the low income earners are left out. Minimum wage for workers must also be raised among other social measures vital in curtailing high crime rates. The Kenya government should also buy land to settle the landless citizens of all ethnic groups to make them productive. In summary, the government must fight with vigor the chief evils of the world that the majority of Kenyans suffer from: malnutrition, diseases, illiteracy, slums and unemployment which are the root causes of crime among the lower class who are the majority.

Eradi
cation of corruption must also be taken seriously. The Kenya government should be ready to curb all forms of graft both in word and deed. Even though corruption is itself a crime, it is a major contributing factor to several property related crimes. For instance, it is corruption that has caused the huge economic disparity that is evident in our society, where a few dishonest people who have misappropriated state resources are extremely wealthy while the majority of Kenyans are destitute. Because of this, some people do not see anything wrong with earning a living through crime. Finally, education and training for those who are soft target for criminals such as children and women is also vital for crime prevention to inculcate social skills that will insulate them against criminals. For instance, the children must be taught to be weary of strangers as a measure against crime victimization.

REFERENCES


INFLUENCE OF COMMUNITY POLICING ON INCIDENCES OF ARMED ROBBERY IN LOW INCOME AREAS OF NAKURU TOWN, KENYA

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ABSTRACT
This study investigated the influence of community policing on incidences of armed robbery in low income areas of Nakuru Town in Kenya. Cross-sectional survey research design was used. The target population was all the residents in four low income areas of Nakuru Town having a combined population of 252,762. A total of 131 respondents participated. The respondents were drawn purposively from each of the four low income areas of Nakuru Town. A questionnaire was used to gather information from the residents. Hypothesis was tested using Pearson’s Correlation Coefficient (r) statistic at α =0.05 level of significance. The results obtained from some of the areas gave statistically significant influence of community policing on incidences of armed robbery in low income areas of Nakuru Town. There also appears to be no statistically significant influence of community policing on incidences of armed robbery in some areas. This implies that community policing is not working uniformly in the areas studied. The findings from this study inform the county government of Nakuru and Kenya at large, on whether community policing which was introduced to reduce and prevent crimes has actually had an influence in the frequency of occurrence of the most prevalent crime (armed robbery).

Key words: Community policing, influence, crime, armed robbery, low income areas.

INTRODUCTION
Crime refers to a form of deviance that involves an infraction of the criminal law. A crime may also involve any offence that is against a public law, a term that in its most general sense entails all offences (Allen & Michael, 2005). Crimes are normally defined and punished by statutes such as Penal Code (PC) and common law. In fact, they are ‘mala in se’ or bad in themselves and ‘mala prohibita’ or bad because prohibited including all offences against the moral law. Crimes happen everywhere around the world. Examples of crime include; sodomy, adultery, incest, bigamy and fornication, public indecency, drunkenness, violating the grave, homicide, mayhem, rape and defilement, kidnappings, poisoning, assault and battery, false imprisonment, abduction, domestic violence cases, burglary, arson, Armed robbery, larceny, forgery, theft, housebreaking, break-ins, and drug/firearm trafficking and possession among others (Lafave& Edward, 2001). They have devastating effects on human beings. For example, crimes lead to loss of lives, body injuries, psychological trauma, fear, displacements, and destruction of property among others. It is because of the above reasons that security intervention strategies such as community policing was initiated to try and reduce these effects (McGoey, 2013).

Community policing is a security intervention strategy that emphasizes on the support of problem solving tactics involving partnerships between the police and the community so as to address the causes and reduce fear of crimes and social disorders. The history of community policing can be traced back to have begun one and half a century ago in London during the London Metropolitan Police District formation. Community policing as a security intervention strategy was then adopted by England and United States in the late 18th Century and early 19th Century (Walker, 1994). The two countries came up with a new strategy of community policing known as team policing in the 1970s which recognized that prior to the introduction of community policing, social climate and techniques of police patrol made the police become isolated from the community making the fight against crime very difficult. Wilson and Kelling (1982) further outline that team policing proceeded to assign a neighborhood to a group of police officers who were expected to learn about the neighborhood members, neighborhood itself and the problems experienced. This method was tried in several parts of the United States of America and was found to be successful in places such as California, in the early mid-1990s. Naude (1999) posits that the outcomes were that the relationship between the community and the police through working in cahoots
did immensely resolve and prevent community crimes and social disorders. Community policing is a security intervention strategy which requires the police and the citizens to join together as partners in fighting crime and disorder through balancing reactive responses to calls for service with proactive problem solving majorly centered on the causes of crime and disorder (Diamond & Weiss, 2009).

In Africa, community policing has been noticed to be successful in places where interactions have been more informal according to Naude (1999). In Nigeria, for example, people have deviated from formal to informal law in an attempt to curb the menace of crime by forming informal ethnic militia groups to provide protection (Rotimi, 2001). Some communities such as the Igbo community of South Eastern Nigeria have put much emphasis on their traditional customs and values as well as other unwritten concepts of law to interpret what law is. For example, they believed that the behavior of citizens was supposed to be regulated by their indigenous people whom they were quite familiar with such as the elders (Okfar, 2006). Nigeria has also experienced reforms which were given by the Inspector General of Police Tafa Balogum and officially launched by the then president Olusegun Obasanjo on April 2004. In fact, the reforms were aimed at creating a partnership between the police and the community that would ensure secure and safe environment for all people. The method has since been found to be effective in curbing crime rates as the police are no longer viewed as strangers but rather as partners in development (Ikuteyijo, 2009).

In Kenya, community policing was introduced in 2003 and officially launched by the government in April 2005 to mainly give the public ownership of the problem solving processes which was to be achieved through the police and the community working together. Its main objectives were: to promote long term conditions for development and community safety; build the capacity of the local institutions and people in the co-ordination and implementation of community policing; strengthen the co-operation and the partnership between the police and the public; strengthen interaction between and amongst the government, institutions and civil societies having an interest in promoting peace, safety and democratic policing; improve trust between the police and the community and develop linkage between development and security. Community policing was also to entail police patrols, community-police meetings, neighborhood security meetings, community cooperation with the police reservists and community policing awareness campaigns according to the Republic of Kenya (2004).

Though community policing has been very difficult to implement since its inception in 2003 and with the criminal activities such as terrorism, theft, burglary, housebreaking, armed robbery, murder and inter-ethnic clashes hitting at an all-time high, the government of Kenya has been continuously emphasizing on the need for citizens to cooperate with the government in rolling out community based policy initiatives such as the “Nyumba Kumii” or “ten households” which calls for dividing neighborhoods in towns and villages nationwide into a cluster of ten houses that would help the police protect neighborhoods and guard against criminal activities.

In Nakuru Town, the level of crime has been high as it is among the fastest growing towns in Kenya. According to a research conducted by Security Research and Information Centre (SRIC, 2012) regarding crimes in urban slums in Kenya and specifically Mishomoroni in Mombasa, Kibera in Nairobi, Bondeni in Nakuru and Manyatta in Kisumu, it was found that theft (35.37%), was the main type of crime across the four sampled slum areas. In addition, armed robbery (15.55%), burglary/break-ins (10.67%) and murder (23.17%) were the other main typologies of crime in slum areas, accounting for combined 84.76% of crimes committed in slum areas in Kenya. According to National Crime Observatory Project Bi-Annual Report, (NCOPBAR) (2012), the highest number of crime incidents reported in Nakuru were ‘theft’ and ‘armed robbery’, accounting to totals of 423 and 342 respectively. By extension, analysis from newspaper reports indicated that most of the thefts and robberies occurred in major urban centers, with Nairobi having the highest number followed by Nakuru (NCOPBAR, 2012). Other prevalent crimes reported in Nakuru included, murder, break-ins, domestic violence cases, rape and defilement, assault, kidnappings, and drug/firearm trafficking and possession. Figure 1 gives a summary of the average number of crime incidences of the most prevalent crimes in Nakuru Town between the period 2004 to 2014 (SRIC & NCOPBAR, 2014).
From Figure 1, it is clear that theft, armed robbery, break-ins and murder were some of the crimes which were most prevalent in Nakuru followed by carjacking, kidnappings, domestic violence, cattle rustling, drug and firearm trafficking, assault and arson according to SRIC and NCOPBAR, 2014. Therefore, the study was only limited to the most prevalent crimes which had the highest average number of incidences reported annually. This study focused on theft and break-ins only.

PURPOSE AND OBJECTIVE OF THE STUDY

The purpose of the study was to determine the influence of community policing on incidences of armed robbery in low income areas of Nakuru Town. The study was guided by the following objective:

i. To establish the influence of community policing on incidences of armed robbery in low income areas of Nakuru Town.

Hypotheses

$H_{01}$ There is no statistically significant influence of community policing on the incidences of armed robbery in low income areas of Nakuru Town.

METHODOLOGY

The cross-sectional survey research design was employed in this study. The study was conducted in Four (4) low income areas of Nakuru Town- Kenya. These were: Kaptembwo, Rhonda, Bondeni and Kivumbini. The target population was all the residents in the four low income areas of Nakuru Town, giving a total population of 252,762 from which a total of 156 respondents who participated was drawn. The sample was selected purposively. First, various chiefs in Nakuru Town West and Nakuru Town East wards were identified, and then they assisted in identifying the residents who could provide the required or relevant information. The questionnaire used was researcher-administered. A structured questionnaire was used to obtain information about community policing and incidences of theft and break-ins in the four areas of study. The questionnaire was administered to 131 residents who were available at the time of the research. The questionnaire contained 5 items (indicators of community policing) that were used to measure community policing. The residents were asked whether or not they agreed with the statements under each indicator by ticking Strongly Disagree, Disagree, Not Sure, Agree and Strongly Agree in the boxes which were provided.

RESULTS

The following hypothesis was tested:

$H_{01}$ There is no statistically significant influence of community policing on the incidences of armed robbery in low income areas of Nakuru Town

In this section, the respondents were asked to indicate whether or not community policing has an influence on incidences of armed robbery cases. Results are given in Table I below.
Table 1: The test of hypothesis one (H₀₁)

<table>
<thead>
<tr>
<th>Area of residence</th>
<th>Community Policing Correlation Coefficient Values</th>
<th>Pearson Correlation Coefficient Values</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaptembwo</td>
<td>-.764*</td>
<td>-.764*</td>
<td>.000</td>
</tr>
<tr>
<td>Rhonda</td>
<td>-.089</td>
<td>-.089</td>
<td>.772</td>
</tr>
<tr>
<td>Bondeni</td>
<td>-.356*</td>
<td>-.356*</td>
<td>.012</td>
</tr>
<tr>
<td>Kivumbini</td>
<td>-.799*</td>
<td>-.799*</td>
<td>.002</td>
</tr>
</tbody>
</table>

* - Means significant at 5% level

Table 1 above shows the results of the analysis of the first hypothesis after it was tested: H₀₁ There is no statistically significant influence of community policing on the incidences of armed robbery in low income areas of Nakuru Town. The results are as follows;

There was a statistically significant influence of community policing on the incidences of armed robbery in Kaptembwo, Bondeni and Kivumbini where the Pearson correlation coefficients were -.764 (strong negative correlation), -.356 (low negative correlation) and -.799 (strong negative correlation), with the P-values less than .05. The coefficients (r) were strong, medium and strong negative correlations which mean that an increase in community policing practice leads to significant decrease in incidences of armed robbery in the three areas. Therefore, the null hypothesis (H₀), ‘there was no significant influence of community policing on the incidences of armed robbery was therefore rejected and alternative hypothesis (Hₐ) accepted.

In Rhonda however, the Pearson’s correlation coefficient (r) of the two variables i.e. community policing (CP) and incidences of armed robbery was not significant at 5% level.

Average Correlation of Community Policing with incidences of armed robbery in Low Income Areas of Nakuru Town (combined)

In this section, the correlation of community policing with incidences of armed robbery in low income areas of Nakuru Town (combined) was conducted. Results are given in Table II.

Table 2: The Average Correlation of Community Policing with Armed Robbery in Low Income Areas of Nakuru Town (combined)

<table>
<thead>
<tr>
<th>Area of residence</th>
<th>Community Policing</th>
<th>Armed Robbery</th>
<th>Pearson Correlation Coefficient Value</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Income Areas of Nakuru Town</td>
<td></td>
<td></td>
<td>-.894*</td>
<td>.000</td>
</tr>
</tbody>
</table>

* - Means significant at 5% level

Table 2 above gives the general analysis, Pearson’s Correlation Coefficient (r) of the variables i.e. community policing (CP) and armed robbery combined is -.894 and a significant level of .000 which is less than .05. This means that there is a statistically significant influence of community policing on incidences of armed robbery in low income areas of Nakuru Town. The coefficient (r) is a strong negative correlation which means that as community policing was being practiced; incidences of armed robbery also reduced significantly.

From the hypothesis tested above (objectives), it can be clearly seen that community policing reduced incidences of armed robbery in Kaptembwo, Bondemi and Kivumbini. It is only in Rhonda however, that community policing never reduced incidences of armed robbery at all. When focus group discussions and interviews were conducted, the respondents noted that community policing was reducing armed robberies (Kaptembwo, Bondeni and Kivumbini).

The following are the reasons that the focus group discussion participants and interviewees attributed to that reduction:

The community members conducted frequent community-police joint meetings. The community
members have been able to meet occasionally with the police and have a discourse on issues affecting them. In some of the areas such as Kaptembwo and Kivumbini, community policing meetings were conducted at least once a month. The meetings were chaired by the Officer Commanding Police Station (OCS) or the chief of that area.

Members of the community have cooperated and coordinated with the authorities i.e. the chiefs and the police. In the three areas, the community members through their representatives such as chiefs and community elders have acted as liaison with the police. The community members have also greatly obeyed the instructions from their respective chiefs.

Presence of heavy police patrols in areas known to be crime prone areas. In Kaptembwo, Kivumbini and Bondeni, the police officers have been able to intensify their patrols in areas that the community members marked as being crime prone areas. In Kaptembwo for example, the OCS categorically marked and deployed police officers to conduct heavy patrols around soko mjinga, an area previously known to harbour criminal gangs. The place has since become secure such that anybody can walk freely at midnight without any fear of being attacked.

The chiefs and the OCSs of the three areas have been able to conduct community policing awareness campaigns. Since the chiefs were taken for community policing training, they have played a major role in ensuring that community members in their respective areas have the knowledge of what community policing is all about. Thus more people have been able to embrace community policing hence reducing armed robberies in the three areas.

The relationship between the police and the community members in the three areas have been good thus facilitating the free flow of information between all community policing stakeholders. The community members have been able to provide information to the police regarding an imminent attack or an already executed attack. The same has enables solve crime is the three areas of residence.

Rhonda on the other hand was found to be an extreme / unique case (extreme or unique cases demonstrate unusual manifestations of phenomenon such as outstanding success and notable failures). When quantitative analysis was done, it was found that community policing never reduced armed robberies in Rhonda. The respondents gave the following reasons as contributing to the inefficacy of community policing in Rhonda:

There is lack of cooperation between the police and the community members. Most participants said that the community members feared cooperating with the police since the police also cooperated with the criminals. They explained that when a community member reports a crime to the police, the criminals are notified that they have been reported by person X at the station. That then endanger their lives and as a result, they prefer not to cooperate with the police.

There is lack of trust towards the police by the community. The participants attributed lack of trust to the following reasons; police are very corrupt, police release suspects after getting bribes and the fact that the police cooperate with the criminals.

There is inadequate volunteering of information by the community to the police. The participants said that since they do not trust police and by extension that they cooperate with the criminals, they do not volunteer information to the police thus crimes have continued to occur in Rhonda.

There is lack of community-police joint meetings. The participants said that the relationship between the police and the community members in Rhonda is like heaven and earth hence there is no day that the two sides would hold joint meetings together unless the current police officers in the area are transferred and new ones with knowledge of community policing brought.

The way the police are trained makes it difficult to interact freely with the civilians (community). The OCS in Rhonda said that since police officers are trained in a rough and ruthless way, it was difficult to interact freely and be at the same level with the civilians. By extension, most of the serving police officers were trained using the old British Curriculum and were consistently told that Raia Ni Adai (civilians are enemies) thus cooperating and reasoning with them would make them look more like social workers which they are not.

The community members are not cooperating with the chiefs. The community members in Rhonda are not hiding the advice of the chief as he also cooperates with the police and the criminals as well.
To be able to curb these challenges, most of the focus group discussion participants and the interviewees adduced the following solutions:

Most of the focus group participants in Rhonda advocated for the transfer of police officers in the area and bring forth others who are not used to the area and people.

Strict police recruitment should be done to ensure that only those who qualify are actually recruited. The respondents further explained that the police officers who were recruited through corruption are the same ones asking for bribes so that they recover the finances that they might have lost during recruitment.

Remuneration of the CP representatives should be done. Most of the respondents and especially community policing representatives advocated for remuneration. Some representatives such as community elders argued that they normally use their own money to discharge community policing mandates and as such, they go at a loss because nobody pays them. Some said that community policing would soon collapse if no action is taken in that direction.

Other solutions given include and not limited to addressing unemployment issues, reducing poverty and granting free public secondary education as opposed to subsidized secondary education.

DISCUSSION

According to Charlotte et al (2014), when 25 different studies containing 65 independent assessments were analyzed before and after the introduction of a range of community policing strategies in reducing criminal activities and fear of crime, the findings were that community-policing strategies have a positive effect in the reduction of individuals’ perception of disorderly conduct, including drug dealing. The findings are in agreement with the present paper as community policing strategies such as CPAC, NKI, CPJM, PP and NSM were found to have reduced incidences of armed robbery in Kaptembwo, Bondeni and Kivumbini and not in Rhonda. In Kaptembwo and Kivumbini, all the community policing indicators were found to have reduced incidences of armed robbery under study. In Bondeni, all the indicators were found to be reducing incidences of armed robbery except CPJM and finally in Rhonda, no indicator of community policing had reduced incidences of armed robbery.

According to Gill (2014), the researchers, based at George Mason University, Arizona State University, Hebrew University and the University of South Wales in 2014 in their book “Community-Oriented Policing to Reduce Crime, Disorder and Fear and Increase Satisfaction and Legitimacy among Citizens: A Systematic Review, sought to better understand the effects of community policing on crime, disorder, fear, and citizen satisfaction with and trust in the police. In 27 of the 65 comparisons where official crime outcomes were analyzed, community policing was associated with 5% to 10% greater odds of reduced crime. In 16 of the 65 comparisons, community policing was associated with a 24% increase in the odds of citizens perceiving improvements in disorderly conduct. While this effect was not statistically significant, the odds increased to 35% and became statistically significant when one study with a small number of observations was removed from the analysis. The findings are in agreement with the present study in that community policing has greater odds of reducing criminal activities such as armed robbery as the results show there was a statistically significant influence of community policing on incidences of armed robbery in Kaptembwo, Bondeni and Kivumbini. Naude (1999) posits that the relationship between the community and the police through working in cahoots did immensely resolve and prevent community crimes and social disorders in the United States of America in the early mid-1990. Naude’s suggestions are also in agreement with the findings of this study. It was however only in Rhonda where the CP had no influence on the crime of armed robbery. This implies that environment has an influence on mechanisms of community policing.

CONCLUSIONS

i. Community policing reduces incidences of armed robbery as the coefficient (r) was a strong negative correlation which meant that as community policing was being practiced; incidences of armed robbery also reduced or become ameliorated significantly.

ii. Community policing indicators such as CPAC, NKI, CPJM, PP and NSM are very essential in reducing criminal activities because areas where they were conducted had the greatest crime reduction.

iii. The level of community policing was not uniform in all areas investigated.
iv. There are numerous challenges facing effectiveness of community policing as noted in the areas investigated.

RECOMMENDATIONS

i. The county and the national government should sensitize the public on the need to enhance police-community interaction as a good measure to reduce the rate of armed robbery in the community.

ii. The government should put in place a structure which ensures that the police and the community are able to conduct joint meetings that focuses on security issues affecting the community and how they could be addressed.

iii. The members of the public also need to be sensitized on the importance of embracing community policing in their residential areas and on the need to take care of personal and community property.

REFERENCES


CLIMATE CHANGE AND NATURAL RESOURCES
MORPHOMETRIC ANALYSIS OF WATERSHEDS FOR FLOOD RISK ASSESSMENT USING QGIS

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ABSTRACT

There is a greater risk of flood damage to infrastructure, property and settlements thus affecting economic development. Moreover, the frequency of floods is expected to increase in the face of climate change. A flood forecast system is, therefore, essential in developing strategies for limiting the damages caused by floods. However, in many developing countries with observed flood incidences, the lack of gauging stations within the drainage basins inhibits the implementation of a full flood forecast system. There is need to provide risk assessment for potentially vulnerable and flood prone areas in light of climate change and population pressure. Within ungauged basins, the morphology of the basin may be used because it intrinsically contains information that is useful in indicating the flood exposure of an area. The availability of the global 30 meter Digital Elevation Models (DEM) has further contributed to the improved accuracy of the basin morphology. This paper describes a workflow that may be used to derive and combine the morphometric parameters of a drainage basin within QGIS, an open source GIS software, for the purpose of assessing flood exposure. Initially the stream network is modelled and redefined to conform to the definition of Strahler streams. Outlet points were objectively generated on the redefined stream segments and used to delineate the watersheds. The geomorphometric parameters were derived from the computed stream and watershed networks, and normalized. The flood risk for each watershed has been quantified based on the relationship between the stream as well as watershed geomorphometry and the transmission of water. This method may, therefore, be used to provide a tentative analysis of the flood exposure of any drainage basin for any part of the world.

Keywords: DEM, Flash Floods, Geomorphometry, QGIS, Risk

INTRODUCTION

Flooding is the most common environmental hazard worldwide (NDA, 2015) and has the greatest damage potential of all natural disasters (United Nations, 2004). There is a higher risk to flood hazards due to climate change and population pressure. The negative consequences of floods include casualties, damage to property, lost livelihoods, disrupted economic activities, damage to the environment and psychological distress to those who are affected. The Hyogo Framework for Action (HFA, 2005-2015), which was developed as a guideline on building the resilience of nations and communities to disasters defines the initial step to reduce disaster risk as lying in the knowledge of hazards and vulnerabilities and the way they change over time. This knowledge must be followed by an action plan.

Risk assessment to determine the nature and extent of flooding and other disaster risks involves analyzing the hazard and evaluating the existing conditions of susceptibility. This assessment may be used in the development of land-use plans, insurance mechanisms and disaster risk reduction policies. Efforts in flood risk assessment include collecting all available information such as meteorological data and mapping at different scales (de Moel et al., 2009) and the use of large-scale physical models of rainfall-runoff and river routing (Pappenberg et al., 2012). However, in many developing countries in Africa, Asia and South America, with observed flood incidences, there is a relatively poor density of gauging stations (Herold and Mouton, 2011). This limits the implementation of a full flood forecast system since the hydrological response cannot be modelled.

A tentative assessment of the flood exposure of a watershed may be determined through quantitative terrain analysis or geo-morphometry. This may be used to reveal information such as the magnitude of peak and mean runoff and subsequently the level of flood exposure of a watershed from parameters such as slope, drainage density, basin shape and area, channel gradient as well as basin relief. One of these assessments is provided by Schröder and Omran (2013). The provided workflow for flood risk assessment based on geomorphometry involves delineation of streams and watersheds from a Digital
Elevation Model (DEM), and then computing and combining geomorphometric parameters to derive a flood hazard map.

Delineation of streams is achieved through preconditioning of the DEM by filling its pits and depressions. From the filled DEM, flow direction and accumulation is determined. To extract the drainage network, a threshold value is applied to the accumulation grid. The threshold represents the area or discharge value required to initiate and maintain a water head. It is one of the critical values which influences the characteristics of the extracted drainage network such as length and density. The extracted streams are ordered according to some rules such as the Strahler (1964) order. Stream outlets are then used to delineate the watersheds. The stream network and watersheds are vectorized and used to compute the geomorphometric parameters which are then classified, ranked and combined to provide a flood risk index for each watershed.

MATERIALS AND METHODS

Study Area
The selected study area for implementing the workflow includes the Breg and Brigach sub-catchments located in the state of Baden-Württemberg, Germany covering a total area of 1080.2 km². The Breg and Brigach rivers form the headstreams for the Danube, the longest River within the European Union. The region has previously suffered frequent extreme floods caused by a combination of intense rain and simultaneous snow melt from the Black Forest. The western part of the selected study area is characterized by a relieved low mountain range with altitudes of between 770 m and 1100m above sea level. The Eastern part of the study area is characterized by low lying flat topography. Metamorphites and sandstone are found in the western part of the study area while the eastern part has areas with limestone and mudstone. Figure (1) shows the location of the study area. In addition, the study area is selected because of the availability of reliable reference stream network which was used in this study to compare the existing reference streams with the delineated stream networks.

Delineation of Stream Network and Watersheds from a DEM
The following workflow was implemented within QGIS, an open source GIS software. Initially, data errors in the form of pits were filled to ensure that there was continuity of flow. From the resulting filled DEM, flow direction was assigned using Deterministic 8 (D8), a single flow direction algorithm developed by O’Callaghan and Mark (1984). The flow accumulation grid was then computed from the flow direction grid. Upward curved cells were determined and applied as a weight field to the flow accumulation grid to identify the most probable channel cells.

The critical value to initiate the streams was determined through stream (constant) drop analysis (Tarboton and Ames, 2001; Tarboton et al., 1992; Broscoe, 1959). The drop of a stream refers to the difference in elevation between the start and end of a stream. The mean drops of the first order streams and higher order streams were compared against each other in a t-test and the threshold value resulting in smaller statistical differences was selected as the most suitable. The selected value was applied to the weighted flow accumulation grid to determine the channel cells. The selected stream channel cells were ordered according to Strahler rules and then vectorized.

The delineated streams were then redefined to conform to the definition of Strahler streams. By definition, sequential stream segments of the same order form a Strahler stream. Contrary to this definition, at every intersection, a new stream segment was formed resulting in a higher stream count. The sequential streams of the same order were, therefore, identified and merged to form a single Strahler stream. The watersheds were then delineated by first identifying a stream outlet and delineating its contributing area. An outlet is defined as the point on each stream segment with the highest accumulation value as well as the lowest elevation. For each stream, therefore, a watershed was delineated and assigned an order number corresponding to the stream segment within it with the highest order number.

Computing Geomorphometric Parameters
The geomorphometric parameters rely on characteristics of the stream network and watershed. They are broadly classified into linear, areal and relief parameters which reveal one, two and three dimensional properties of the hydrologic networks and watersheds. The parameters computed within this study are shown in table (I). Within QGIS, in built functions were used to determine geometries such as length and count of the streams as well as perimeter and area of the watersheds. The length of the streams were used in computing the drainage density and drainage frequency within each watershed. Geoprocessing tools were used to obtain stream counts of each order within a
watershed. Stream count was then used to determine parameters such as bifurcation ratio and stream frequency. The relief geomorphometric parameters for each watershed were determined using zonal statistics. The watershed defines the zone of interest while elevation values are provided by the DEM. Additional morphometric parameters were calculated using the field calculator.

**Flood Risk Assessment**

A multi-criteria approach was adopted in determining the flood risk assessment of the watersheds by combining the computed geomorphometric parameters. The computed geomorphometric parameters were initially normalized to a common evaluation scale. In this study, the selected range of values was one to ten (1-10) where 1(one) represents low flood risk while 10(ten) represents a high flood risk. The normalization equation as demonstrated by Omran (2012) is given below.

\[ X_j = \frac{(R_j - \text{Rmin})}{(R_{\text{max}} - \text{Rmin})} \]

where: \( X_j \) is the normalized score, \( R_j \) is the raw (calculated) score, and \( (R_{\text{max}} - \text{Rmin}) \) is the range of the raw scores.

The relationship between the morphometric parameter and the risk of flooding determined how the normalization range was set. For parameters such as the drainage density, basin area and circularity ratio which are directly proportional to the risk of floods, the minimum values were set to 1 while the maximum values were set to 10. All other values were normalized within this range. Parameters such as the bifurcation ratio and basin area have an inverse relationship to the risk of floods, so the maximum value was set to 1 while the minimum value was set to 10. This meant that a low bifurcation value would have a high flood risk index and vice versa. For each watershed, a flood risk index was obtained by combining the geomorphometric parameters using arithmetic operations. To provide a visually interpretable map of the watershed’s flood risk index, the values were classified using equal interval classification.

**RESULTS AND DISCUSSION**

**Extracted Stream Network**

The optimum threshold value obtained from the stream drop analysis was used to define the channel cells. The selected value of 161.87 m² from the weighted accumulation grid had an absolute t-test value less than 2, which is the 95% confidence interval. Table (II) shows a section of the results of the constant drop analysis. In the first column, different thresholds were determined on a logarithmic interval. For every evaluated threshold, its corresponding drainage density, number of first order and higher order streams, the average drop of the first order and higher order streams as well as the standard deviations of the first order and higher order streams were subsequently determined. Higher threshold values resulted in higher drainage densities and vice versa. The highest order stream according to Strahler rules was the Order 5 stream.

The extracted stream network (Figure 2, left) was compared to the reference stream network (Figure 2, right). Since the reference stream network was unordered, quantitative comparison was not possible. A qualitative comparison is thus shown. The mean drainage density of streams within a neighborhood of 50 pixels was computed. The value of 50 pixels represented the average number of pixels contributing drainage to a headwater stream in the study area. A lower drainage density was obtained at the hillslopes while a higher drainage density was obtained in the low lying flat areas relative to the reference stream network. A lower drainage density on the hillslopes indicates that a lower threshold value was applied. Within the relatively flat areas of the study area, the higher drainage density implies that the 30m resolution of the DEM was not sufficient to capture the slight variations in terrain. The parallel streams in the flat areas (plains) shows that flow was forced from high areas to low-lying flat areas.

**Watersheds**

Outlet points (Figure 3) were generated on each stream segment by identifying the point along each segment with the lowest elevation as well as the highest contributing area value. The decision to use both the elevation and contributing area information is so that only one point (pixel) per stream is selected as the outlet point. While it is possible for two neighboring points (pixels) have the same elevation value, the probability of both points having the same accumulation value is low. The outlet points were used to define the contributing area for the corresponding stream segment, thus defining the watersheds. Watersheds of streams of order 1 to order 5 (based on the Strahler order) were delineated. These watersheds form the basic spatial units for which the geomorphometric analysis is performed. (4) shows an example of an order 5 watershed containing all the land surface and stream segments contributing drainage to the order 5 stream.

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*11th Egerton University International Conference and Innovation Week*
Geomorphometric Parameters and Flood Risk Map

Two examples of the normalized parameters for order 3 watersheds are visualized individually (Figure 5). The values of the parameters are grouped into three classes using equal interval classification which are labelled as low, medium and high risk. Figure (5, left) shows the basin area parameter. Smaller basins have a higher risk of flooding. The bifurcation ratio like the basin area has an inverse relationship to flood risk as is visualized in figure (5, right). Parameters such as the drainage density and frequency, circularity and elongation ratios, and relief ratio indicate high discharge, peak time and volume hence a higher flood risk. In this study, equal weights for the parameters were assumed. The parameters were summed together to derive the flood risk index for each watershed as shown in figure (6). The flood risk map was classified into four classes using the equal interval classification. Smaller watersheds with higher drainage densities, high elongation ratios, and lower bifurcation ratios have a higher risk of flooding.

CONCLUSION

The morphometric analysis of a drainage network and the corresponding watersheds may be used to provide a tentative assessment of the watershed’s risk of flooding. The workflows described were modelled within QGIS, an open source GIS software while the base data used was the 30m DEM. This makes it possible to use this assessment in any part of the world since global coverage data is freely available while there exists many suitable algorithms within QGIS to undertake the morphometric analysis of watersheds. These algorithms exist either as built in tools or as plugins from external providers such as Terrain analysis using DEM (TauDEM), Geographic Resources Analysis Support System (GRASS) and System for Automated Geoscientific Analyses (SAGA).

Delineating streams is the most critical task as this will determine the accuracy of the morphometric parameters. In this study, the constant drop analysis was used to determine the most suitable threshold value for initiating streams. The selected threshold was however insufficient as indicated by the relatively lower drainage density obtained. This, combined with the low resolution of the DEM, resulted in an inaccurate drainage density over the study area. There exists other spatially adaptive algorithms and methods for defining stream segments. A comparison of these methods may be undertaken to determine the optimal conditions within which these methods may be used.

The level of influence of each parameter on the risk of floods is not sufficiently known. In this study, equal influence was assumed. The parameters may, further, be correlated with the hydrological response to understand the level of influence on the flood risk. Finally, there exists global coverage DEMs from both Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) as well as Shuttle Radar Topography Mission (SRTM). A comparison of both datasets may be undertaken to determine which is better suited for hydrological and related studies.

REFERENCES


FIGURES AND TABLES

Figures

Figure 1: Map showing the Breg and Brigach catchments within the state of Baden-Württemberg, Germany.

Figure 2: Average stream densities for the computed streams (left) and the reference stream networks (right).

Figure 3: Pour points generated on every stream segment.
Figure 4: A watershed with its corresponding streams and outlet point (in green).

Figure 5: Classified basin area (left) and bifurcation ratio (right) of the order 3 watersheds.

Figure 6: Flood risk map of the order 3 watersheds.
Tables

Table I: Linear, Areal and Relief Geomorphometric parameters under consideration in this study

<table>
<thead>
<tr>
<th>Linear Parameters</th>
<th>Symbol</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stream Order</td>
<td>Sμ</td>
<td>Hierarchical rank</td>
</tr>
<tr>
<td>Bifurcation Ratio</td>
<td>Rb</td>
<td>Rb = N / N +1 Where, Rb = Bifurcation ratio, N = No. of stream segments of a given order and N +1= No. of stream segments of next higher order.</td>
</tr>
</tbody>
</table>

Areal Parameters | Symbol | Formula |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Basin Area</td>
<td>A</td>
<td>The area from which water drains into a common stream and boundary determined by opposite ridges.</td>
</tr>
<tr>
<td>Drainage Density</td>
<td>Dd</td>
<td>Dd = L /A Where, Dd = Drainage density (Km/Km2) L = Total stream length of all orders and A = Area of the basin (Km2).</td>
</tr>
<tr>
<td>Drainage Frequency</td>
<td>Fs</td>
<td>Fs = N /A Where, Fs = Drainage frequency. N = Total no. of streams of all orders and A = Area of the basin (Km2).</td>
</tr>
<tr>
<td>Infiltration Number</td>
<td>If</td>
<td>If = Dd x Fs Where, Dd = Drainage density (Km/Km2) and Fs = Drainage frequency.</td>
</tr>
<tr>
<td>Circularity Ratio</td>
<td>Rc</td>
<td>Rc = 4πA/P2 Where, A = Basin area (Km2) and P= Perimeter of the basin (Km)</td>
</tr>
</tbody>
</table>

Adapted from Hajam et. al, 2013

Relief Parameters | Symbol | Formula |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Basin Relief</td>
<td>H</td>
<td>H = Z - z where Z = Maximum elevation of the basin (m) and z = Minimum elevation of the basin (m)</td>
</tr>
<tr>
<td>Relief Ratio</td>
<td>Rr</td>
<td>Rr = H / Lb where H = basin relief (m) and Lb = Basin length (m)</td>
</tr>
<tr>
<td>Basin Slope</td>
<td>Sb</td>
<td>Sb = H / Lb where H and Lb are given above</td>
</tr>
</tbody>
</table>

Table II: A section of the constant drop analysis result showing the selected threshold

<table>
<thead>
<tr>
<th>Threshold</th>
<th>DrainDen</th>
<th>No. of First Order</th>
<th>No. of High Order</th>
<th>Mean Drop of First Order</th>
<th>Mean Drop of High Order</th>
<th>StdDev of First Order</th>
<th>StdDev of High Order</th>
<th>T-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>122.10</td>
<td>1.42E-02</td>
<td>340</td>
<td>86</td>
<td>49.382</td>
<td>70.686</td>
<td>64.068</td>
<td>72.483</td>
<td>-2.681</td>
</tr>
<tr>
<td>134.135</td>
<td>1.35E-02</td>
<td>309</td>
<td>76</td>
<td>50.515</td>
<td>71.553</td>
<td>68.616</td>
<td>69.370</td>
<td>-2.389</td>
</tr>
<tr>
<td>147.353</td>
<td>1.30E-02</td>
<td>277</td>
<td>71</td>
<td>51.939</td>
<td>70.873</td>
<td>68.870</td>
<td>71.716</td>
<td>-2.049</td>
</tr>
<tr>
<td>161.873</td>
<td>1.25E-02</td>
<td>256</td>
<td>66</td>
<td>52.508</td>
<td>69.924</td>
<td>69.080</td>
<td>73.434</td>
<td>-1.803</td>
</tr>
<tr>
<td>177.824</td>
<td>1.19E-02</td>
<td>231</td>
<td>61</td>
<td>54.197</td>
<td>68.393</td>
<td>75.388</td>
<td>72.985</td>
<td>-1.317</td>
</tr>
<tr>
<td>195.347</td>
<td>1.13E-02</td>
<td>203</td>
<td>51</td>
<td>55.305</td>
<td>68.373</td>
<td>77.191</td>
<td>71.071</td>
<td>-1.097</td>
</tr>
<tr>
<td>214.597</td>
<td>1.08E-02</td>
<td>180</td>
<td>46</td>
<td>59.133</td>
<td>67.130</td>
<td>78.406</td>
<td>71.384</td>
<td>-0.628</td>
</tr>
</tbody>
</table>

Adapted from Hajam et. al, 2013
DIFFERENTIATED COSTS AND BENEFITS OF CONSERVATION:
DECENTRALIZED WILDLIFE MANAGEMENT IN TANZANIA

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ABSTRACT

This paper attempts to understand the differentiated costs and benefits of implementing a community based approach to wildlife conservation through decentralized environmental governance. Based on a survey of communities in 7 villages within and outside Idodi-Pawaga Wildlife Management Area (WMA) in Iringa district, Tanzania, we find that direct benefits to communities from conservation have proven to be elusive. Efforts to ensure direct benefits to communities from conservation are jeopardized by individual costs due to curtailed access to the WMA, perceived as an opportunity cost to their livelihoods. This trend continues despite the promises of community participation, equity, accountability, democratization and transparency in this community based approach to conservation. We argue that achieving a win-win scenario between conservation and development objectives can be challenging. Nonetheless, we recommend a more transparent sensitization of communities, a limited number of participating villages and capacity building in negotiating investment contracts in the WMAs. This can contribute to realizing tangible benefit and offset the costs of conservation to local communities.

Key words: conservation, decentralization, costs and benefits, Wildlife Management Areas, Tanzania

INTRODUCTION

Environmental degradation and biodiversity loss continues unabated despite global efforts to address the problem. Increasing poverty levels, and increased consumption (McShane et al., 2011) decline in conservation funding and increased attention to high profile issues such as climate change (Agrawal and Redford, 2009) have shifted, to some extent the attention to biodiversity-related problems such as declines in populations, habitat degradation and species extinction (Adams et al., 2004). Meanwhile, the need to halt environmental degradation and alleviate poverty is of paramount importance particularly in rural areas. It has been suggested that environmental degradation and other biodiversity related problems can be reduced through integrating conservation and development programmes (McShane and Wells, 2004). In the past three decades, there have been massive investments and advocacy in programmes popularly known as Integrated Conservation and Development Approaches (ICDPs)1 (Adams and Hulme, 2001; McShane et al., 2011; Oldekop et al., 2010; Roe et al., 2009; Songorwa, 1999; Suich, 2010). These programmes are usually implemented through decentralized governance regimes, in which powers and authority are devolved towards actors at the local level (Agrawal and Gupta, 2005; Agrawal & Ostrom, 2001; Agrawal and Ribot, 1999).

In the wildlife conservation sector, notable efforts in the past three decades in decentralizing wildlife management have received mixed results (Agrawal and Gibson, 1999; DeGeorges and Reilly, 2008; Goldman, 2003; McShane et al., 2011). Studies on the success of this approach point to perceived failures in design, implementation process, and the apparent inability to realize the intended benefits (Igoe and Croucher, 2007; Songorwa, 1999). Examples of success are more of the exception not the rule (McShane et al., 2011). Much focus has been on conservation and simplistic understanding of approaches that integrate conservation and development (Roe et al., 2009).

This paper attempts to understand how differentiated costs and benefits of wildlife conservation are shaped by the decentralized governance approach through Community Based Conservation (CBC). The paper is based on empirical field research in Idodi-Pawaga Wildlife Management Area (WMA) situated in the...
larger Rungwa-Ruaha Ecosystem south western Tanzania. To better understand this, we follow Adams and Hulme (2001) in asking whether (1) the available wildlife resources can yield sustainable revenue flow, i.e. can the revenue from wildlife resources compete with alternative forms of land use, and offset the costs of conserving wildlife (2) revenue from wildlife resources is sufficient to ensure the support of local actors, and (3) how conflicts in revenue sharing may jeopardize the intended benefits of conservation. This WMA is of interest because it is one of the celebrated WMAs that have been implementing CBC over more than two decades. For this reason, it has continuously attracted interest and investments from various actors in the CBC approach, and there is no evidence that this will end soon. Moreover, the WMA is an important component of the Rungwa-Ruaha Ecosystem that harbours important species of flora and fauna and important ecosystem services. Understanding the benefit sharing mechanisms in the CBC projects is critical to not only understand the linkages between conservation and development in temporal and spatial dimensions, but also factors that account for failure to achieve both objectives.

Decentralization and Community Approaches to Conservation

We follow Ribot et al., (2006, p. 1865) in defining decentralization as “any political act in which central government formally cedes power to local actors and institutions at lower levels in a political-administrative and territorial hierarchy”. This implies the act in which central governments supposedly transfer powers and authority to make decisions over the use of natural resources to local actors (Larson and Soto, 2008; Ribot et al., 2006). On the other hand, Lemos and Agrawal (2006, p. 298) define environmental governance as a “set of regulatory processes, mechanisms and organizations through which political actors influence environmental actions and outcomes”. Decentralized environmental governance can be used as a mechanism through which powers and authority are supposedly devolved to local actors who are downwardly accountable. Local actors are assumed to exercise some levels of autonomy in making decisions related to environmental issues and, in order to achieve this, sufficient discretionary powers is an important component in the institutional set up ensuring efficiency, equity and development (Ribot, 2003).

Community approaches in achieving development and environmental conservation goals gained popularity among international development organizations, conservation organizations and government bureaucrats (Neumann, 1997). This was a result of the perceived failure and unpopularity of strict conservation approaches, commonly known as fortress conservation (Adams and Hulme, 2001; Brockington, 2002; McShane et al., 2011; Nelson & Agrawal, 2008; Songorwa, 1999). However, Berkes (2004, 2006) and Adams and Hulme (2001) cautions that CBC is not a ‘panacea’ for conservation. Debates in the environmental conservation have ensued on the efficacy of this approach, and examples of their success are rare (Kellert et al., 2000; McShane et al., 2011; Oldekop et al., 2010; Songorwa, 1999). In many cases, projects that seek to integrate conservation and development have tended to be highly ambitious and underachieving (Adams et al., 2004; Newmark and Hough, 2000), prompting a resurgence of the protectionist approaches to conservation (Oldekop et al., 2010). In East and Central Africa, Nelson (2012) argue that efforts undertaken in the past 20 years to empower communities to have greater rights and control over resources have not had the intended impacts due to institutional and political forces. An important element to this debate is the emphasis on learning and understanding the conditions under which CBC does or does not work, and not why CBC work or does not work (Adams and Hulme, 2001; Berkes, 2004). In the following section, we present case study on the costs and benefits of the CBC approach as experienced by local communities in the Idodi-Pawaga WMA, along the larger Ruaha-Rungwa Ecosystem.

STUDY AREA AND METHODS

Study Area

Idodi-Pawaga WMA is situated in Iringa District, south-western part of Tanzania (Fig 1) Administratively, it is located in Idodi and Pawaga divisions, Iringa district, in Iringa region, hence the name. The WMA falls between latitudes 6.9° to 8.0° and longitudes 34.8° to 35.7° E., Lunda-Mkwambi Game Controlled Area (LMGCA). It borders Ruaha National Park (RUNAPA) to the West and North - West, Usangu Game Reserve (UGR) to the South and Lunda-Mkwambi Game Controlled Area (LMGCA) to the north. The WMA is formed by 21 member villages located to the east and north east. The WMA covers an area of about 777 km² of village land adjacent to Ruaha National Park.
The WMA is part of the larger Ruaha Ecosystem that comprises different categories of protected areas. These include RUNAPA, Rungwa, Muhesi and Kigosi Game Reserves (GR), two forest reserves with different management approaches (Table 1). The Ruaha Ecosystem is important in maintaining biodiversity connectivity; protecting migratory routes and species which could not otherwise be protected in isolated protected areas, and maintain the general ecosystem functioning and important ecological processes (Abade et al., 2014).

The WMA traverses a diverse vegetation of Miombo and Acacia woodlands. This vegetation diversity provides excellent habitat to 64 mammal species, reptiles, amphibians, fish, about 500 species of birds, and insects (MBOMIPA, 2014). As a result, the diverse vegetation and wildlife species presents an opportunity to assess wildlife conservation as an alternative land use to the local communities, in line with the Wildlife Policy of Tanzania (WPT).

Its biological diversity notwithstanding, the area is suitable for agriculture; particularly rice cultivation along the Great Ruaha River. Communities are mainly engaged in intensive cultivation in irrigated farms along Ruaha River and Mtera Dam through traditional and improved canals and schemes (IDC, 2013; USAID, 2000). Other crops include maize, sugar cane, vegetables, Irish potatoes, banana, and sweet potatoes. Although Pawaga and Idodi division occupies about two thirds of the total land area in Iringa district, they
have the least habitable and arable land for human activities (IDC, 2013). The district has a total population of 254,032, of which 123,243 are male and 130,789 are female, residing in 123 villages. Idodi and Pawaga divisions have a total population of 26,503 and 33,229 respectively, accounting for 24% of the district’s total population (MBOMIPA, 2014). However, there has been a rapid increase in population in the ecosystem due to immigration of other ethnic groups searching for better pasture, soils, water and settlements (Dickman, 2009; Williams, 2007). Furthermore, National level policies to improve agriculture and food security, such as the Southern Agriculture Growth Corridor of Tanzania (SAGGOT) threatens even more intensive agriculture in the ecosystem Consequently, increased pressure from both agriculture and livestock keeping renders the protection of the WMA and other protected areas increasingly difficult in the face of competing land uses.

Table 1: Categories of protected areas, administration and land use classification with regards to wildlife use in the Ruaha Ecosystem

<table>
<thead>
<tr>
<th>Category of PA</th>
<th>Number</th>
<th>% of total land surface</th>
<th>Size (Km²)</th>
<th>Types of use</th>
<th>Human settlement allowed</th>
<th>Administered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ruaha National Park</td>
<td>1</td>
<td>56.2</td>
<td>20,226</td>
<td>Non-consumptive</td>
<td>No</td>
<td>Tanzania National Authority (TANAPA) Parks</td>
</tr>
<tr>
<td>Rungwa, Kigosi and Muhesi Game Reserves</td>
<td>3</td>
<td>41.7</td>
<td>15,000</td>
<td>Consumptive/non-consumptive</td>
<td>No</td>
<td>Wildlife Division (WD)</td>
</tr>
<tr>
<td>Wildlife Management Area</td>
<td>1</td>
<td>2.1</td>
<td>777</td>
<td>Consumptive/Non consumptive</td>
<td>No</td>
<td>Wildlife Division, Iringa District Councils, MBOMIPA Authorized Association.</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>35,976</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Coppolillo and Dickman,(2007); MNRT (2013).

Idodi-Pawaga WMA in the Context of CBC in Tanzania

Commonly referred to as MBOMIPA, a Swahili acronym for Matumizi Bora ya Malihii Idodi na Pawaga (Sustainable use of Wildlife resources in Idodi and Pawaga), the WMA is one of the first pilot WMAs, established according to the Wildlife Policy of Tanzania 1998 (WPT) and WMA (2003). Like other pilot WMAs, had to undertake the arduous process of formalization in accordance to the WMA regulations and guidelines (Igoe and Croucher, 2007; MNRT, 2002, 2012; WWF, 2014). It was officially gazetted in 2007 and granted user rights in the same year under MBOMIPA as the Authorised Association (MNRT, 2013).

Study Design and Data Collection

Both primary and secondary data were used in this study, collected from November 2014 to February 2015. Primary data were collected from seven villages, namely Tungamalenga, Malinzanga, Mbuyuni, Itunundu, Mnadani, Makuka and Kipera. Quasi experimental design was employed to allow for retrospective comparison of outcomes between participating and non-participating groups in the WMA implementation process over a period of 10 years (Campbell & Stanley, 2015; Cook, 1979; Shadish, Cook, and Campbell, 2002; Songorwa, 1999). Four villages (Tungamalenga, Malinzanga, Mbuyuni and Itunundu) participating in the WMA process were purposefully selected to form the ‘experimental group’ while three villages (Mnadani, Makuka and Kipera) formed the ‘control group’ for the study (Fig 2). The control group villages formed part of this ecosystem and had similar social economic characteristics to the experimental villages before and during the implementation of CBC (see also Kangalawe and Noe, 2012; Noe and Kangalawe, 2015).

Household questionnaires were administered to randomly selected households in all 7 villages. In total 210 household questionnaires (30 per village) were
administered to all 7 villages. The questionnaires were administered by the principal researcher, with assistance from three previously trained research assistants and a local guide. The interviews were conducted in Swahili after translating the questionnaire. The local guide was responsible for identifying the households and arranging meetings with key informants and also helped in translation where it was not possible to communicate in Swahili. The household questionnaire covered a range of topics from the general social economic characteristics, natural resources use, livestock keeping, and knowledge of the WMA, participation in the WMA creation and implementation activities, attitudes in the overall benefits and costs of conservation, land uses, poaching, income governance, and investment opportunities in the WMA.

After data cleaning and processing, a total of 207 questionnaires were statistically analyzed. In addition to the household questionnaire, participatory Rural Appraisal (PRA) methods (as described by Chambers, 1994a, 1994b) and Conroy (2002) were employed. Particularly, Focus Group Discussions (FGDs) were used at the village level in all 7 villages sampled using pre-designed open-ended questionnaire. To ensure heterogeneity of the participants, the composition of the focus groups included village and sub-village level leaders, elders, influential people, women, the youth, government officials and members of the village natural resources committee-all accounting for 15-20 participants per group. The discussions were normally conducted in Swahili. Important issues were identified and transcribed while, with their consent, the discussions were tape recorded for further analysis. Another primary source of data included Semi structured interviews conducted with village and MBOMIPA association leaders in the participating villages. Key informant interviews were conducted with wildlife officers at the community and district level, and Tanzania National Parks (TANAPA) officials in the bordering RUNAPA in order to obtain an in-depth information and knowledge on the WMA implementation.

Secondary data for this study included reports and publications obtained from the village, project, district and national levels. The MBOMIPA office in Tungamalenga village, Idodi division and the District Game officer’s office in Iringa provided important baseline information on the WMA, while the Wildlife Division (CBC section) was invaluable for the national level reports on the implementation of WMA. Other sources of Secondary data included the African Wildlife Foundation and the WWF (Tanzania Country Office) who provided valuable information related to the various WMA assessment conducted over the last decade. The Statistical Package for Social Sciences (SPSS) software (Version 16.0, SPSS Inc, and USA) and Microsoft Excel computer software were used for all statistical analyses.
RESULTS AND DISCUSSION

Benefits and Costs from the WMA and Competing Land Uses
The general assumption of CBC programmes is that economic benefits would change communities’ attitudes and behaviour towards wildlife and that wildlife can compete with other forms of land use (MNRT, 2007; Songorwa, 1999). This is largely not the case as it tends to ignores people’s history and interactions with wildlife (Alexander and McGregor, 2000), as well as the competitiveness of other forms of land use such as agriculture and livestock keeping.

Results from household surveys indicate that majority of the households depend on agriculture as their main source of cash income. Respondents were asked to indicate their average income obtained from various livelihood options in order to compare the importance of various sources of income to their livelihoods. Results show that cash income is mainly derived from agriculture (both selling and consumption of agricultural produce). Nothing from wildlife was reported to have contributed to cash income and very little from forest products (Fig 3). Tungamalenga village appears to be the wealthier among the other sampled villages. The General Management Plan for
MBOMIPA support this finding by listing Tungamalenga village as one of the villages with the highest household income in Idodi division with an average of $318 per year (MBOMIPA, 2014). This is mainly due to booming tourist activities (e.g. tourist lodges and tented camps) owing to its proximity to RUNAPA. Agricultural activities are also intensive in the area.

![Fig 3: Average income per year (In TSh) from various livelihood sources in Idodi-Pawaga WMA](source)

Source: Field data, 2014. 1$=2200Tsh

According to Idodi-Pawaga WMA reports, revenue from wildlife related activities from 2002/2003 financial year to 2011/2012 financial year amounted to Tanzania shillings 914,777,113 (roughly $415,807 or $37,800 per year). If this income was to be distributed equally to the population in participating villages; currently at 59,732 (MBOMIPA, 2014) each individual would receive a mere $0.63 per year (1392Tsh). Compared to earnings from agriculture, clearly this is far from making wildlife conservation a competitive land use option and offset the costs of conservation.

To elucidate individual wildlife costs, respondents were asked on the experience of problem animals and their associated damages and impacts. Results indicate that opportunity cost of the WMA to individuals included loss of land for agriculture and grazing, loss of rights to access, increased attacks by wildlife, as well as fines and penalties due to encroachment and poaching (Fig 4). Loss of crops due to crop raiding by wildlife, loss of land for agriculture and livestock predation by wildlife, fines and penalties for breaching wildlife laws were the major concerns by the respondents associated with the presence of the WMA.
Figure 4 depicts trends in revenue (in $) from 2002 to 2013. There is a notable variation in revenue over the years ($=6.38, P ≤0.05). This is mainly due to the official granting of wildlife user rights to the WMA in 2007 that led to a significant increase in direct revenue to the WMA. A significant drop in the 2010/2011 financial year was attributed to conflicts in investment contracts related to tourist hunting; hence very little revenue was obtained.
In other CBC programmes in Tanzania, channelling of wildlife related revenues has also been the practice where the large share of income is directed towards development activities at the community level and not at the household level. In Burunge WMA, located in the northern tourist circuit, Igoe and Croucher (2007) observe that although the WMA is envisaged to generate $230,000 per year for 45,000 people, this equals to $5.20 per year per person. Similarly, Mwakaje et al. (2013) report that in the average household income from conservation for 20 villages in the Serengeti ecosystem is $9.65. With this kind of benefit, they argue, “nobody in the community would appreciate the existence of protected areas…” (Mwakaje et al., 2013, p. 61). In Ikona WMA, it was observed, albeit the WMA receives significant amount of revenue from investors and the state (through revenue sharing in tourist hunting blocks), there is general lack of transparency at the village level on the actual amount Ikona WMA received from investors (Robinson and Makupa, 2015).

**Dependency on Natural Resources, Land Use Plans and Curtailing of Access to Resources**

To determine the respondents’ dependency on natural resources respondents were asked to identify their main sources energy for cooking and heating; and their means of acquisition. Majority of the respondents indicated firewood as their main source of energy (N=247). It is acquired mainly through own collection from their surroundings and nearby PA (Fig. 6a, b, N=232).

![Graph a)](image)

**Fig 6: Main sources of energy for the respondents (a) and their means of acquisition (b)**

Rapid population growth rate in the area, accentuated by immigration (Dickman, 2009; Williams, 2007) has exacerbated encroachment in the WMA and other PAs in the ecosystem for fuel wood, timber and other forest products has not decreased. The immigration to the area by the pastoralist groups such as the Maasai and Barbaig has intensified the pressure for more land not only for livestock keeping but also for cultivation as a means for livelihood diversification (Dickman, 2009). For example, respondents in focus group discussions reported that there had been encroachment in the WMA for rice cultivation. This conforms to earlier suggestion by Goldman (2003) that land use plans, required in the WMA implementation process, often
ignore the traditional land use techniques and social organizations that have been in place.

In addition to curtailing access to resources in ‘protected areas’, land use plans usually help to safeguard the interest of conservation (safeguarding wildlife migratory corridors, dispersal areas, critical water sources) and in effect disciplines local communities to excluding themselves from their own land (Benjaminsen et al., 2013; Igoe and Croucher, 2007; Neumann, 2001). According to Adams and Hulme (2001), benefit sharing in CBC projects is often too small to permanently compensate local communities who frequently forego their rights of ownership to a particular land area (opportunity cost). As a result, they tend to re-occupy the land whenever an opportunity arises.

Disputes in Investment Contracts and their Impacts on WMA Revenues
Notwithstanding the notable increase in revenues over the years since its inception, there remains a potential for more revenue from wildlife related activities in the area if internal conflicts with regards to investment contracts are resolved, and transparency and accountability are improved. Results from key informant interviews and focus group discussions indicate that disputes in investment contracts have contributed to the slow implementation of WMA activities and loss of revenue from potential investors. For instance, the drop in revenues in the financial year 2010/2011 was reported to be a consequence of disputes on the award of resident hunting quota to investors resulting in court battles between the WMA and investors. One source of the dispute arises from language in which the contracts are written. Usually, the contracts (between the investors and WMA) are written in English, a language understood mostly by government officials and investors. The template for this is appended as the eleventh schedule of the Wildlife Conservation (WMA Regulations) Act 2012 (also in English). The implication is that majority of the communities are not aware of the contents in the contracts and their implications to conservation and livelihoods. They only come to realize the implications during the enforcement of the contracts; fuelling conflicts between the MBOMIPA officials, communities and investors. One key informant in Malinzanga village was critical of the language:

“[.....first, what is troubling us most (apart from problem and dangerous animals) in MBOMIPA is the understanding of the investment contracts process…how to enter into contracts with investors…I fail to understand why the Minister for Natural Resources and Tourism decided that contracts should be written in English while Swahili is the national language?……as a result, technical officials use this language to con us…..because what is written is not what is read and vice versa…..they have forgotten that these WMAs belongs to communities who have not gone to school …..)”

Secondly, it is alleged that corrupt MBOMIPA, district and central government have colluded with some investors and signed investment contracts that undermines the communities in terms of revenue sharing. According to one key informant, significant financial and technical resources have been spent in solving these disputes both within and outside courts of law, delaying implementation in the process. One court case between MBOMIPA and investors relates to delays in issuing hunting permits from the Wildlife Division (WD). The delays implied that the investor could not hunt in the WMAs tourist hunting zone, while payments had already been made to MBOMIPA. Consequently, the investor sued the association for not fulfilling its contractual obligations. As a result the government has been criticized for failing to decentralize meaningful decision making powers to local communities and right to benefit from the wildlife resource (Benjaminsen et al., 2013; Goldman, 2003; Igoe and Croucher, 2007; Kiwango et al., 2015; Ribot et al., 2006; USAID, 2013).

CONCLUSION AND RECOMMENDATIONS

This study attempted to examine the differentiated costs and benefits of conserving wildlife through CBC. We found that although communities in Pawaga Idodi WMA are envisaged to cooperate and participate in the management of the WMA, the benefits from conservation have been difficult to realize. Most of the little income generated has been directed towards social projects that aim to benefit the community as whole and not individual households. Meanwhile, the costs of conservation such as crop raiding, livestock predation, loss of grazing and agricultural land, fines and limited access to the WMA continue to impact individuals and not the communities as a whole.

We recommend that first, in order for the communities not to feel cheated in the CBC approach (see Songorwa, 1999), the communities must be made aware of the true costs and benefits (if any) of conservation prior to agreeing to setting aside areas for conservation. Secondly, actors in the WMA process
must appreciate that benefits and costs from conservation vary across geographical scales as it is biodiversity. Therefore, the same yardstick should not be used to measure success or failure of single WMA, rather solutions that fit specific WMAs should be pursued and adapted. Third, the number of participating villages must be kept at minimum to ensure that communities affected the most by wildlife conservation benefit the most, in order to minimize conflicts. Fourth, investment contracts should be negotiated in a language that is understood to all parties, in order to safeguard the interest of both parties. The state should facilitate these negotiating and build the capacity of the local leaders to negotiate with investors. This will minimize future conflicts and court cases that have affected MBOMIPA association and subsequently reducing its income generating potential.

ACKNOWLEDGEMENTS

We sincerely thank the Tanzanian government through the Commission for Science and Technology for funding this study and the Wildlife Division for granting permission to conduct field work in Idodipawaga WMA. We highly appreciate the logistical and administrative assistance offered by MBOMIPA officials and the district game officer for Iringa district. We sincerely thank the three research assistants for their tireless efforts in data collection.

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Determination of L-Carnosine, L-Anserine and L-Carnitine of Meat-Type Quails and the Preliminary Study of Its Antioxidant Activity on Human Adenocarcinoma Colon Cancer Caco-2 Cells

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ABSTRACT

This study determined the distribution of two histidine-containing dipeptides (HCDs), namely L-carnosine and L-anserine, and L-carnitine from breast and thigh-leg tissues in the common quail Coturnix coturnix var Iberia (CC) and the domesticated Japanese quail Coturnix coturnix japonica (CCJ). The antioxidant potential of the dipeptides was also evaluated on human adenocarcinoma colon cancer (Caco-2) cells, control were cells treated with DCFH-DA (2′-7′-dichlorofluorescin diacetate) and the oxidant ABAP (2,2′-azobis (2-amidinopropane) dihydrochloride. CCJ and CC breast muscles had 4 to 6-fold and 6 to 7-fold higher carnosine content compared with thigh muscles (P < 0.0001), making carnosine the dominant HCD in quail tissue. The effect of quail species on carnosine content was dependent on breast carnosine contents. Heat treatment either as a method of cooking (80°C / 15 min or 120 °C / 30 min) or as a technological step in the extraction of dipeptides produced a significant difference in the carnitine levels of breast muscles (P < 0.05), but not in carnosine and anserine content. Spring-fed CCJ had significantly lower breast anserine content (P<0.05) than summer and winter feeds. Cellular Antioxidant Activity (CAA) assay showed the oxidation of cellular Dichlorofluorescin (DCFH) to fluorescent dichlorofluorescein (DCF) by measuring the capacity of HCDs to inhibit the formation of DCF by 2,2′-azobis(2-amidinopropane) dihydrochloride (ABAP)-generated peroxyl radicals in Caco-2 cell monolayers. The antioxidant activities of 2mM, 4mM and 6mM breast extracts from CCJ were reported in comparison to the control (DCFH-DA + ABAP), each having lower fluorescence than the control. At P value of 0.2785, the differences in fluorescence intensity as a result of the various concentrations were not significant. Further analysis on antioxidant capacity of quail extracts should be carried out so as to enable the application of histidine-containing dipeptides as a bioactive food component which, when applied as a functional food ingredient can offer versatile health benefits for humans in addition to its technological functions in food processing.

Key words: Coturnix coturnix japonica, carnosine, anserine, antioxidant, L-carnitine

INTRODUCTION

The common quail (Coturnix coturnix) is the smallest avian species farmed for meat and egg production (Lofti et al., 2011). There is limiting data on characteristics of quail meat since most breeding research has focussed selection on layer-quails and egg production (Genchev et al., 2008). Additionally, the histidine-containing dipeptides (HCDs) that are regarded as potent antioxidants, have been extracted from numerous vertebrates (Boldyrev and Severin, 1990); but to date quail data on HCD’s is not available. In connection to this, the use of synthetic antioxidants in food products is strictly regulated due to persistent concerns about toxicity at higher amounts prompting research on alternative sources.

Carnosine (β-alanyl-L-histidine) is exclusively found in animal skeletal muscle and nervous tissue and synthesized in the liver from β-alanine and L-histidine. Anserine (β–alanyl-3-methyl-L-histidine), its homolog is present in several mammalian tissues noticeably in the brain and skeletal muscle (Boldyrev and Severin, 1990). Carnosine functions as a buffer in skeletal muscle undergoing anaerobic glycolysis (Skulachev, 2000). It also plays the role of a free-radical scavenger and a metal chelator (Chan and Decker, 1994), inhibiting lipid oxidation catalysed by reactive oxygen species (ROS) (MacFarlane et al, 1991). Carnosine prevents formation of protein carbonyls and cross-links that are induced by reducing sugars and other reactive aldehydes for instance, malondialdehyde and
methylglyoxal, thus termed an anti-glycosylation agent. An anti-aging mechanism of carnosine describes its protective role against telomere fragmentation, and thus remarkably reducing the rate of telomere shortening in continuously subcultured cells (Shao et al., 2004). L-carnitine (γ-tri-methylamino-ß-hydroxybutyric acid) is a quaternary ammonium compound synthesized from lysine and methionine and plays a key role in human fat metabolism and it has been suggested that its deficit could impair the oxidation of long-chained fatty acids in the mitochondria (Luppa, 2004).

**MATERIALS AND METHODS**

32 birds were grouped by race, CC and CCJ then coded as Winter12, Spring13 and Summer13, after their arrival dates at the lab. Samples were slaughtered and packed in ice before transportation to the laboratory then stored at -80 °C awaiting analysis. Breast and thigh muscles were separated, deboned, skin removed, minced and homogenised in a stomacher. “Thigh” refers to the lower extremity parts, thigh and leg. A day before analysis, samples were maintained at 4°C to allow overnight thawing. Dipeptides extraction followed a method described by Manhiani et al., 2013, with modifications (Figure 1). To one part of minced quail sample, 2 parts of precooled (4°C) nano-pure water was added, homogenized. The homogenate was centrifuged at 20,000 xg for 30 minutes at 4°C. The supernatant was filtered then subjected to treatment at 80°C for 15 minutes in a water-bath. The heated samples were then immediately cooled in an ice bath and then centrifuged at 6,000 xg for 20 minutes to remove precipitated proteins. The supernatant was filtered then ultrafiltered using an Amicon Ultra-15 Filter with a 3,000 molecular weight cut-off, and a centrifugal force of 5,000 xg for 55 minutes at 14°C. The ultrafiltrate permeate was then analysed for carnosine, anserine and carnitine by HPLC using a Perkin Elmer 200 series unit together with an API 150 detector unit set at an excitation wavelength of 150 nm. The standard curves were prepared using pure solutions of L-carnosine and L-anserine at 0.1, 1, 5, 10 and 20 mM solutions, while pure L-carnitine curves were prepared with 0.025, 0.05, 0.1, 0.5 and 1 mM solutions.

Effect of temperature study used ultra-filtrates of 4 birds of CCJ species each from Winter12 and Summer13. The first temperature used was a sterilization temperature of 120°C for 30 minutes. Quail tissue was placed in a test tube and the tube was immersed in hot oil-bath maintained at 120°C until the tissue had achieved the same temperature. A heat treatment of 80 °C for 15min was the second heat regimen that was used as an important technological step in dipeptide extraction for protein denaturation.

Procedure for Cell culture: Human adenocarcinoma colon cancer Caco-2 cells of passage 30-50 were removed from storage at -80 °C. The cells grew in growth medium consisting of DMEM supplemented with 5% FCS, 1% L-Glutamine and 1% Penicillin-Streptomycin and maintained at 37 °C with 5% CO₂ then let to grow to confluence (2-3 days). The culture medium was changed every 3 days. A treatment medium was prepared consisting of DMEM, 1% Penicillin-Streptomycin, without FCS.

The cellular antioxidant activity (CAA) assay used followed the procedure of Wolfe and Liu, (2007) with slight modification (Figure 2). Antioxidant activity of HCDs was assessed by measuring fluorescence intensity. Dichlorofluorescin (DCFH, DCFH-DA) is a probe that is confined within cells gets readily oxidized to fluorescent dichlorofluorescein (DCF), thus measuring the capacity of compounds to inhibit the formation of DCF by 2,2'-azobis(2-aminopropene) dihydrochloride (ABAP) generated peroxyl radicals in human adenocarcinoma colon cancer (Caco-2) cell monolayers. Caco-2 cells were the preferred cell line for studying intestinal permeability of bioactive compounds due to their similarity to the intestinal epithelial cells (Liu and Finley, 2005). The decrease in cellular fluorescence when compared to the control cells indicates the antioxidant capacity of the compounds.

Procedure for CAA of dipeptides: The procedure was based on Liu and Finley (2005) with a slight modifications. The cells were seeded at a density of 2 × 10⁴/well on a 96-well microplate in 100 L of growth medium/well and incubated for 24 hours at 37 °C and 5% CO₂ atmosphere. The other bordering empty wells were filled with 200 µL of Hanks` solution.

Following incubation, the growth medium was removed and the wells were washed with PBS. Triplicate wells were treated with 100 L of pure L-carnosine and L-anserine or quail dipeptide extracts plus 25 M DCFH-DA dissolved in treatment medium and incubated for 1 hr. Following incubation, the wells were then washed with PBS. 600 M ABAP was applied to the cells in 100 L of HBSS, and the 96-well microplate was placed into a Cary Eclipse Fluorescence spectrophotometer plate-reader (Agilent...
Technologies, USA). Measurements were read at an emission and excitation wavelength of at 538 nm and 485 nm respectively every 20 minutes for 1-2 hrs. Each plate included triplicate control and blank wells where control wells contained cells treated with DCFH-DA and the ABAP oxidant; blank wells contained cells treated with HBSS without oxidant.

**Procedure for Determining Antioxidant Differences in Pure Dipeptides and Quail Extracts**

This experiment compared the antioxidative differences between pure L-anserine and pure L-carnosine with quail extracts from CCJ Winter12. 6mM of pure carnosine and anserine were prepared from corresponding stock solutions of 200mM while breast extract of CCJ had a concentration of 6.178 mM carnosine from which 6mM, 4mM and 2mM carnosine concentrations were prepared.

**STATISTICAL ANALYSIS**

Experiments on moisture content, crude protein and ash were analysed in quadruplet samples, while fat, dipeptide content and CAA experiments were analysed in triplicate samples. Statistical analysis was evaluated in a two-way ANOVA factorial design with SAS (Statistical Analysis Software Edition 9.2, SAS Institute Inc., 2008) and comparison of means by Fishers Least Significant Difference (LSD) test. All tests applied a Type I Error probability of 0.05.

**RESULTS AND DISCUSSION**

Results of dipeptide and carnitine concentration are summarized in Table 1.

i. **Effect of Quail Muscle Types and Race on Dipeptides**

Effect of muscle type on dipeptides and carnitine was highly significant (P < 0.001). Breast mean carnosine content in quails from CCJ Winter12 and Spring13 and CC Winter12 and Spring13 were 1396.94, 1362.40, 606.57 and 1178.77 µg/g wet tissue; while thigh content was 352.75, 240.16, 87.92 and 197.20 µg/g wet tissue respectively; which indicates that carnosine content was about 4.0, 5.7, 6.9, and 6.0 times higher (P< 0.001) in breast than in thigh-leg muscle in that order. In comparison to findings on chicken and turkey carnosine content, breast meats were 2 to 4 times and 10 times higher respectively, than thigh meats (Intarapichet and Maikhunthod, 2005; Davies et al., 1978). CCJ quails had notably higher mean carnosine levels than the CC quails. However, the effect of species on carnosine was dependent on the muscle type. There were no significant differences in breast mean anserine quantities (P>0.05) across all the races. Anserine content was highly significantly different between the two muscles, (P ≤0.001). In CCJ Winter12 and Spring13 and CC Winter12 and Spring13, breast muscle contained 3.0, 4.4, 3.6 and 4.7 times more anserine than thigh muscles. Therefore, the high level of HCDs in breast suggests that they perform a more important role of buffering in physiological range of pH in this muscle than in the leg muscle. Carnitine content was also highly significantly different between the two muscles (P ≤0.001), breast having 2.5, 5.7, 5.1 and 3.5 times higher carnitine than in thigh muscles in CCJ Winter12 and Spring13 and CC Winter12 and Spring13 in that order.

ii. **Effect of Heating Temperatures on Dipeptides**

Sterilization method of cooking and demineralization heat treatment had a significant effect on carnitine content in breast muscles of CCJ Winter11 (P= 0.0064) and CCJ Summer12 (P= 0.0141), but produced no significant difference in carnosine and anserine content, summarized in Table II of Appendix This result indicated that cooking temperature and duration can affect the levels of health-promoting compounds in quail and possibly other meats.

iii. **Effect of Seasonal Feeding on Dipeptides**

Spring-slaughtered breast had significantly lower anserine content (P< 0.05) than Summer12 and Winter12, which were similar. There was no significant difference in carnosine and carnitine levels due to seasonal feeding (P > 0.05). The anserine X season interaction was unsupported in previous studies and this suggests that further investigation must be made to validate this interaction.

iv. **Antioxidant Activity of Pure Dipeptides and Quail Extracts**

The inhibitive capacity to oxidation was assayed for 6mM pure anserine, 6mM pure carnosine, 2mM, 4mM, 6mM breast extract of CCJ Winter12 (Figure 3). The control had the highest fluorescence reading indicating its inability to inhibit oxidation of DCFH by ABAP-generated peroxyl radicals. All breast extracts had greater antioxidative potential compared to the control.
Pure carnosine (6 mM) showed the highest antioxidative potential, followed by the breast extracts at 2mM, 6mM and 4mM carnosine concentrations. Pure anserine (6mM) showed the lowest antioxidant potential. These results contradicted to our expectations, partly due to the lack of strict correlation between increase in antioxidant dose and decrease in fluorescence intensity (as seen with the 2mM sample), and also most importantly, our expectation that the quail extracts would have a higher antioxidative capacity than the pure dipeptides, considering that they may have a synergistic advantage of the three identified compounds. At P value of 0.2785, the differences in fluorescence intensity as result of the various concentrations were not significant. Of special note to mention, the fluorimeter was operating at a set temperature of 21.5 °C. In order to maintain the cells and the experiment at optimum physiological temperature, the 96-well plate was incubated at 37°C for 10 minutes following ABAP addition, after which the fluorescence readings were briefly taken (2 minutes) and again returned the cells for further incubation at 37 °C. This lack of continuity in the fluorimeter readings may have caused interferences in cellular enzyme function during the experiment.

CONCLUSION

Quail has carnosine as the dominating dipeptide in both breast and thigh muscles, different from chicken and turkey. Quail breast muscles had higher carnosine content respectively compared to thigh muscles (P < 0.0001). The effect of the various quail species on carnosine content was dependent on carnosine content of the breast muscles. Species did not produce a significant difference on anserine and carnitine contents (P > 0.05). Application of heat produced a significant difference in the carnitine levels of breast muscles (P < 0.05), but not in carnosine and anserine content. Our results also revealed that Coturnix coturnix japonica slaughtered in Spring had significantly lower breast anserine content (P < 0.05) than Summer and Winter slaughtered quails and further research is needed to validate this finding. This being the preliminary study, further research on antioxidant capacity of quail extracts should be carried out in the near future so as to enable the application of histidine-containing dipeptides as a bioactive food components which, when applied as a functional food ingredient can offer versatile health benefits for humans in addition to its technological functions.

ACKNOWLEDGEMENT

My heartfelt appreciation goes to my principal supervisor Dr. Montserrat Mor-Mur and my co-supervisors Dr. Anna Bassols and Prof. Anders Karlsson for their mentorship during my Graduate study at Universitat Autonoma de Barcelona. I am similarly most grateful to my Institute Director, Beef Research Institute, KALRO, for his enthusiasm, encouragement and conference facilitation.

REFERENCES


and Cellular Cardiology, 1991, 23(11), 1205-1207.

APPENDIXES

Appendix 1
Figure 1: Extraction of dipeptides by heat and ultrafiltration. Adapted and modified from Mahniani et al., 2013.

Quail minced tissue

Homogenization

CENTRIFUGATION 20,000x g for 30 min at 4°C

Filter

Heat supernatant at 80°C for 15 min

CENTRIFUGATION 6,000x g for 20 min at 4°C

Filter

Supernatant

ULTRAFILTRATION Centrifugation 5,000x g for 55 min at 14°C

Ultrafiltrate (extract)
Appendix 2

Figure 2: Proposed method and principal of Cellular Antioxidant Assay (CAA) as adapted from Wolfe and Liu, 2007

Figure 2 caption:
Cells were pre-treated with pure antioxidant compounds or quail meat extracts and DCFH-DA. The antioxidants are believed to have bound to the cell membrane and/or passed through the membrane to enter the cell. DCFH-DA diffused into the cell where cellular esterases cleaved the diacetate moiety to form the more polar DCFH, which was trapped within the cell. Cells were treated with ABAP, which diffused into cells. ABAP spontaneously decomposed and release peroxyl radicals. These peroxyl radicals attacked the cell membrane to produce more radicals and oxidized the intracellular DCFH to the fluorescent DCF. Antioxidants prevented oxidation of DCFH and membrane lipids and reduced the formation of fluorescent DCF.

Appendix 3

Table I: Carnosine, Anserine and L-carnitine content in quail breast and thigh tissue of *Coturnix coturnix* (CC) and *Coturnix coturnix japonica* (CCJ) quails

<table>
<thead>
<tr>
<th>SPECIE</th>
<th>SEASON</th>
<th>MUSCLE</th>
<th>CARNOSINE (µg/g wet tissue)</th>
<th>ANSERINE (µg/g wet tissue)</th>
<th>L-CARNITINE (µg/g wet tissue)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCJ</td>
<td>WINTER12</td>
<td>BREAST</td>
<td>1397.65 ± 55.5*</td>
<td>694.15 ± 17.0</td>
<td>0.557 ± 0.038</td>
</tr>
<tr>
<td></td>
<td>SPRING13</td>
<td>BREAST</td>
<td>1363.12 ± 74.4*</td>
<td>751.85 ± 18.6</td>
<td>0.471 ± 0.032</td>
</tr>
<tr>
<td>CC</td>
<td>WINTER12</td>
<td>BREAST</td>
<td>607.29 ± 20.1*</td>
<td>686.74 ± 7.4</td>
<td>1.009 ± 0.133</td>
</tr>
<tr>
<td></td>
<td>SPRING13</td>
<td>BREAST</td>
<td>1179.48 ± 34.7*</td>
<td>698.67 ± 11.1</td>
<td>0.748 ± 0.066</td>
</tr>
<tr>
<td>CCJ</td>
<td>WINTER12</td>
<td>THIGH</td>
<td>353.46 ± 39.6*</td>
<td>231.69 ± 19.2</td>
<td>0.231 ± 0.030</td>
</tr>
<tr>
<td></td>
<td>SPRING13</td>
<td>THIGH</td>
<td>240.88 ± 24.5*</td>
<td>170.46 ± 11.0</td>
<td>0.095 ± 0.004</td>
</tr>
<tr>
<td>CC</td>
<td>WINTER12</td>
<td>THIGH</td>
<td>88.63 ± 2.0*</td>
<td>192.61 ± 6.1*</td>
<td>0.211 ± 0.032</td>
</tr>
<tr>
<td></td>
<td>SPRING13</td>
<td>THIGH</td>
<td>197.92 ± 10.1*</td>
<td>147.14 ± 3.2*</td>
<td>0.223 ± 0.011</td>
</tr>
</tbody>
</table>

All values are mean ± standard deviation (n = 3 per bird and per muscle). Superscript letters a-c and x-z on breast and thigh means along a column are not significantly different (P ≥0.05).
Appendix 4

Table II: Effect of heating temperatures on histidine-containing dipeptides and L-carnitine

<table>
<thead>
<tr>
<th>Specie</th>
<th>Muscle</th>
<th>Temperature</th>
<th>Carnosine (µg/g wet tissue)</th>
<th>Anserine (µg/g wet tissue)</th>
<th>Carnitine (µg/g wet tissue)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCJ</td>
<td>Breast</td>
<td>120 °C</td>
<td>1324.44</td>
<td>889.61</td>
<td>1.4351^a</td>
</tr>
<tr>
<td></td>
<td>Breast</td>
<td>80 °C</td>
<td>1259.92</td>
<td>863.62</td>
<td>0.6031^b</td>
</tr>
<tr>
<td></td>
<td>Thigh-leg</td>
<td>120 °C</td>
<td>253.52</td>
<td>180.40</td>
<td>0.1460</td>
</tr>
<tr>
<td></td>
<td>Thigh-leg</td>
<td>80 °C</td>
<td>258.63</td>
<td>181.83</td>
<td>0.1696</td>
</tr>
<tr>
<td>CCJ</td>
<td>Breast</td>
<td>120 °C</td>
<td>1646.2</td>
<td>940.11</td>
<td>1.1501^w</td>
</tr>
<tr>
<td>SUMMER13</td>
<td>Breast</td>
<td>80 °C</td>
<td>1584.1</td>
<td>877.39</td>
<td>0.4746^A</td>
</tr>
<tr>
<td></td>
<td>Thigh-leg</td>
<td>120 °C</td>
<td>305.07</td>
<td>265.54</td>
<td>0.1339</td>
</tr>
<tr>
<td></td>
<td>Thigh-leg</td>
<td>80 °C</td>
<td>268.6</td>
<td>224.17</td>
<td>0.1192</td>
</tr>
</tbody>
</table>

All values are mean (n = 3). Similar letters a-c (for breast) and w-x (for breast) per column indicate that the mean values are not significantly different (p ≥ 0.05).

Appendix 5

Table III: Effect of Seasonal feeding on histidine-containing dipeptides and L-carnitine

<table>
<thead>
<tr>
<th>Specie</th>
<th>Carnosine (µg/g wet tissue)</th>
<th>Anserine (µg/g wet tissue)</th>
<th>Carnitine (µg/g wet tissue)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCJ</td>
<td>Winter12</td>
<td>1259.9</td>
<td>863.62</td>
</tr>
<tr>
<td>SUMMER13</td>
<td>Summer13</td>
<td>1584.1</td>
<td>877.39</td>
</tr>
<tr>
<td></td>
<td>Spring13</td>
<td>1363.1</td>
<td>751.85</td>
</tr>
</tbody>
</table>

All values are means (n=3). ^a^ Similar superscripts along a column indicate no significant difference (P > 0.05).
Appendix 6

Figure 3: Graph of antioxidant activity of pure dipeptides and various concentrations (mM) of quail breast extract

Figure 3: Oxidation of DCFH to DCF induced by ABAP-generated peroxyl radicals in Caco-2 cells over 60 minutes of intermittent readings every 10 minutes. Inhibition to oxidation by pure L-carnosine, pure L-anserine and various concentrations of quail breast extract. Control, cells with DCFH + ABAP only. The curves shown are from a single experiment (mean, n=4) using CCJ Winter12 denoted as no. 31.
ABSTRACT

Cancer is a leading cause of deaths worldwide. Chemotherapy is the main method of treatment in cancer cases but is expensive often associated with negative effects. Finding alternative drugs is imperative. This study evaluated the phytochemical composition and antiproliferative activity of Methanol-Dichloromethane (1:1) extracts from the aerial parts of *Oxygonium sinuatum*. This plant has traditionally been used to treat syphilis, pneumonia, inflammations and presumably cancer. Phytochemical screening was done using standard procedures. The MTT cell proliferation assay was used to test for the anti-proliferative activity on 4T1 (mouse breast), 22Rv1 (prostate), Hcc 1395 (breast), DU145 (prostate) and HeLa (Cervical) cancer cell lines. In addition normal Vero cells were used. 5-flourouracil, a standard drug used against cancer was positive control across all cell lines. One way ANOVA was used to statistical significance of the means (P ≤ 0.05), using SPSS v20. Results from this study revealed that the stem, leaves and fruits extracts contained alkaloids, cardiac glycosides, saponins, tannins, flavonoids, terpenoids, steroids and phenols. The leaves, stem and fruits extracts showed anti-proliferative activity on 4T1 (745.460±17.126 µg/ml, 22.792±2.220 µg/ml, 35.841±3.459 µg/ml), Hcc 1395 (867.058±7.354 µg/ml, 529.199±12.707 µg/ml, 367.485±16.108 µg/ml), 22Rv1 (181.480±13.972 µg/ml, 956.966±10.996 µg/ml, 759.836±4.985 µg/ml) and DU 145 (559.292±16.532 µg/ml, 114.870±15.825 µg/ml) respectively. The fruit extract showed no activity on DU 145. None of the extracts showed activity on HeLa (cervical) cancer cells. The leaves and fruit extract were not toxic to Vero cell line (CC<sub>50</sub> >1000 µg/ml) while the stem were toxic (413.733±21.022 µg/ml). The fruits, leaves and stem extracts showed selectivity (SI > 3) on 4T1, 22Rv1 and DU 145 cells respectively. *Oxygonium sinuatum* showed antiproliferative activity on various selected cancer cell lines. This activity can be attributed to the phytochemical compounds present in the plant extracts. Further studies are necessary to isolate the bioactive components and define their mechanisms of action in cancerous cells growth inhibition.

**Keywords:** *Oxygonium sinuatum*, Antiproliferation, Phytochemicals, Selectivity Index (SI)

INTRODUCTION

Cancer is one of the leading causes of deaths worldwide accounting for 8.2 million deaths annually, an estimated 13% of the total deaths (Bray et al., 2008, WHO, 2014). New cancer cases per year are estimated at 14 million a figure predicted to rise to 22 million within the next two decades (WHO, 2014). Regrettably, 70% of the total cancer deaths occur in low and middle income countries (Bray et al., 2008, WHO, 2014). The major cancer predisposing factors include: tobacco use, excessive alcoholism, some infectious agents, obesity, physical inactivity and westernized diet (Anand et al., 2008). In Africa cancer mortality rate is greater than that of HIV, TB, and malaria combined (Bray et al., 2008, WHO, 2014). Cancer causes 7% of the total national mortality annually in Kenya making it third after infectious and cardiovascular diseases (Kenya National Cancer Control Strategy, 2011-2016). The poor prognosis of cancer is due to lack of enough facilities for diagnosis and treatment, limited access to health facilities and high cost of conventional treatment (Bray et al., 2008, WHO, 2014). The major conventional treatment methods include chemotherapy, radiotherapy, immunotherapy and surgery. Despite being expensive...
and beyond reach by majority of people in poor countries, these methods are also laden with various side effects (WHO, 2014). This calls for search for alternative cancer management and chemo-preventive agents. In Africa, up to 80% of the population relies on the use of herbal medicine for their primary healthcare (Bandaranayake, 2006, Huosain et al., 2009). The conventional medicine in Kenya provides for only 30% of the population, this means that more than two-thirds of Kenyans rely on traditional medicine for their healthcare needs (National policy on traditional medicine and regulation of herbal medicines, 2005). Many people perceive medicinal plants to be safer than their synthetic alternatives. Wide range of plant extracts have been used as raw or processed drugs in treatment of various diseases. The different parts used include root, stem, flower, twigs, exudates as well as whole plant (Srivastava et al., 1996). Various phytochemical compounds found in medicinal plants have been a source of innumerable therapeutic agents and a tool for development of conventional medicine (Kroschwitz et al., 1992).

Oxygonium sinuatum (Meins) Dammer (polygonaceae) is an annual weed growing in the dry areas and widely distributed in Kenya (Hamill et al., 2010). Oxygonium sinuatum is a decumbent plant, its stem grows up to 90cm long (Kokwaro, 2009). The plant is polygamous with prickly fruits. Traditionally the plant is used in treatment of various diseases including cancer (Kareru et al., 2007, Mainen et al., 2009, Amadi, 2013, Dominic et al., 2014). However, its antiproliferative potential has not been fully investigated.

Study Site
This study was done at Kenya Medical Research Institute (KEMRI), Centre for Traditional Medicine and Drug Research (CTMDR) labs.

MATERIALS AND METHODOLOGY

Plant Collection
The plant was collected from Ngong Hills (1.3618°S, 36.6566°E) Kajiado County and transported to the Center for Traditional Medicine and Drug Research CTMDR, KEMRI for taxonomic identification and processing. The plant parts were sorted into leaves, stems, and fruits, dried at room temperature and ground into fine powder using a laboratory mill.

Extraction Procedures
The grounded samples were weighed using a top balance and put in a 500ml flat bottomed flask, methanol and dichloromethane (DCM) ratio 1:1 was then added until the plant material was completely submerged. The mixture was then agitated for thorough mixing then left to extract for 24 hours with frequent shaking to ensure effective extraction. After the 24 hours the mixture was filtered using Butchner funnel; Whatman no. 1 filter paper. The extracts were then concentrated using a rotary vacuum evaporator with a water bath at 40°C. The concentrated extracts were stored at 4°C until use.

Qualitative Phytochemical Analysis
The extracts’ phytochemicals composition was tested using standard procedures with slight modifications of the procedures (Harbone, 1976, Trease and Evans, 2008).

1. Alkaloids; Mayer’s Test: About 0.5ml of the plant extract was put in a clean test tube. Few drops of Mayer’s reagent was added and observations made. Appearance of white precipitate indicated the presence of alkaloids.

2. Glycosides; Keller Killiani Test: Approximately 0.5 ml of the plant extract was put in a test tube, 1ml of glacial acetic acid containing 1 drop of ferric chloride was added. This mixture was added to 1ml of concentrated sulphuric acid and observations made. Formation of a brown ring indicated presence of cardiac glycosides.

3. Saponins: The crude extract was mixed with 5ml of water and vigorously shaken. The mixture was left to stand for about 15 seconds. Formation of a stable form indicated the presence of Saponins.

4. Tannins: To about 0.5g of the plant extract in a test tube, 20ml of distilled water was added and heated to boiling. The mixture was then filtered and 1% FeCl₃ was added to the filtrate and observation made. A brownish green coloration indicated the presence of tannins.

5. Flavonoids: To a portion of the plant extract in a test tube, 5ml of dilute ammonia was added followed by addition of 2ml of concentrated sulphuric acid. The appearance of a yellow color indicated the presence of flavonoids.

6. Terpenoids: About 0.5ml of the plant extract was put in a test tube. To this, 2ml of chloroform was added followed by 1ml of concentrated sulphuric acid. Observations were then made. A brown ring at the junction of two layers was formed indicating the presence of terpenoids.

7. Steroids; Liebermann Rurichard Reaction: To a sample of the plant extract in a test tube, 10ml
of chloroform was added and filtered. To 2ml of the filtrate, 2ml of acetic acid was added followed by addition of concentrated sulphuric acid. The formation of blue-green ring at the junction of two layers indicated the presence of steroids.

8. **Phenols**: Portion of the plant extract was put in a test tube and treated with few drops of 2% ferric chloride. Observations were then made. The appearance of blue green coloration indicated the presence of phenols.

**Anti-Proliferative Assay**

**Sample Preparation**

Briefly, 10mg of the plant extracts (leaves, stem, and fruits extracts) were weighed in a 1.5 ml ependorf tube using a top balance. To each sample 100µl dimethyl sulfoxide (DMSO) solution was added and the mixture vortexed, 900µl of PBS was added to the mixture to make 1ml of the solution.

**Cell line Culturing**

Vero cell line (normal) and 4T1 (breast), 22Rv1 (prostate), HCC 1395 (prostate), DU 145 (breast) and HeLa (cervical) cancer cell lines (ATCC) were obtained from Center for Virology Research (CVR), KEMRI. The cells were revived in a water bath at 37°C and cultured in T-75 flasks with Minimum Essential Medium (MEM, SIGMA USA) supplemented with 10% Fetal Bovine Serum (FBS) and 100µg/ml streptomycin then incubated for 72 hours to attain confluence. All incubation was done at 5% CO₂ and 37°C (Masters, 2000).

**Anti-Proliferative Experiment**

Upon attainment of confluence, both vero and cancer cells were washed using Phosphate Buffer Saline (PBS) and harvested by trypsinization. The number of viable cells was determined by Trypan blue exclusion test. An aliquot of 2.0 ×10³ cells/ml suspension for both the vero and cancer cells were seeded in 96-well plates and incubated for 24 hours for the cells to attach to the plates (McCauley et al., 2013). Briefly, 15µl of the test sample extracts was then added to the wells in rows H in plates and topped up to 150 µl using media. Three fold serial dilution was performed from rows H-B and the plates incubated for 48 hours. Row A acted as the cell control. The viability of the cells after extracts addition and incubation was determined using MTT cell proliferation assay which is based on the ability of the living cells to reduce the yellow 3-(4,5-dimethyl-2-thiazoly)-2, 5-diphenyltetrazolium bromide (MTT) dye to a purple formazan product (McCauley et al., 2013). After 48hrs 10µl MTT dye was added to the cells and incubated for 4hrs. All the media was then removed from the plates and 50µl of DMSO was added to solubilize the formazan product. Absorbance was read on a scanning multi well spectrophotometer at 562 nm (Tim, 1983). The inhibitory concentration (IC₅₀) on cancer cells and cytotoxic concentration (CC₅₀) on normal vero cells was determined (Nemati et al., 2013). The Selectivity index (SI=CC₅₀/IC₅₀) was also calculated.

**Data Analysis and Presentation**

All the undertakings of this study were recorded in a laboratory hand book. The Cruzi 7 Drug Cytotoxicity Software was used to obtain the IC₅₀s and the CC₅₀s from the raw data. The differences between the treatments and the control were tested for statistical significance using one way ANOVA (p ≤ 0.05) in the Statistical Package of Social Science (SPSS Version20). The IC₅₀ and CC₅₀ values were expressed as Mean ± Standard deviation (SD). Tables were used for the presentation of the results.

**RESULTS**

**The Yield of the Extracts**

The plant extracts yield was calculated and recorded in percentage. The fruit extract had the highest yield of eleven percent. The leaves extract had ten percent while the stem extract had the lowest yield of five percent as shown in table 1 below.

<table>
<thead>
<tr>
<th>Plant part</th>
<th>Weight of plant part soaked (g)</th>
<th>Weight of concentrated plant sample (g)</th>
<th>Percentage yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaves</td>
<td>40</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Stem</td>
<td>40</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Fruits</td>
<td>18</td>
<td>2</td>
<td>11</td>
</tr>
</tbody>
</table>

**The Phytochemistry Results**
The phytochemistry result revealed the presence of alkaloids, cardiac glycosides, saponins, tannins, flavonoids, terpenoids, steroids and phenols in all the extracts but these phytochemicals were in different intensities and/or different precipitations. Table 2 shows these results.

Table 2: Phytochemical screening results and observations

<table>
<thead>
<tr>
<th>Phytochemical tested</th>
<th>Plant part</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Leaves</td>
<td>Stem</td>
</tr>
<tr>
<td>Alkaloids</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glycosides</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saponins</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tannins</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flavonoids</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terpenoids</td>
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<td>++</td>
</tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>Steroids</td>
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</tr>
<tr>
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<td></td>
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</tr>
<tr>
<td>Phenols</td>
<td>+</td>
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</tr>
<tr>
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</tr>
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</table>

The three plant extracts registered significantly higher antiproliferative activity (P ≤0.05) on 4T1 (mouse model breast cancer), 22Rv1 (human prostate cancer), Hcc 1395 (human breast cancer) and DU145 (human metastatic prostate cancer). The highest activity was registered by fruit extract on 4T1 with an IC₅₀ of 35.841±3.549µg/ml which was statistically comparable to that of the reference drug on the same cell line. The fruits extract had no activity on DU145 cell line. All the extracts showed no activity on HeLa (Cervical cancer cells) cell line. The stem extract was toxic to Vero normal cells while the leaves and fruit extract showed no toxicity to the Vero cells (CC₅₀ >1000µg/ml). The selectivity index (SI) which is a ratio between the CC₅₀ of an extract on the Vero cell and the IC₅₀ of the extract on cancer cell line was also calculated. An extract with the SI greater than three was considered to be highly selective (Nabende et al., 2015). The highest selectivity index was registered by fruit extract on 4T1 (SI=27.901±1.714). The leaves and stem extracts also showed high selectivity (SI >3) on 22Rv1 and DU145 respectively. These results are shown in table 3 below.

Table 3: Antiproliferation results; CC₅₀s, IC₅₀s, and selectivity index (SI) of the methanol- dichloromethane leaves, stem and fruits extracts from O. sinuatum on Vero (normal), 4T1, 22Rv1, Hcc 1395 and DU 145 cancer cell lines

<table>
<thead>
<tr>
<th>Cell line</th>
<th>Plant part</th>
<th>Reference drug 5-Flourouracil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Leaves</td>
<td>Stem</td>
</tr>
<tr>
<td>Vero (Normal)</td>
<td>&gt;1000</td>
<td>413.733±21.022a</td>
</tr>
<tr>
<td>4T1 (breast)</td>
<td>745.460±17.126a</td>
<td>222.792±2.220a</td>
</tr>
<tr>
<td></td>
<td>1.341±0.023a</td>
<td>1.857±0.045a</td>
</tr>
<tr>
<td>22Rv1 (prostate)</td>
<td>181.480±13.972a</td>
<td>956.966±10.996e</td>
</tr>
<tr>
<td></td>
<td>5.543±0.427a</td>
<td>1.045±0.012a</td>
</tr>
<tr>
<td>Hcc 1395 (breast)</td>
<td>867.058±7.354a</td>
<td>529.199±12.707a</td>
</tr>
<tr>
<td></td>
<td>1.153±0.007a</td>
<td>1.891±0.046a</td>
</tr>
<tr>
<td>DU 145 (prostate)</td>
<td>559.292±16.532a</td>
<td>114.870±15.825e</td>
</tr>
<tr>
<td></td>
<td>1.798±0.036a</td>
<td>3.602±0.632a</td>
</tr>
</tbody>
</table>

a – Mean values are statistically different compared to that of the reference drug
b – Means values statistically comparable to that of the reference drug
DISCUSSION

The extracts from leaves, stem and fruits of Oxygonium sinuatum displayed antiproliferative potential against 4T1, Hcc 1395, 22Rv1 and DU 145. According to the National Cancer Institute (NCI) a crude extract with an IC50<30µg/ml is considered to have high activity, 30µg/ml<IC50<1000µg/ml is moderate activity and an extract with IC50>1000µg/ml is considered to be inactive (Boik, 2001, Prayong et al., 2008, Siti et al., 2011). Therefore, the three extracts had moderate activity on four of the five cancer cell line used in this study. HeLa cell line was insensitive to any of the three extracts. Further, these results supports a study by Kamuhabwa et al., (2000) which showed that the whole plant methanolic extract of Oxygonium sinuatum had antiproliferative activity on HT29 (colon adenocarcinoma) and A431 (skin carcinoma) but registered no activity on HeLa cell line. The antiproliferative activity of these extracts against the four cancer cell lines can be attributed to the presence of various secondary metabolites that were found to be present in the plant extracts (table 2). The secondary metabolites might have interacted amongst themselves to bring about the antiproliferative activity observed. Phytochemical compounds are produced by plants in response to stressful conditions such as infections. However these plant based compounds have been found to have therapeutic value and produce physiological action on the human body (Nostro et al., 2011). Various phytochemicals have being shown to have activity against various diseases including cancer (Cragg and Newman, 2005, Okwu and Josiah, 2006). Alkaloids are a group of cyclic compounds that have nitrogen atom in their chemical ring structure. Alkaloids have being isolated from various plants and their therapeutic activity tested. Vinblastine and vincristine are alkaloids isolated from the Madagascar periwinkle and Cantharanthus roseus. They were the first alkaloids to be used as anticancer agents (Cragg and Newman, 2005). Cardiac glycosides are effective therapies for congestive heart failure and arrhythmia (Ehle et al., 2011). Recently, cardiac glycosides have being documented to have antiproliferative activity on human carcinoma and leukemia cells (Newman et al., 2008). Saponins have also being documented to have antiproliferative effect on various cancer cells (Sun et al., 2010).

Phenolic compounds form a large group of molecules including the flavonoids, tannins and coumarins (Carocho and Ferreira, 2013). Phenolic compounds are known for their antioxidant and antiproliferative activity on various cancers including leukemia, glioma, colon adenocarcinoma, cervical carcinoma prostate and bladder carcinomas (Carocho and Ferreira, 2013). Phenols from whole plant methanolic and aqueous extracts of Oxygonium sinuatum showed a high antioxidant activity (Uma and Bharti et al., 2008). Flavonoids are a group of water soluble compounds containing 15 carbon atoms. Takemura et al., (2012) provided a comprehensive review of chemoprevention by flavonoids on breast cancer. Flavonoids isolated from flowers of Tecomastains demonstrated significant antitumor activity on Hep-2 (Human larynx carcinoma cell line (Kameshwaran et al., 2012). Tannins a subclass of hydroxybenzoic acids also manifests antiproliferative activity against human hepatocellular carcinoma, human prostate cancer, human cervical cancer and mouse sarcoma cell lines (Wang et al., 1999). Terpenoids and steroids are unsaturated cyclic or linear hydrocarbons with varying number of isoprene units. Corticosteroids have been in use in management of cancer (James et al., 2001). A Study by Joao et al., (2010) showed that oxysterols were active against LAMA-84(leukemia) cells.

CONCLUSION

This study provides the phytochemical profile of methanol-dichloromethane stem, leaves and fruits extracts from O. sinuatum, and further gives the antiproliferative activity of the three extracts against breast and prostate cancer cell lines. The antiproliferative activity of these extracts can be attributed to the phytochemicals that were present in the extracts. This study provides important basis for further investigation on the development of herbal medicine from O. sinuatum as alternative therapy for cancer treatment and management. This study recommends further studies to isolate the bioactive components from the three extracts and elucidate their mechanisms of action.

CONFLICT OF INTEREST

The authors declare no conflicting interests exist.
ETHICAL APPROVAL
Ethical approval was sought from Kenya Medical Research Institute (KEMRI) CTMDR Centre Scientific Committee (CSC) and Scientific and Ethics Review Unit (SERU) KEMRI before conducting the study.

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ABSTRACT

Agriculture is extremely vulnerable to climate change. Increased temperature eventually reduces yields of desirable crops while promoting weed infestation and proliferation of pest. Decline in precipitation increase the likelihood of crop failures and exacerbate food insecurity. Although there could be gains in some crops in some regions of the world, the overall impacts of climate change on the Agro-ecosystems are expected to be negative, threatening food security. The continued dependence of crop production on light, heat, water and other ecological and climatic factors warrants the need for a comprehensive consideration of the potential impacts of climate on global agriculture. Tropics are more dependent on agriculture compared to the temperate regions and therefore more valuable to climate change. Hydrological regimes in which crops grow will surely change with global warming; climate change will also have an impact on the soil, a vital element in agricultural ecosystems. Higher temperatures will increase evapotranspiration and soil temperatures which increase chemical reactions rates and diffusion controlled reactions. While crops could be impacted by climate change, it is likely that farm animals would be ever more susceptible to change in climate. It is expected that increased air temperatures will cause more heat stress to livestock. Livestock are endodermic hence they are affected by increased heat and humidity. During stifling heat livestock reproduction declines as well as appetite due to hormonal changes. Decreased appetite will lengthen the time needed for livestock to reach their target weight. Heat stress can also increase fighting among animals. This theoretical review paper encapsulates these concepts in conceptual framework. A conclusion is drawn illustrated by a conclusive working model.

Key Words: Climate Change, Agro-Ecosystems, Agriculture, Food Security

INTRODUCTION

Agro-ecosystems are ecological systems modified by human beings in order to produce food or other agricultural products (Conway, 1987). The agro-ecosystems in the Highveld region of South Africa produce 70% of the country’s commercially grown cereal crops, with 90% of its maize being cultivated there (du Toit et al., 2000). The sustainability of the maize producing agro-ecosystems is of huge consequence to food security in South Africa and to the well-being of the rural economy of the Highveld. Chambers (1997) recognizes that humans are at the centre of agro-ecosystems and that their well-being is a key issue for the sustainability of agro-ecosystems. Sustainability is applying long term perspectives, in regard to human well-being and ecological integrity, to policies and actions. (Walker and Schulze, 2006). This definition of sustainability is used by the authors in this paper. The sustainability of agro-ecosystems in Africa will be influenced, inter alia by climate change and by land use changes and related factors resulting from the above two (Hansen and Jones, 1996).

The inter-relationships between social, economic and environmental influences are associated with sustainability, a systems approach to sustainability is therefore essential (Ikerd, 1993). For such a systems approach, a framework was adapted with a goal-orientated system. Incorporating Hansen and Jones (1996) method to characterize sustainability, the framework has the following four steps: 1. Goal definition; 2. Sustainability modeling; 3. Evaluation strategy and 4. Making recommendations that are predictive, with constraints to sustainability being identified. Hansen (1996) considers it necessary to characterize the concept of sustainability when using it to identify constraints, to identify research foci and for policy development. A case in point is the influence of El Nin o on the seasonal rainfall in the Highveld region in South Africa, a reality for farmers (du Toit and Prinsloo, 1998), since it influences directly both their economic security in the long term and local food security in the shorter term.
LITERATURE REVIEW

Linkage between Agro-ecosystems, Land use Changes and Climate Change

Olson et al. (2004) observe that expansion of cultivation in many parts of East Africa has changed land cover to more agro-ecosystems; food production in Kenya, for example, is reported to have increased steadily between 1980 and 1990. In East Africa, natural vegetation cover has given way not only to cropland, native or planted pasture.

Further, Olson et al. (2004) posit that land use changes in East Africa has also experienced the expansion of urban centers and urban population between 1960 and 2000; during the last few decades the area under cultivation more than doubled in Kenya and Tanzania, but in Uganda the change has been moderate. In Mbeere, in Kenya cultivation expanded by 70% between 1958 and 2001, leaving only isolated pockets of forest and bush. Similarly, in Tanzania, report a significant expansion of cultivation in the Moshi area over the same period. However, in Uganda, agriculture only expanded in the drier rangelands, not in the wetter highlands.

Globally, there was realization that land surface processes influence climate and that change in these processes impact on ecosystem goods and services (Antrop, 2000). The impacts that have been of primary concern are the effects of land use changes on biodiversity, soil degradation and the ability of ecosystems to support human needs (Alcamo, et al., 2005). The sequence of land cover and land use change in East Africa is complex (Mugisha, 2002). In some places pastoralists modify wooded landscapes into more open landscapes by burning, the changes are quite subtle and pastures can quickly revert to bush land and woodland when burning ceases (Olson et al., 2004).

Campbell et al. (2003) observe that land use changes and climate variations influence each other. Numerous studies have shown that land use changes and climate variations affected the structure and function of ecosystems and then affected the supply of ecosystem services (Olson et al., 2004). Land use changes might increase provision and value of some services but decrease others (Antrop, 2000). The effects of land use changes and climate variations may increase changes in ecosystem services delivery (Alcamo, et al., 2005). As to the impacts of climate variations on human wellbeing, it can aggravate the situation for food security by increasing risks of crop failure because of the higher frequency of extreme events and progressive changes of climate (Sivakumar and Brunini, 2005). In addition, as some ecosystem services decline, some new human actions, such as the excessive use of fertilizers and pesticides, have had adverse impacts on ecosystems and further on human wellbeing (Power, 2010, McCarthy et al., 2001).

Hydrological Regimes, Climate Change, Water Security and Food Security

Hydrological regime refers to changes with time and space in rates of flow of rivers and in levels and volumes of water in rivers, lakes, reservoirs marshes and other water bodies. A hydrological regime is closely related to seasonal changes in climate (Cowx, 2000). In regions with a warm climate, the hydrological regime is affected mainly by atmospheric precipitation and evaporation; in regions with a cold or temperate climate, the air temperature is a leading factor (Nilsson and Berggren, 2000).

The hydrological regime of rivers consists of a number of characteristic periods (phases) that vary with seasonal changes in the conditions under which rivers are fed (Nilsson and Berggren, 2000). These phases are known as high water, freshet, and low water. Rivers are fed unevenly in the course of a year because of varying amounts of precipitation and uneven melting of snow and ice and entry of their water into the rivers (Cowx, 2000). The fluctuations observed in the water level are caused mainly by changes in the flow rate and by the effects of wind, ice, and man’s economic activities (Kundzewicz et al., 2007).

Cowx, 2000 posits that the hydrological regime of lakes is determined by the relationship between the amount of precipitation reaching the lake’s surface, evaporation, surface and underground flow into the lake, and surface and underground outflow of water from the lake, as well as by the size and shape of the lake, the pattern of change in the surface area with change in level, and wind activity, which determines the size of the waves and the extent to which the level rises and falls. Kundzewicz et al., 2007 conclude that the hydrological regime of marshes is dependent on climatic and hydrological conditions, terrain, and the nature of the vegetation. Nilsson and Berggren (2000) observe that man’s economic activities are introducing ever greater changes in hydrological regimes.

The impact of climate change on the quantity and quality of groundwater resources is of global
importance because 1.5–3 billion people rely on groundwater as a drinking water source (Kundzewicz and Döll, 2009). There has been very little research on the impact of climate change on groundwater (Kundzewicz et al., 2007). Studies of Global Climate Models (GCMs) projects significant changes to regional and globally averaged precipitation and air temperature, and these changes will likely have associated impacts on groundwater recharge (Kurylyk and MacQuarrie, 2013). Studies show that agricultural yield will likely be severely affected over the next hundred years due to unprecedented rates of changes in the climate system (Jarvis et al., 2010; Thornton et al., 2011). In arid and semi-arid areas the expected precipitation decreases over the next century would be 20% or more.

According to UNEP (2004), the world experienced unprecedented high-impact climate extremes during the 2001–2010 decade that was the warmest since the start of modern measurements in 1850. In 1955, only seven countries were found to be with water stressed conditions. In 1990 this number rose to 20 and it is expected that by the year 2025 another 10–15 countries shall be added to this list. It is further predicted that by 2050, 2/3rds of the world population may face water stressed conditions (Gosain et al., 2006); majority of the Arab countries depend on the international water bodies for their requirements.

UNESCO (2004) reports that the Nile river basin is the home of approximately 190 million people of Ethiopia, Eritrea, Uganda, Rwanda, Burundi, Congo, Tanzania, Kenya, Sudan and Egypt. Since majority of nations of the Nile river basin are among the top 10 poorest countries of the world therefore it is absolutely difficult for them to adopt any strategy of water management, which require investment. The OSS (Observatory of the Sahara and the Sahel) regions, which have the least natural water resources, both in absolute terms and in relation to its population will be affected severely. Over 90% of Sub-Saharan Africa agriculture is rain-fed, and mainly under smallholder management (Batino et al., 2011). de Wit and Stankiewicz (2006) identify three river systems in Africa: the areas receiving very low rainfall have virtually no perennial drainage (dry regime), then the areas with an intermediate range in which drainage density increases with increasing rainfall (intermediate rainfall regime) and the areas of high rainfall (high rainfall regime). The dry regime covers the largest area of the African continent, approximately 41%; the intermediate rainfall regime which covers approximately 25% because this is the area where changes to precipitation would result in serious changes in drainage supply. Further, as predicted by an ensemble of global climate change models by the second part of this century, climate change would directly affect African countries, 75% of which belongs to the intermediate stage. Fig. 1 shows the present rainfall regimes in Africa and Fig. 2 shows the expected changes in the precipitation by the end of the 21st century on the basis of composite leading fully coupled GCMs adapted by IPCC for forecasting purposes (CSAG, 2002). A net 2.5 °C rise in temperature in Africa will result in a decline of net revenues from agriculture by US$ 23 billion (Kurukulasuriya and Mendelson, 2007).
The shortage of water can be augmented from wastewater utilization after suitable treatment (FAO, 2012). Water recycling by giving technological support can speed up can help in minimizing the impact of climate change on crop yield and water resources (de Wit and Stankiewicz (2006).

The Relationships between Soils, Climate Change and Food Security

Soils are important to food security and climate change has the potential to threaten food security through its effects on soil properties and processes (Brevik, 2012). It requires an understanding of how climate and soils interact and how changes in climate will lead to corresponding changes in soil (Pimentel, 2006). Respective of soils and climate change interactions are the carbon and nitrogen cycles because C and N are important components of soil organic matter (Brady and Weil, 2008); because carbon dioxide (CO$_2$), methane (CH$_4$), and nitrous oxide (N$_2$O) are the most important of the long-lived greenhouse gases (Hansen, 2002). Human management of soils can have a profound impact on the balance of C and N gas emissions from those soils, and therefore influences global climate change (Post et al., 2004).

The largest active terrestrial C pool is in soil, which contains an estimated 2,500 Pg of C compared to 620 Pg of C in terrestrial biota and detritus and 780 Pg of C in the atmosphere (Lal, 2010). Carbon is readily exchanged between these pools; therefore, they are called active pools. In addition to the active pools, there are approximately 90,000,000 Pg of C in the geological formations of Earth’s crust, 38,000 Pg of C in the ocean as dissolved carbonates, 10,000 Pg of C sequestered as gas hydrates, and 4,000 Pg of C in fossil fuels (Pimentel, 2006). However, most of the C in these pools is locked up over long periods of geologic time and not readily exchanged; leading to these pools being referred to as inactive pools (Post et al., 2004); the release of C from the inactive pools, particularly though the combustion of fossil fuels is also an important anthropogenic source of greenhouse gases. Soils naturally sequester C through the soil-plant system as plants photosynthesize and then add dead tissues to the soil (Post and Kwon, 2000). Carbon is also naturally emitted from soils as CO$_2$, CO and CH$_4$ gases due to microbial respiration (Brady and Weil, 2008).

However, other management changes such as using cover crops, crop rotations instead of monocropping, and reducing or eliminating fallow periods can lead to C sequestration in soil; as can returning land from agricultural use to native forest or grassland (Brevik, 2012). Sequestration of C tends to be rapid initially with declining rates over time (Dixon-Coppage et al., 2010). Most agricultural soils will only sequester C for about 50–150 years following management changes before they reach C saturation (Mosier, 1998).

The C and N cycles are key parts of the global climate system, and soils are an integral part of these cycles (Post and Kwon, 2000). Agriculture contributes a particularly large percentage of annual anthropogenic CH$_4$ emissions to the atmosphere (Mosier, 1998). Agriculture contributes CO$_2$, CH$_4$, and N$_2$O into the atmosphere; hence management systems have the potential to influence climate change (Dixon-Coppage et al., 2010). The interactions between soils and the atmosphere in a changing climate are important variables as we seek to understand climate change and its potential influence on food security through the biogeochemical cycles (Pimentel, 2006).

Food systems, Food security and the link to Climate Change

Food security depends on robust food systems that encompass issues of availability, access and utilization, not production alone and consequently that the nature of key research issues changes as more questions related to food security are formulated (Ingram et al., 2005). There are several definitions of what constitutes food systems each formulated in relation to a specific range of issues such as globalization of the agri-food systems (Goodman, 1997); community food systems (Gillespie and Gillespie, 2000); ecological interests (Barling, 2004).

Ingram et al. (2005) posits that food systems are defined as a set of dynamic interactions between and within the biogeochemical and human environments which result in the production, processing, distribution, preparation and consumption of food. They encompass components of: (i) food availability; (ii) food access and (iii) food utilization.

Access to culturally acceptable food Food systems may be simple, as in the case of a subsistence farmer who produces processes and consumes food on farm. Ingram et al. (2005) conclude that intensification of agricultural production, since the 1940s has been accompanied by profound changes in the organization.
of food systems around the world including changes in distribution, marketing, affordability and preferences for particular food items.

Food systems around the world are changing very rapidly as urbanization and globalization proceeds apace (Ingram et al., 2005). The urbanization of many predominantly rural countries in the last three decades has been accompanied by the rapid growth of supermarkets in many countries, often accompanied by foreign investment by global retail chains (Reardon et al., 2003). However, even in African countries such as Kenya, supermarkets have grown from a tiny niche market in 1997 to be greater than 20% of urban food retailing today (Neven and Reardon, 2004). Success within Kenya is now spreading to other East African countries with important effects on the market conditions faced by farmers including the decline of traditional wholesalers and the increase in direct purchases from larger farms. Table 1 shows changes in the supply of fresh fruit and vegetables to the Uchumi supermarket chain in Kenya by supplier type for the period 1997–2008.

Table 1: Changes in the supply of fresh fruit and vegetables to the Uchumi supermarket chain in Kenya by supplier type for the period 1997–2008.

<table>
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<tr>
<td>small farms</td>
<td>13 10 15</td>
<td>5 10 10</td>
</tr>
<tr>
<td>medium farms</td>
<td>10 25 30</td>
<td>10 10 10</td>
</tr>
<tr>
<td>large farms and plantations</td>
<td>5 15 35</td>
<td>0 15 35</td>
</tr>
<tr>
<td>traditional brokers/wholesalers</td>
<td>70 45 10</td>
<td>70 40 10</td>
</tr>
<tr>
<td>imports</td>
<td>2 5 10</td>
<td>15 25 35</td>
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The values are the percentage contribution to the total supply. (Source: Neven and Reardon, 2004).

According to Gregory and Ingram (2000), climate change may affect food systems in several ways ranging from direct effects on crop production to changes in markets, food prices and supply chain infrastructure. For example in southern Africa, climate is among the most frequently cited drivers of food insecurity because it acts both as an underlying, ongoing issue and as a short-lived shock. Because of the multiple socioeconomic and biophysical factors affecting food systems and hence food security, the capacity to adapt food systems to reduce their vulnerability to climate change is not uniform across regions (Jones and Thornton, 2003). Several reviews have further assessed the potential consequences of changes in climate on the growth and yield of crop plants (Amthor, 2001); their linkage to plant physiological processes hence concluding that the earlier-anticipated benefits of CO2 fertilization would be largely offset by nutrient limitations, pollutants and further interactions with climatic factors (Long et al., 2005). This, and other similar projections that use a process-based crop production model to link climate change to crop yield can then be modeled for a uniform crop yield and up scaled to a larger area normally within some form of geographic information system (GIS). Figure 3 shows the three components of food systems with their main elements.

Figure 3: The Three Components of Food Systems with their Main Elements
(Source: (Gregory and Ingram, 2000)).

Misselhorn (2005) observes that, to better address the food security concerns that are central to economic and sustainable development agendas, it is desirable to develop a broader research framework, which integrates biophysical and socio-economic aspects of food systems and thereby addressing two key questions:

(i) Which aspects of food systems are most vulnerable to climate change?
(ii) What can be done to reduce the vulnerability of these food systems and thereby improve food security?

In studies of household food security in southern Africa, climate was one of some 33 drivers mentioned as important by householders (Misselhorn, 2005). It has become clear that the key to assessing vulnerability is to develop research frame-works which can
explicitly consider the social and political constraints which condition the capacity of food systems to cope with external stressors such as climatic change (Mustafa, 1998). Finally, changes in the food systems aimed at reducing vulnerability feedback to environmental and societal changes themselves may reinforce agricultural practices that either reduce or exacerbate land degradation, and increase or reduce farm profitability (Adger, 1999; Scholes and Biggs, 2004). According to Gregory and Ingram (2000) not all food systems are equally vulnerable to environmental changes. Human vulnerability and poverty are often interrelated because both the likelihood of exposure to stresses is greater among the poor and because a large proportion of their resources are spent either purchasing or producing food, thereby reducing their capacity to cope with perturbations (Hume et al., 2001). Regional policy decisions do not always convert to successful local implementation especially if distribution services are inadequate, or food preferences are ignored (Ellis, 2003). The following adaptation actions are illustrated below using an example from each of the three elements of the food system as depicted in figure 1.

(a) Reducing food system vulnerability by increasing food production: Past increases in agricultural production have occurred as a result of both extensification (altering natural ecosystems to generate products) and intensification (producing more of the desired products per unit area of land already used for agriculture (Gregory and Ingram, 2000). In future, intensification will be the dominant means for increasing production although the cultivation of new land will be important in some regions (e.g. an estimated contribution of 47% from extensification in sub-Saharan Africa to cereal production by 2020 (Alexandratos, 1995).

(b) Reducing food system vulnerability by improving food distribution: Pingali and Khawaja (2004) assert that infrastructural and non-infrastructural controls on food distribution can be significant impediments to reducing food system vulnerability in a timely manner. This became strikingly apparent during the drought relief effort mounted in 1990/1991 in southern Africa in response to the estimated 86 million people at risk in the region of whom some 20 million were deemed at serious risk. Food availability for the region was severely constrained due not to lack of food per se but by lack of investment in distribution systems and institutional constraints. This brief summary highlights several ways in which regional food insecurity could be reduced, and shows that adaptation options can include a range of issues including, among others, regional investment in port, rail and grain storage infrastructure and in region-wide political agreements to facilitate the flow of food in an emergency.

(c) Reducing food system vulnerability by increasing economic access to food: In the case of southern Africa, Arfitzen et al. (2004) indicates that the discussion centers on varied means. According to Mahendra Dev et al. (2004); first, price mechanisms and policies could be designed that serve the interest of producers and consumers. Second, regional specialization in food production and regional trade would lower production costs and food prices and, therefore, improve access. Third, economic growth will lead to income and employment generation, both of which will facilitate access to food. Finally, stability in political governance supported by an effective pool of human and institutional resources facilitates the establishment and maintenance of food systems. Figure 4 shows the conceptual framework as envisaged in this review, depicting the main drivers of Food Insecurity in Africa. This conceptual framework can be adopted for research.
An Overview of Impacts of Climate Change on Crop Yield and Growth

Agro-ecosystems may be strongly influenced by projected increase in atmospheric CO₂ concentration and associated climate change (Reilly, et al., 1996). The direct effect of increasing CO₂ concentration on plant growth is of particular interest because of the possibility of increasing crop yields in the future once the substrate for photosynthesis and the gradient of CO₂ concentration between atmosphere and leaf will increase (Reid, et al., 2005). Current atmospheric CO₂ concentration (about 360 µmol mol⁻¹) is insufficient to saturate the ribulose 1, 5-bisphosphate carboxylase (Rubisco), the enzyme responsible for primary carboxylation, the metabolic process that drives photosynthesis, in C3 plants (Sivakumar and Brunini, 2005); very few studies indicate a yield depression at elevated CO₂ concentration and those are primarily with flower crops.

Probably the most important physical effect of transpiration in plants is the cooling that takes place at the transpiring surface (Sivakumar and Brunini, 2005). Because large quantities of energy are required in the phase change from liquid to vapor, evaporation provides a very efficient mechanism for heat dissipation.

An Overview of Impacts of Climate Change on Livestock Productivity

Thornton et al. (2007) posit that the situation in Africa and other developing countries is that generally, climate can affect livestock directly and indirectly. Although indirect, feed resources can have a significant impact on livestock productivity, the carrying capacity of rangelands, the buffering ability of ecosystems and their sustainability, and the distribution of livestock diseases and parasites. In Africa the main pathways in which climate change can affect the availability of feed resources for livestock are as follows:

1. Land use and system changes can lead to different compositions in animal diets and to alteration in the ability of smallholders to manage feed deficits in the dry season (Thornton et al., 2007).
2. Changes in the primary productivity of crops, forages and rangelands are probably the most visible effect of climate change on feed resources for ruminants with the end result, for livestock production, a change in the quantity of grains, stovers and rangelands available for dry season feeding (Thornton et al., 2007).
3. Changes in species composition in rangelands and some managed grasslands will have significant impact on the types of animal species that can graze them, and may alter the dietary patterns of the communities dependent on them (Thornton et al., 2007).
4. The quality of plant material will be altered (from C3 to C4) by increased temperatures and will reduce the digestibility and the rates of degradation of plant species which will lead to reduced nutrient availability for animals (Thornton et al., 2007).
4. However, increased levels of CO₂ may favour C3 plants; it is also possible that C4 grasses may be replaced with C3 grasses owing to increased levels of CO₂ (Taub, 2010); or climate change may result in the deterioration of pasture towards lesser quality sub-tropical C4 grasses.

Climatic changes directly influence livestock health through a number of factors, including the range and abundance of vectors and wildlife reservoirs, the survival of pathogens in the environment, and farming practice (Gale et al., 2009; Semenza and Menne, 2009). Transmission of zoonotic diseases occurs when there is an overlap of activities between reservoir, vector and humans; changes in climate may impact on all of these factors involved in disease transmission and interactions (Gray et al., 2008; Randolph, 2008a). Abiotic factors, such as temperature and day length, impose constraints on when and how ticks quest for hosts (Randolph, 2008b). Beyond vector-borne diseases, intestinal nematodes develop in soil, and factors such as soil humidity and temperature have a strong influence on developmental rates (Brooker et al., 2002). Direct effects are also related to radiation; the animal's inability to dissipate environmental heat causes heat stress (Fuquay, 1981; Bucklin et al., 1992). Evaporation is the most important methods of heat transfer as it does not depend on a temperature gradient (Ingram and Mount, 1975). Humidity affects the evaporation rate; therefore, the temperature humidity index (THI) becomes relevant under conditions of high temperature and high humidity (Thom, 1958).

**Theoretical Analysis**

Compiling and analyzing the results of more than 770 reports about the CO₂ enrichment on the economic yield of 24 agricultural crops and 14 other species, Jarvis et al. (2010) showed that only 39 out of 437 separate observations (i.e. 9%) yielded less than their respective controls and the average relative increase was 28% considering all of the crops or 36% excluding flowers. The effect of CO₂ enrichment on flower yield was generally lower than on food crops. Mean yield increases were 23%, 32%, 42%, 54% and 52% for fruit, cereal C3, leaf, legume and root crops, respectively. Hansen (2002) estimated that a doubling CO₂ concentration, holding other factors constant, could lead to a 34 ± 6% increase in agricultural yields of C3 plants and a 14 ± 11% in C4 plants with a 95% confidence interval. Gregory et al., 2005 concluded that provided adequate water, nutrients and pest control, yields of C3 and C4 crops growing in about 700 µmol CO₂ mol-1 would be about 30 to 40% and 9%, greater than present yields, respectively. Below-ground growth is also increased at elevated CO₂ concentration.

**Application: Suggested Adaptation Mechanisms**

Food systems, underpin food security, which is the state achieved when food systems operate such that all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (McClain-Nhlapo, 2004); food security is diminished when food systems are stressed. For the future, continued technological developments are anticipated to facilitate the adaptation of crops to changing environments (Gregory et al., 2005).

There are many plant characters and elements of crop management that contribute to the efficient use of water by crops (Gregory, 2004), but relatively little attention has been paid to root characters that may allow more water to be exploited or used more efficiently, largely because root systems are very difficult to measure. However, genotypic differences are known to exist in many features of root systems which may be exploitable to improve crop yield in drier climates (O'Toole and Bland, 1987). Studies with existing genotypes in dry areas may inform the adaptation possible under conditions of changed climate (Champoux et al., 1995). Porter and Semenov (2005) posit that the development of DNA-based molecular markers has opened up opportunities for identifying the genetic factors (quantitative trait loci) underpinning various root traits. Again, this science is at an early stage of development for root traits, but significant progress has been made in studies of drought tolerance with rice (Babu et al., 2001). In reducing food system vulnerability by increasing economic access to food, this important adaptation is as yet hardly pursued, but should gain momentum with trade liberalization and policy shifts towards food security.

**CONCLUSION**

Studies on the impacts of Land use changes and climate variations on ecosystem provisioning services and the impacts of provisioning services changes on human wellbeing will provide scientific and theoretical basis for global policy making especially focusing on food security. At present, our understanding of how changes in climate will influence the C and N cycles is incomplete, meaning additional research into these questions is needed. Notably, it has become necessary
now to take very seriously the impact of climate change on the present water resources and take necessary actions without any further delay; because food grows where water flows.

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ROLE OF KNOWLEDGE ACQUISITION IN ENHANCING THE PERFORMANCE OF MICRO, SMALL AND MEDIUM ENTERPRISES IN MIGORI COUNTY, KENYA

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ABSTRACT

This paper explores the role of knowledge acquisition in enhancing the performance of Micro, Small and Medium Enterprises in Migori County, Kenya. The author interviewed 297 owner and employed managers from Micro, Small and Medium Enterprises (MSME) in Migori County to rate their enterprises’ knowledge acquisition behavior and their effects on performance. The views of MSME managers were later correlated with performance. In addressing this situation, the authors drew on quantitative research methodology - multiple regression analysis in particular. The study found that MSMEs that were active in their knowledge acquisition had a significantly positive effect on Micro, Small Medium Enterprises performance in Migori County, Kenya. Based on the findings from this study the author advises that Micro, Small and Medium enterprises should fast track their MSMEs’ knowledge acquisition to accelerate their overall performance.

Keywords – Knowledge acquisition, MSMEs, Performance.

INTRODUCTION

Today’s economy is characterized by rapid rate of change, globalization and knowledge based products (Radwan et al., 2012). The survival and performance of an organization is influenced by its ability and speed in developing knowledge based competencies (Prusak, 2001). The ability to promote an organization’s knowledge acquisition behavior ultimately results in smarter and more capable organization thus enabling it to manage its assets cheaper, better and more effectively than its competitors (Ahmed et al., 2002). By fostering knowledge acquisition as part of their daily business activities, Micro, Small and Medium Enterprises can remain competitive and sustainable (Radwan et al., 2012). These practices were implemented by multinationals in Malaysia in the 1990’s and brought positive transformation in their performance.

Essentially, the knowledge acquisition is vital to the organization as it is a key source of competitive advantage and innovation in organizations (De Geus, 1997). External knowledge is also important and can be acquired from suppliers, competitors, partners and external experts (Gamble and Blackwell, 2001).

Tsang, Nguyen and Erramilli (2004) in their study of Knowledge acquisition and performance of international Joint Ventures in the transition economy of Vietnam, developed a model that proposed: that certain international joint venture characteristics influence the joint venture's knowledge acquisition from its foreign parent, and: that the amount of knowledge acquired affects venture performance. The authors tested the model in Vietnam and found that parental conflict, commitment, and receptivity affect knowledge acquisition. They found out that the amount of knowledge acquired contributes significantly to venture performance.

Friesl (2012) in his study of Knowledge acquisition strategies and company performance in young high technology companies found four distinct knowledge acquisition strategies (low key, mid range, focus and explorer) and shows that these strategies differ in their relation to company performance as a result of their configuration of knowledge acquisition activities and the type of knowledge acquired.

Micro, Small and Medium Enterprise performance is manifested in their market share, new product success and profitability (Choi et al., 2003). Performance either at the employee or organizational levels has had a robust discourse in management literature (Ghalayani & Noble, 1996; Kaplan & Norton, 2001; Robins, 2003; Chenhall, 2005). It is importantly discussed with the organizational ideology of an entity with goal focus. Therefore the imperative is the need to assess if such goals are being met or are progressively achieved. A common point arising from the multi positions in literature is the agreement on the multi dimensions that
are applicable in expressing performance at the employee and organizational levels (Pannel & Wright, 1993; Dennison & Mishra, 1995; Peter & Crawford, 2004; Lee, 2005; Nagho, 2009). In addition, Philemon, (2009) has espoused that in measuring performance at the employee level, much of the attention is on social behavior. This circumstance subtly shifts from the traditional financial orientation measurement which has hitherto and primarily constitutes the basis of measurement for the construct. Particularly, Lailya (2004) posits that at the employee level of analysis in the performance debate, a realization of non financial related measure for assessing employee performance will probably be more realistic.

Studies in knowledge acquisition and its effect on performance in organizations, has been done based on using secondary literature (Khan (2012). Furthermore, emphasis has been given to large organizations (Radwan et al., 2012). The failure to address many aspects of Micro, Small and Medium Enterprises needs to be addressed. Given the crucial role of Micro, Small and Medium Enterprises play in the economies of both developing and developed countries, a study of knowledge acquisition and its effect on Micro, Small and Medium Enterprises performance is of crucial importance.

LITERATURE REVIEW

Knowledge Acquisition
The changing world of work has strikingly initiated the discourse on knowledge as a critical resource that strategically induce organization performance outcome. The thinking is that the human resource is imbued with knowledge that instigates his ability to contribute and undertake work tasks. Knowledge is the impetus for acquired skills and competencies. The importance of knowledge has been underscored in strategic management literature therefore its management has assumed same dosage in the discourse (Helfert & Liberman, 2002; Trispas, 2009). According to Helfert & Liberman, (2002) and Trispas (2009) knowledge acquisition is a candidly initiated effort to strategically alter attempt at competitiveness with a view to ensuring dominance among competitors.

With the arrival of the knowledge economy era, knowledge has become an important basis for improving enterprise performance and obtaining competitive advantage (Weiwei et al., 2010). Furthermore, knowledge is a key source of innovation in organizations (De Geus, 1997) which translates into improved service delivery and better quality goods, hence improved sales margins in the MSMEs. Small firms are in an advantageous position in acquiring customers’ knowledge as managers tend to have close and direct contact with customers (Haksever, 1996). The proximity to customers ultimately facilitates a more direct and faster flow of knowledge to employees; hence they are in a position to know competitor’s actions and behavior, market trends and related developments (Wong and Aspinwall, 2004).

Billa (2006) opined that knowledge seeking firms are operational string to the extent that they sufficiently share through structural flexibility and infrastructure that facilitate sharing. These positions suggest there is a premium ascribed a firm’s ability to acquire knowledge for all purposes. Prahlad and Hammel (2002) relying on the knowledge based view had noted that competencies are seen as the basis for a company’s ability to acquire competitive advantage. They had further observed that employees improved work action in relation to assigned responsibilities is not a function of tangible or extrinsic incentives or the conducive work environment rather. Today’s worker characteristically acquire knowledge which constitute the asset that reengineer all work processes towards goals. The acquisition component of the entire knowledge management process is fundamental as it precedes other activities in the entire knowledge management spectrum.

Ewang (2006) noted that to generate employee support for organizational success, knowledge acquisition provides the strategic leverage that is empowering both in psychological and practical context of work. The willingness to acquire and strengthen what is eventually shared as shown in the literature had seemingly shown the link between knowledge acquisition and several work outcomes. While these links are empirically biased they have been contextualized within the functions and levels of work structure especially when viewed in the light of responsibility variance that may result from different levels of the organization.

Weiwei et al., (2009) in their study of the relationship between knowledge acquisition and enterprise performance mediated by technological capability, reviewed literature and determined the relationships underpinning knowledge acquisition, technological capability vis a vis enterprise performance theoretically. The study found that knowledge acquisition had a positive effect on technological
capability and enterprise performance. The research used data generated from empirical surveys of 151 enterprises. Due to little investment in technology in MSMEs due to comparatively low capital, an empirical study targeting MSMEs with less emphasis on technology is of essence. This study nevertheless pointed to a vital relationship involving knowledge acquisition and performance.

Wan et al., (2012) in knowledge management and firm performance in SMEs: the role of social capital as a mediating variable varied knowledge acquisition and knowledge conversion (KC) to financial performance (FP). All the variables were significantly related to performance, with knowledge acquisition the main contributor. This study in Malaysia was performed using standard beta coefficient for independent variables using empirical data from SMEs. This study, despite providing useful relationships regarding knowledge acquisition and SME performance provided little insight into the relationship that exists in MSMEs, particularly in developing country like Kenya.

THEORETICAL ANALYSIS

This study adopted the ‘Knowledge Based View theory of the Firm’, which was propounded by Penrose (1959) and later expanded by other writers including Wernerfelt (1984), Barney (1991) and Connor (1991). It states that knowledge is the most significant resource of a firm. This theory explains the Effects of Knowledge Management in Micro, Small and Medium Enterprises’ performance. Its proponents argue that heterogeneous knowledge base and capabilities among firms are the main determinants of sustained competitive advantage and superior corporate performance (Decarolis and Deeds. 1999; Winter and Szulanski, 1999). Today’s Micro Small and Medium Enterprises therefore need to foster knowledge acquisition in their ranks to achieve the competitive edge and enhanced performance.

Researchers’ adopting the Knowledge Based View perspective highlight that the firm’s future growth is dependent on the productive integration of knowledge resources and the derivative decision making capabilities (Spender, 1996). However the theory is silent on the specific Knowledge acquisition behavior and practices that may be adopted by Micro Small Medium Enterprises to create enhanced performance. The study therefore, undertook to assess the extent to which Micro, Small and Medium Enterprises’ Knowledge acquisition behaviour were catalysts for improved productivity.

METHOD

Data Collection

Questionnaires were mailed through post office, personally delivered and in certain instances emailed to owner managers and employed managers of the 297 Micro, Small and Medium Enterprises in Migori County. In cases where data could not be generated using this method, alternative methods like interview schedules were adopted to supplement it. In particular, structured interviews were used by the researcher to supplement the collection of data. Structured interviews are time saving since the respondents only answer what has been asked by the researcher (Kombo and Tromp, 2010). The researcher should be aware that some types of instruments are unsuitable for some groups of people due to factors such as literacy levels, profession and culture (Kombo and Tromp, 2010). Questionnaires enable collection of data from large samples in diverse regions. It upholds confidentiality, saves time and reduces interviewer bias (Kombo and Tromp, 2010). The questionnaire elicited feedback on a scale of 1-5, which is adopted on a Likert-scale (Gotzamani and Tsiotras, 2001). It ranged from strongly disagree (1) to strongly agree (5).

Data Analysis

The researcher first formulated codes from the responses which were then summarized for each question. The questionnaire and interview responses the researcher and his assistants obtained from the field were then converted into SPSS data files from which frequency distribution tables were drawn for various variables. In addition, multivariate analysis was performed.

Multiple regression analysis was performed. Multiple regression is a flexible method of data analysis that may be appropriate whenever a quantitative variable (the dependent or criterion variable) is to be examined in relationship to any other factors expressed as independent or predictor variables (Cohen et al., 2003). A researcher can examine the effects of a single variable or multiple variables with or without the effects of other variables taken into account (Cohen et al., 2003).
Variables were first assessed by obtaining their mean and standard deviation. The mean gave an indication on the average rating by the respondents whereas standard deviation indicated spread around the mean for the data. In addition, an assessment of each independent variable was made in relation to the dependent variable. Afterwards, the relationship between all the independent variables with each other was ascertained through correlation. The regression equation was then derived.

**Findings**

The study attempted to find out the relationship between each variable and performance in MSMEs in Migori County, Kenya.

The role of knowledge acquisition on the performance of Micro, Small Medium Enterprises in Migori County, Kenya was sought. Descriptive results of knowledge acquisition revealed that documented information played the biggest role in fostering improved Micro, Small Medium Enterprises’ performance. Next was knowledge from external sources and expert inputs. Lastly, was a computer file with pertinent information? Overall, these findings suggest that in general organizations should encourage documenting of information, knowledge from external sources and expert inputs to achieve enhanced performance. Correlation results for knowledge acquisition and Micro, Small Medium Enterprises’ performance (r=0.731) was positive and strong, implying that knowledge acquisition and Micro, Small Medium Enterprises’ performance tend to move together in the same direction, that is, they tend to increase or decrease together. Multiple regression results revealed that unstandardised coefficient relating knowledge acquisition and Micro, Small Medium Enterprises’ performance was 0.731 implying that when knowledge acquisition improves by one unit percent, Micro, Small Medium Enterprises’ performance improves by 73.1%.

**DISCUSSION**

**Inferential Statistics**

Inferential statistics involve inferences about a population on the basis of results obtained from samples in the population studied. In this study, multiple regression analysis was used to analyze the data obtained from the field.

**Correlations Statistics for Linear Relationship between Variables**

This section presents and discusses the correlation statistics for the linear relationship between the organizational performance, organizational learning, knowledge sharing and knowledge acquisition.

<table>
<thead>
<tr>
<th>Table 1: Correlations statistics for linear relationship between variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
</tr>
<tr>
<td>Performance</td>
</tr>
<tr>
<td>Organizational Learning</td>
</tr>
<tr>
<td>Knowledge sharing</td>
</tr>
<tr>
<td>Knowledge acquisition</td>
</tr>
</tbody>
</table>

* Correlation is significant at 0.05 level (2-tailed)
** Correlation is significant at 0.01 level (2-tailed)

Source: SPSS Data Analysis, 2014

A simple correlation was carried out to establish the degree of relationship between Micro, Small and Medium Enterprises performance, and the independent variables organizational learning, knowledge sharing, and knowledge acquisition, and the results obtained as shown on table 1.

Pearson Correlations results in table 1 shows that knowledge acquisition was positively and significantly associated with MSME performance as indicated by r=0.731, and p<0.05 indicating that knowledge acquisition had 73.1% positive relationship with MSME performance. With the positive coefficient, it was evident that the two variables (knowledge acquisition and MSME performance) move in tandem in the same direction.

All the three correlation coefficients are positive which indicates the fact that such aspects as organizational learning, knowledge sharing and knowledge acquisition would ultimately contribute positively to MSME performance in any County.
**Multiple Regressions**

Multiple regression is a flexible method of data analysis that may be appropriate whenever a quantitative variable (the dependent or criterion variable) is to be examined in relationship to any other factors (expressed as independent or predictor variables) (Cohen et al., 2003). Importantly, a researcher can examine the effects of a single variable or multiple variables with or without the effects of other variables taken into account (Cohen et al., 2003). In this study, the dependent variable was performance of MSMEs, denoted by Y. The dependent variable was made up of three sub-variables namely profitability, new product success and market share. The three sub-variables were summed up and averaged to derive the dependent variable for this research. The independent variables included knowledge acquisition. Knowledge acquisition was made up of sub-variables which were averaged to derive its effect as follows:

Knowledge acquisition ($X_3$) was derived from the average of the following sub-independent variables including knowledge from external sources, expert inputs, computer files with pertinent information and documented information. The results were summarized in table 1 as shown.

<table>
<thead>
<tr>
<th>Table 2: Multiple regression model</th>
<th>Unstandardised Coefficients</th>
<th>Standardised Coefficients</th>
<th>Collinearity Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td>T</td>
</tr>
<tr>
<td>(Constant)</td>
<td>0.745</td>
<td>0.224</td>
<td>3.326</td>
</tr>
<tr>
<td>Organizational Learning</td>
<td>0.015</td>
<td>0.049</td>
<td>0.031</td>
</tr>
<tr>
<td>Knowledge Sharing</td>
<td>0.554</td>
<td>0.068</td>
<td>0.614</td>
</tr>
<tr>
<td>Knowledge Acquisition</td>
<td>0.683</td>
<td>0.051</td>
<td>0.129</td>
</tr>
<tr>
<td>R Square</td>
<td>0.579</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted R Square</td>
<td>0.579</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Durbin-Watson</td>
<td>1.291</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>29.117</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig</td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Dependent Variable: MSME performance

**Source:** Author, 2014

The regression equation

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \epsilon_i$$

Where:

$Y =$ MSME performance in Migori County

$\beta_0 =$ Constant term

$\beta_1 =$ slope of Organizational Learning

$X_1 =$ Organizational Learning

$\beta_2 =$ slope for Knowledge Sharing

$X_2 =$ Knowledge Sharing

$\beta_3 =$ slope for Knowledge Acquisition,

$X_3 =$ Knowledge Acquisition

$\epsilon_i =$ Error Term.

$$Y = 0.745 + 0.015X_1 + 0.554X_2 + 0.683X_3 + \epsilon_i$$

Hence;

MSME Performance = 0.745 + 0.015 Organizational Learning + 0.554 Knowledge Sharing + 0.683 Knowledge Acquisition + Error Term.

From the model in table 2, it is noted that there exist a positive relationship between $Y$ (MSME performance) and all the three independent variables namely organizational learning ($X_1$), knowledge sharing ($X_2$) and knowledge acquisition ($X_3$); based on the positive coefficients of the variables; $\beta_1 = 0.015, \beta_2 = 0.554$ and $\beta_3 = 0.083$. Unstandardized coefficients indicate how much the dependent variable varies with an independent variable, when all other independent variables are held constant.

$\beta_3 = 0.683$ is the sample parameter estimate of the true parameter $\beta_3$. From the model, it is deduced that a one
percentage improvement in knowledge acquisition would bring about an 68.3% improvement performance for the MSMEs in Migori County. Indeed, a unit increase in knowledge acquisition would encompass all the sub variables that make it up including knowledge from external sources, expert inputs, computer files with pertinent information and documented information. Because the sample of MSMEs in Migori County selected by the researcher for this study is assumed to be representative of the population of the MSMEs, the deductions made herein would surely apply to the entirety of the MSMEs in Migori County. VIF (Variance Inflation Factor) quantifies the severity of multicollinearity in an ordinary least squares regression analysis (Longnecker, 2004). Multicollinearity arises when the independent variables are related and can yield distorted data results. The VIF value for Knowledge acquisition was found to be 1.335. This is a pointer to the fact that multicollinearity was inexistent in the data. The threshold for strong models is 10 whereas that of weak models is 2.5 (Longnecker, 2004). In this study, however, the Variance Inflation Factor values were way below the threshold.

CONCLUSION

Knowledge acquisition significantly affects Micro, Small Medium Enterprises performance in Migori County. On average, the respondents regarded both documented information with pertinent information and knowledge from external sources as the most prevalent, followed by inputs from experts. Least favored contributor in this category was computer files with pertinent information. The correlation results pointed to the fact that knowledge acquisition and Micro, Small Medium Enterprises performance in Migori County relate positively, albeit weak. Knowledge acquisition, therefore, has no significant effect on Micro, Small Medium Enterprises performance in Migori County.

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