

# **DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY**



## **PROCEEDINGS OF THE 4<sup>TH</sup> DeKUT INTERNATIONAL CONFERENCE ON SCIENCE, TECHNOLOGY, INNOVATION & ENTREPRENEURSHIP**

**THEME:**

**‘Harnessing Science, Technology, Innovation and Entrepreneurship  
for Sustainable Development’**

**February 2019**

**PROCEEDINGS OF THE 4<sup>TH</sup> DeKUT INTERNATIONAL CONFERENCE ON  
SCIENCE, TECHNOLOGY, INNOVATION & ENTREPRENEURSHIP**

**Dedan Kimathi University of Technology**

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Better Life through Technology.

## PREFACE

The 4<sup>th</sup> DeKUT International Conference on Science, Technology Innovation and Entrepreneurship (STI&E) was held on 7<sup>th</sup> – 9<sup>th</sup> November, 2018 at Dedan Kimathi University of Technology (DeKUT) Main Campus in Nyeri. The theme of the conference was ‘*Harnessing Science, Technology, Innovation and Entrepreneurship for Sustainable Development*’. Conference sub themes were;

1. Engineering Technologies and Innovations for Industrialization.
2. Business Management and Entrepreneurship for Sustainable Development.
3. Basic and Applied Sciences for Advancement of Research and Innovations.
4. Innovative Agricultural Sciences and Technologies for Sustainable Food and Nutrition Security.
5. Water, Energy, GIS and Remote Sensing, Environment, and Climate Change.
6. Health Sciences and Community Development.
7. Information and Communication Technology for Development.
8. Tourism, Wildlife and Hospitality Management.
9. Policy, Culture and Governance for Sustainable Development
10. Security Trends and Innovations.
11. Trends in Technical Education and Training.
12. African Development and Harnessing Traditional Knowledge
13. Data Science

The conference provided researchers from local and international institutions, a forum to discuss and share ideas on latest innovations and research outputs that address local and global challenges and those that improve the quality of life for the people and inform the decision-making process in matters of development by government and businesses. International delegates came from countries such as Germany, Japan, Ethiopia and Mozambique and Rwanda. The conference was officially opened by the representative of the Director General, Energy Regulatory Commission (ERC) Dr. John Mutua.

Identified high quality papers have been selected for publication in the Journal of Applied Science, Engineering and Technology for Development. This journal has a reputation of high international standards and a reference in engineering, applied sciences and development. We continue to seek collaboration with the largest number of authors and institutions, to assist us in maintaining our reputation.

The conference organizing committee would like to thank all the key note speakers, authors and sponsors for their great effort to make this outstanding conference come true. We look forward to seeing you again during the 5<sup>th</sup> DeKUT International Conference on STI&E to be held **on 6<sup>th</sup> – 8<sup>th</sup> November, 2019.**

**Dr. Ogutu Keroboto**  
**Chairman, Conference Organizing Committee**



## ACKNOWLEDGEMENT

We acknowledge with appreciation the Chief Guest, the Director General, Energy Regulatory Commission (ERC) who was represented by Dr. John Mutua for officially opening of the conference; Mr. Newton Owino, CEO Alisam Product Design and Development for delivering a key note address; the University Management Board led by the Vice Chancellor. Prof. P. Ndirangu Kioni for financial support given towards organizing the conference and publication of the conference proceedings; Dr. Moses. A. Ollengo Director RIMCL, Dr. Ogutu Keroboto School of Science for their tireless efforts in making the conference and publication of conference proceedings a reality; conference delegates, DeKUT staff and students for attending and presenting papers during the conference.

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# **BAS**

## **Modelling of the abundance of malaria mosquitoes using Poisson mixed model**

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*Anopheles funestus* and *Anopheles gambiae* are malaria vector mosquitoes. Knowing their resting behavior is important for implementing control methods. The aim of this study was to investigate the resting behaviour of the two malaria mosquitoes. The study was conducted in Kilombero River Valley and mosquitoes were collected using indoor and outdoor traps from 2012 - 2015. Poisson mixed models were used to quantify the impact of environment variables on resting behaviour. A log ratio rate between the type of trap and its interaction with environmental variables was used to determine if there was a change overtime in the resting behaviour. A total of 4,696 mosquitoes were resting indoors of which 57% were *A. funestus* and 43% were *A. gambiae*. Similarly, a total of 12, 028 mosquitoes were resting outdoor of which 13% were *A. funestus* and 87% were *A. gambiae*. Temperature was significant and affected the resting behaviour of *A. funestus*. Humidity, saturation deficit and temperature were significant variables influencing the resting behaviour of *A. gambiae*. *A. funestus* was resting indoor while *A. gambiae* was resting outdoor over time generally. The findings of this study on the effects of environmental variables and the variations in the resting behaviour of *A. gambiae* and *A. funestus* could be used as a guide to implementing appropriate intervention measures such as IRS, ITNs and mosquito repellents.

Keywords: *A. gambiae*, *A. funestus*, resting behaviour, type of trap, mosquito density, Environmental variables.

## **A Biology and Chemistry Primer for Undergraduate Students**

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### **Abstract**

A Biology and Chemistry Primer for Undergraduate Students (ABACUS-1) is a project that has so far developed a General Chemistry Primer which introduces basic chemistry concepts and integrated relevant practical experiments to allow a refresher for Undergraduate students and enhance better performance in science related courses regardless of pre-university subjects studied. Data on applicants' education background, enrolment and performance was obtained from the Uganda Christian University Faculty of Science and Technology and Admissions Office. Chemistry experts developed ten chapters of the Primer that was made available to students as a reference text. Feedback was obtained in a structured Knowledge, Attitude and Practice survey. Continuous performance tracking was done on tests and exams of students with whom the Primer was piloted. Data was analysed using SPSS and Microsoft Excel 2010. In the 2013/14 Bachelor of Environmental Science (BES) cohort, 3 out of 15 students had sat for Advanced Level Chemistry, 53 % of the students in this program scored below 70% in General Chemistry course unit and all scored above 65% in Environmental Chemistry I before piloting the Primer. After piloting the Primer, 80% of the students in BES program that did not sit for Advanced Level Chemistry scored above 65% in Environmental Chemistry II. In the 2013/14 Bachelor of Science in Civil and Environmental Engineering (BSCEE) cohort, 26 out of 74 students had sat for Advanced Level Chemistry, 81% of these scored above 71% in Environmental Chemistry I and 4 students who scored below 65% did not sit for Advanced Level Chemistry. After piloting the Primer, 74 % of the students in the BSCEE program who did not sit for Advanced Level Chemistry scored above 65%. The Primer could have increased the confidence of the students who did not sit for Advanced Level Chemistry thus boosting students' education and training.

**Keywords:** *General Chemistry Primer, Education Background, Enrolment, Performance*

### **1. INTRODUCTION**

A Biology and Chemistry Primer for Undergraduate Students (ABACUS-1) developed a General Chemistry Primer that introduced basic chemistry concepts and integrated relevant practical experiments to allow a foundation or refresher for Undergraduate students and enhance better performance in science related courses regardless of pre-university subject combination. Science programs at Uganda Christian University especially where chemistry knowledge is required indicate that some of the enrolled students lack an Advanced Level chemistry background which



affects their academic performance. This is normally reflected in the data collected by the Department of Engineering and Environment through informal interviews with first year students during a departmental orientation about the subjects offered at an Ordinary (O) and Advanced (A) Level. This is important to introduce basic chemistry concepts and integrated relevant practical experiments to allow a foundation and/or a refresher for Undergraduate Students. It was done through development of a General Chemistry Primer for Undergraduate students incorporating relevant basic theory and practicals, piloting the Primer in selected science related courses and tracking any changes in student enrolment, uptake and performance in the selected science related courses during the study period.

## 2. METHODS

First, baseline data was compiled on the selected science related undergraduate courses requiring chemistry knowledge at the Uganda Christian University, as several programs included core course units in Chemistry. This included data on: applicants (numbers, education background including Advanced Level subjects taken), gender, enrolment and performance. Data on students' education background was obtained from informal interviews from the Engineering and Environment departmental first year students' orientation and data on enrollment and performance was obtained from the Faculty of Science & Technology database. Only data on the Bachelor of Environmental Science and Bachelor of Science in Civil & Environmental Engineering programs was obtained. Chemistry experts developed ten chapters of the Chemistry Primer and it was made available to Undergraduate Students in the Bachelor of Science in Civil and Environmental Engineering and the Bachelor of Environmental Science programs as a reference text during the Environmental Chemistry II course unit. Feedback was obtained in a structured Knowledge, Attitude and Practice survey. Continuous performance tracking was done on tests and exams of students with whom the Primer was piloted. Data was analysed using SPSS and Microsoft Excel 2010.

## 3. RESULTS AND DISCUSSION

Using knowledge on relevant environmental samples such as soil extracts, wastewater, potable water, plant extracts among others, the students were able to conceptualize more advanced uses of the General Chemistry learned and show the relevance and contextualization of the General Chemistry to applications in Environmental Science, Civil and Environmental Engineering fields thereby ensuring student appreciation for the knowledge and skills within their chosen career.

**Table 1:** Grading System for Universities in Uganda

Grade	Marks (%)
A(U)	80-100
B+(U)	75-79

<b>B(U)</b>	70-74
<b>B-(U)</b>	65-69
<b>C+(U)</b>	60-64
<b>C(U)</b>	55-59
<b>C-(U)</b>	50-54
<b>R(U)</b>	Retake
<b>UN(U)</b>	Unknown
<b>DO(U)</b>	Dropped off

**Source: National Council for Higher Education (2006)**

**Table 2:** Uganda Advanced Certificate of Education grades

<b>Grade</b>	
<b>A</b>	
<b>B</b>	
<b>C</b>	
<b>D</b>	
<b>E</b>	
<b>O</b>	
<b>F</b>	
<b>NA</b>	Not Applicable

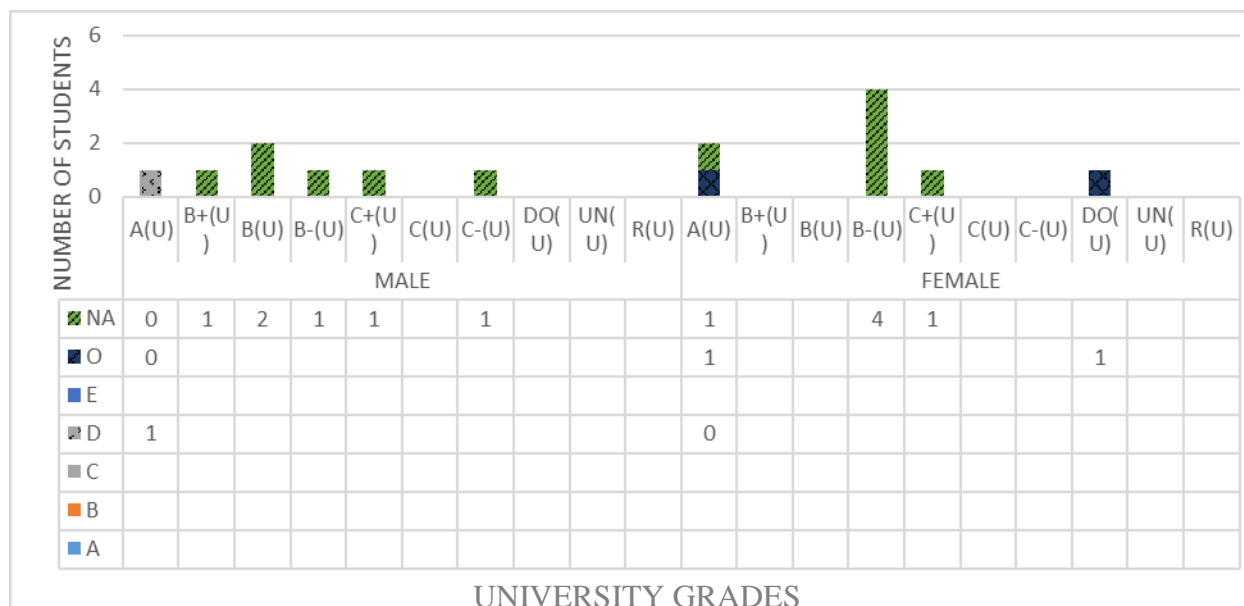
**Source: Uganda National Examinations Board (2012)**

The Advanced Level grades vary with students' performance in a given year.

Figures 1 - 5 show performance of the Bachelor of Environmental Science and the Bachelor Science in Civil and Environmental Engineering students in Chemistry related subjects including General Chemistry, Environmental Chemistry I and Environmental Chemistry II which were gauged using university grades. The performance of the students in General Chemistry, Environmental Chemistry I and Environmental Chemistry II was tracked basing on Advanced Level Chemistry grades and Gender. General Chemistry and Environmental Chemistry I was done before piloting the Chemistry Primer while Environmental Chemistry II was done after piloting the Primer. The Bachelor of Science in Civil and Environmental Engineering students did not sit for General Chemistry course unit.

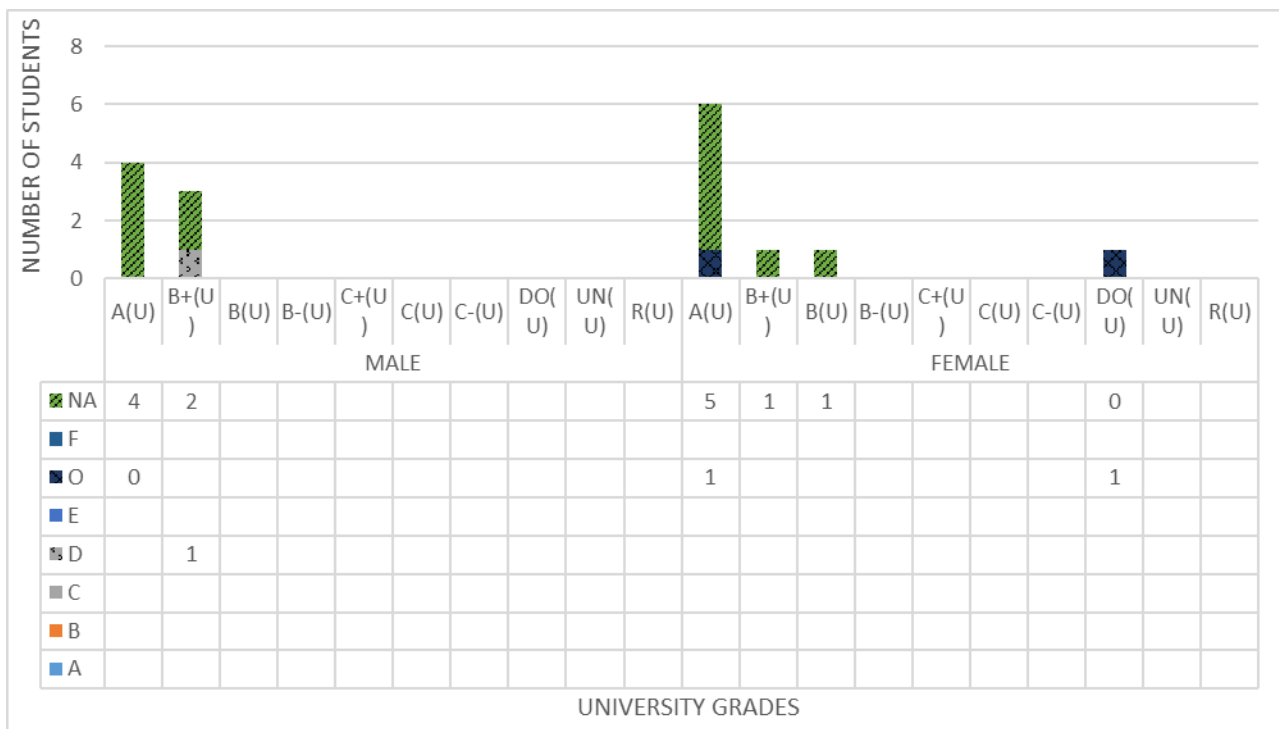
**Bachelor of Environmental Science (2013/14)**

Out of 15 students who enrolled for this program, only 3 students sat for Advanced Level Chemistry subject.



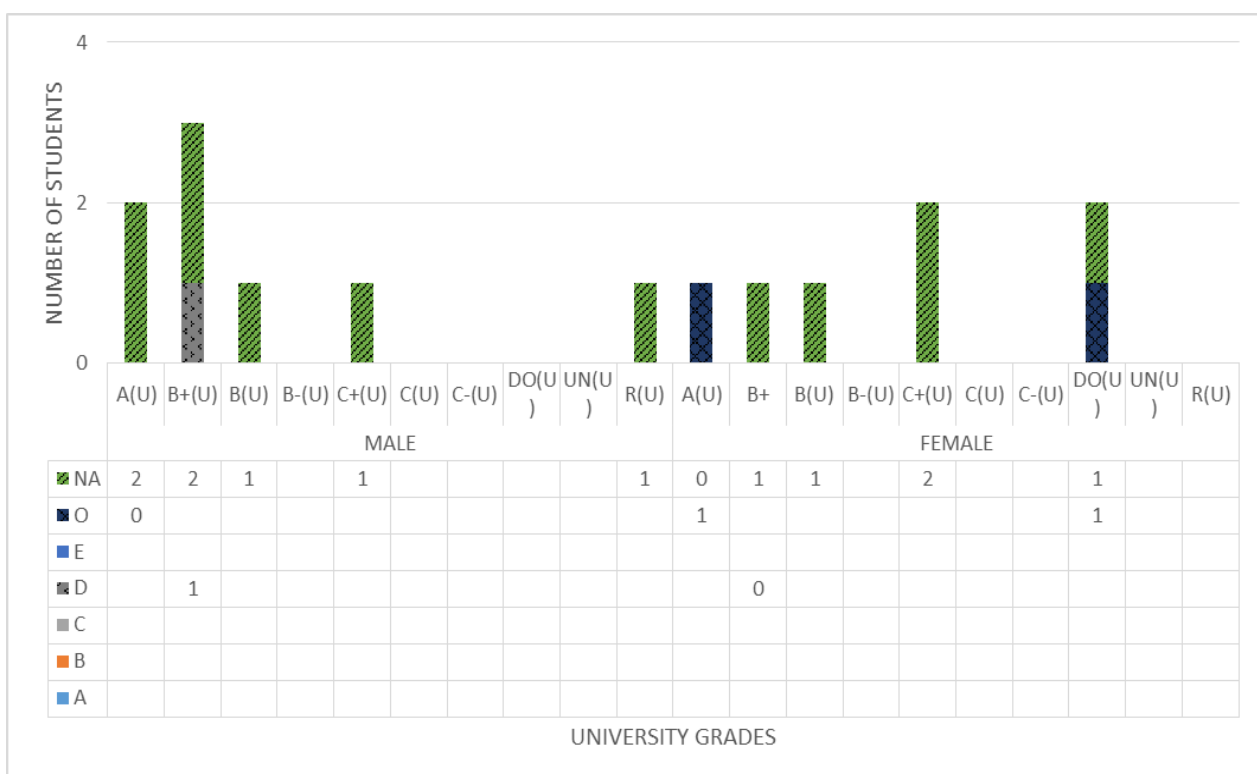
**Figure 1:** Advanced Level grades for students who enrolled for the Bachelor of Environmental Science and their performance at University in General Chemistry Course unit.

Following Figure 1, the general performance of students in General Chemistry was poor as 53% of the students scored below B- (65%). This poor performance could be because the majority (12 students) did not have a chemistry back ground. 100% of the students who sat for Advanced Level Chemistry scored grade A.



**Figure 2:** Advanced Level grades for students who enrolled for Bachelor of Environmental Science and their performance at University in Environmental Chemistry 1 Course unit.

As shown in Figure 2, the general performance of the students was good as the average score was A (80%) and all students scored above 70 % (B) in Environmental Chemistry I. The female students performed better than their male counterparts. All the students that sat for Advanced Level chemistry scored grade A.

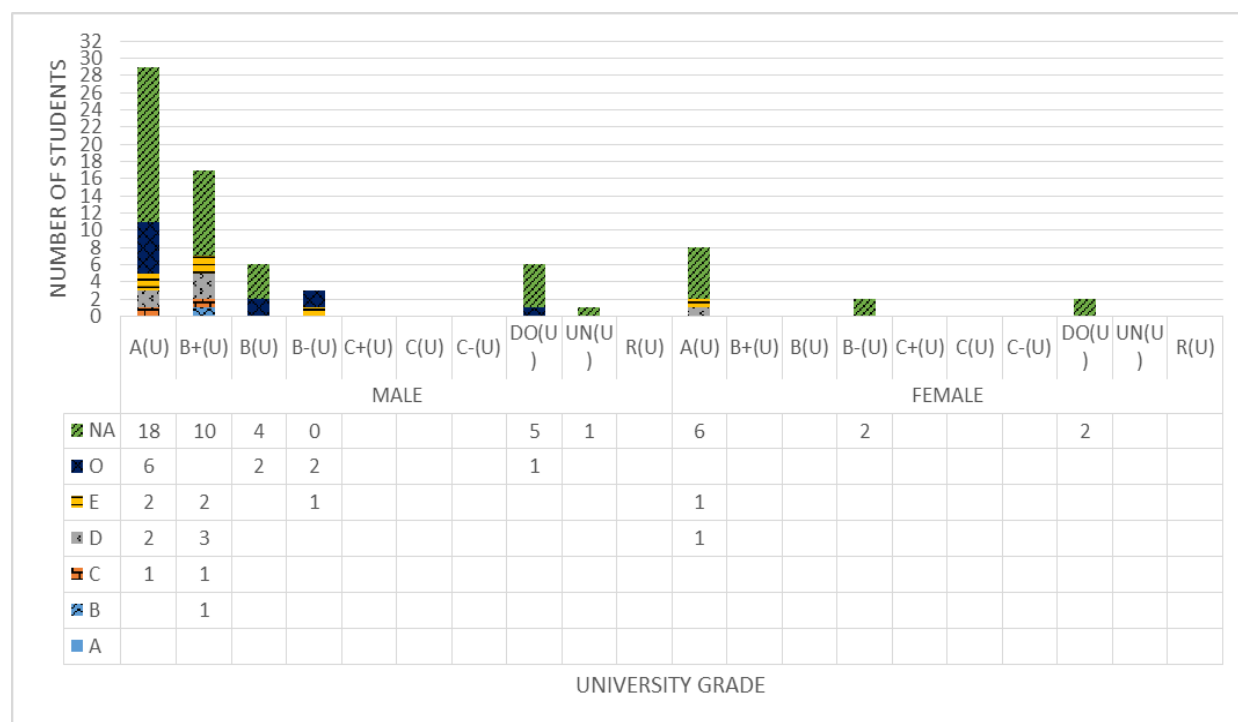


**Figure 3:** Advanced Level grades for students who enrolled for Bachelor of Environmental Science and their performance at University in Environmental Chemistry II Course unit.

All the students scored above 65% (C+) with best students scoring grade A in Environmental chemistry II as shown in Figure 3. The average score of the class was B (65%) and 80% of the students who did not sit for Advanced Level chemistry scored above B (65%). This implies that students could have been referring to the Chemistry Primer.

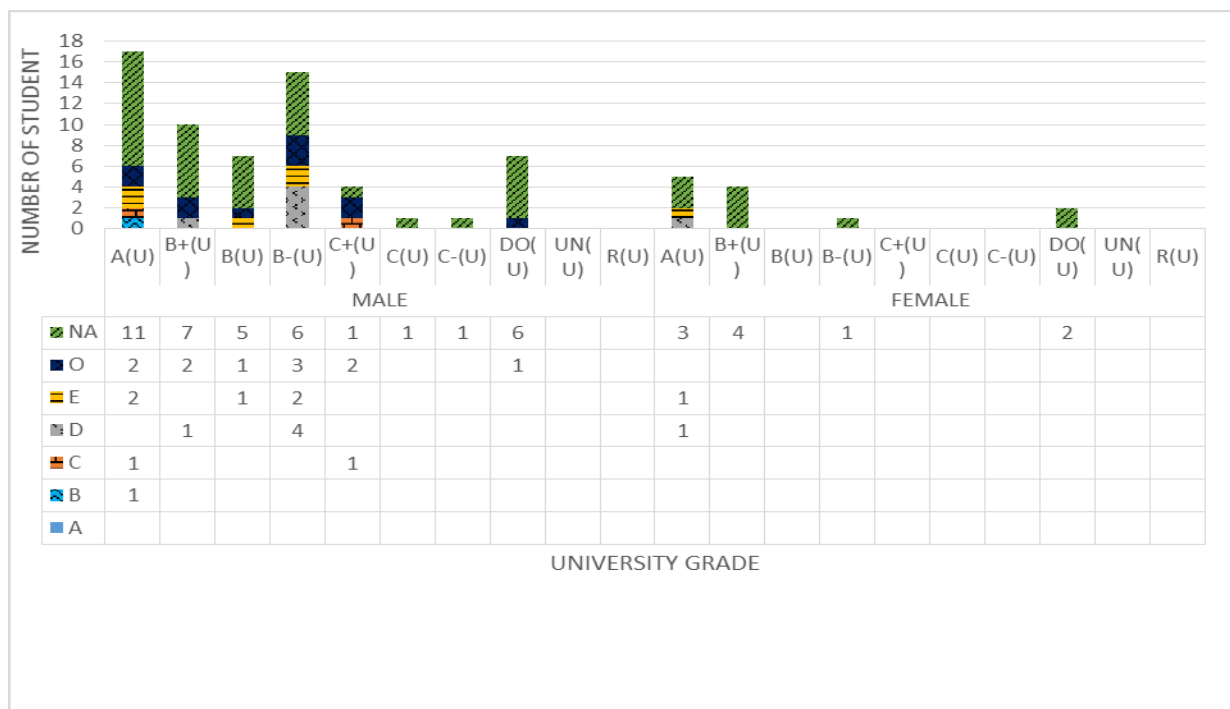
**Bachelor of Science in Civil & Environmental Engineering (2013/14)**

74 students registered and enrolled for this program. Out of these, only 26 students sat for Advanced Level Chemistry subject.



**Figure 4:** Advanced Level grades for students who enrolled for Bachelor of Science in Civil & Environmental Engineering and their performance at University in Environmental Chemistry I Course unit.

All the Bachelor of Science in Civil and Environmental Engineering students that enrolled in 2013/2014 scored above B- (65 %) in Environmental Chemistry I (Figure 4). 81% of the students who sat for Advanced Level Chemistry scored above B+ (75 %). The female students performed better than the male students.



**Figure 5:** Advanced Level grades for students who enrolled for Bachelor of Science in Civil & Environmental Engineering and their performance at University in Environmental Chemistry II Course unit.

From Figure 5, 74 % of the students that had not sat for Advanced Level Chemistry scored above B (65%). These performed better than the students who sat for Advanced Level chemistry as they had 54% scoring above B (65%). One of the possible explanations of this performance could be that the use of the chemistry primer increased the confidence of the students who did not sit for Advanced Level chemistry.

#### 4. CONCLUSIONS

After piloting the Chemistry Primer, findings show that the overall performance in Bachelor of Environmental Science, 80% of the students in this class who did not sit for Advanced Level Chemistry scored above grade B (65%) in Environmental Chemistry II course unit implying that students could have been referring to the Chemistry primer.

In the Bachelor of Science in Civil and Environmental Engineering, 74 % of the students who did not sit for Advanced Level chemistry also scored above grade B (65%) and performed better than the students who had sat for Advanced Level chemistry. The explanation of this improved performance could be that the use of the Chemistry primer increased the confidence of the students who did not sit for Advanced Level chemistry.

#### ACKNOWLEDGEMENT

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## **REFERENCES**

- [1] Uganda National Council for Higher Education (2006): Quality Assurance Framework for Ugandan Universities and the licensing process for Higher Education Institutions.
- [2] Uganda National Examinations Board (2012): Uganda Advanced Certificate of Education Grading System.



## **Influence of light and nutrient enrichment on phytoplankton photosynthetic capacity in South-eastern Lake Victoria, Africa**

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### **Abstract**

The effect of light and nutrient (N; P) enrichment on phytoplankton photosynthetic capacity was assessed using Pulse Amplitude Modulation (PAM) fluorometer in three stations along a biogeochemical gradient in southeastern Lake Victoria. Measurement of rapid light curve (RLC) and yield ( $F_v/F_m$ ) of dark adapted samples on filter paper was done before and after enrichment with N and P (final concentration 300ug/l and 100ug/l respectively) and incubating in dark for 24 hours – a dark control triplicate was incubated with no enrichment. Another triplicate was kept in natural light and in darkness during the night and the same measurements made. The derived points from the RLC ( $\alpha$ ,  $E_k$  and  $rETR_{max}$ ) varied spatially and responded differently to light and nutrient enrichment. The main lake station consistently responded to light enrichment, an indication of existence of light limited conditions due to high mixing depth (>15m), whereas the station in exchange zone, between the gulf and the main lake, always had higher  $rETR_{max}$  values compared to the other stations, indicating a higher photosynthetic capacity. Yield values varied spatially but showed no sensitivity to light and nutrient enrichment. Spatial variation in the measured and derived parameters can be due to differences in phytoplankton species composition, environmental conditions (light attenuation, nutrients etc) and morphometry along the study area. Results from this study shows that fluorometric measurements, when carefully interpreted, can be useful and rapid tool in photosynthetic studies of phytoplankton in natural systems and useful tool in aquatic environmental management.

**Key Words:** Lake Victoria; Nutrients; Photosynthesis; Fluorometry

# The Efficacy of Liquorice Root Extract In Enhancing The UV Photostability Of Three Commonly Used Sun-Active Agents

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## Abstract

The photostabilizing potential of liquorice root extract on commonly used UV absorbers in the market was investigated. The effect of UV light on the photochemical stability of 2-ethylhexyl-*p*-methoxy cinnamate (EHMC), benzophenone-3 (BP3), and *tert*-butylmethoxy dibenzoylmethane (BMDBM, avobenzene) mixed with liquorice root extract was studied by irradiating the mixture(s) with simulated solar radiation. The photochemical transformations were monitored by standard spectrophotometric methods; GC-MS, and HPLC-UV-ESI-MS-MS. The extract showed good UV absorption but degrades on prolonged UV exposure. The mixture of BP3 with liquorice root extract showed enhanced photostability arising from the chemical interaction of BP3 with the extract. EHMC showed photostability upon prolonged exposure and BMDBM showed spectral photodegradation. This extract may not be good photostabilizer for BMDBM but reacts with EHMC to yield compounds that are photostable. Liquorice root extract stabilizes EHMC and BP3 and diminishes the *keto-enol* tautomerism of BMDBM in favour of *enol*-BMDBM. The phenolic secondary metabolites present in liquorice root extract may participate in free radical scavenging activity.

**Keywords:** Liquorice root extract, 2-ethylhexyl-*p*-methoxy cinnamate, benzophenone-3, *tert*-butylmethoxy dibenzoylmethane, photostability, sunscreens.

## 1.0 Introduction

Plant extracts are commonly added to most cosmetic products, including sunscreens. The list of plant extracts added to cosmetic formulations grows each day but the most common ones are derived from aloe vera, liquorice root, mulberry, grape seed, and soybean. Despite the widespread use of these extracts in sunscreens, the fate of their photodegradative products and role in ultraviolet (UV) photoprotection remain largely unknown and requires further investigation.

The medicinal properties of liquorice extract (*Glycyrrhiza glabra*) belonging to the *Leguminosae* family have been known since ancient Greece, Rome, and China (Fiore et al. 2005; Patil et al. 2012). The extracts have anti-inflammatory, immune-boosting, and anti-cancer effects, including protective effects against DNA damage. It is reported that in Japan liquorice extracts have been used to treat chronic hepatitis, offering therapeutic benefit against other viruses, including human immunodeficiency virus (HIV), cytomegalovirus (CMV), and *Herpes simplex* (Patil et al. 2012). There is a demonstrated efficacy of these extracts in treating atopic dermatitis, an allergy-related, and intensely itchy swelling of the skin (Morteza-Semnani et al. 2003). Liquorice root extracts are commonly used in skin-lightening preparations because of one of its major components, glycyrrhizin (Fig. 1), is associated with the whitening effect.

Some organic sunscreens undergo photodegradation when exposed to sunlight, specifically UV light. Our investigation of the photostability of sunscreens in skin-lightening preparations showed a unique photostability of formulations containing plant extracts. Preparations containing among other ingredients, liquorice root extract showed an enhanced photoprotective effect. A major component of the liquorice root extract, glycyrrhizin (Fig. 1), first isolated and identified in the early 1990's shows good absorption of harmful UVB (290-320 nm) and UVA (320-400 nm) radiation. It has been reported to protect human skin against UVB light-induced damage (Yokota et al. 1998; Rossi et al. 2005). Therefore, there may be benefit in incorporating liquorice root extract in sunscreen preparations because of its UV protective effects.

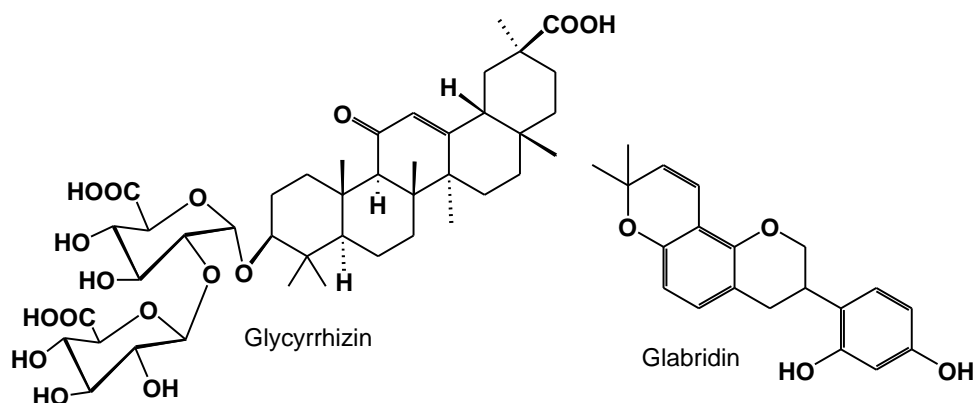


Figure 6: The major constituents of liquorice root extract.

A glycyrrhizin-rich liquorice extract has been shown to reduce inflammation resulting from UV light exposure when applied to the skin before exposure to UV light, thereby preventing redness and pigmentation (Yokota et al. 1998). There are claims that enzymes in liquorice extract aid in stimulating cell renewal following damage from UV rays for healthier glowing skin. Studies investigating the inhibitory effects of glycyrrhizin on melanogenesis and inflammation have shown that it inhibits tyrosinase activity of melanocytes. This is its proposed mechanism in the treatment of hyperpigmentation and in reversing the damage caused by acne scars. Another major constituent of liquorice root extract, namely, glabridin (Fig. 1), has been shown to protect against skin tumour initiation and promotion (Wang et al. 1991). Other studies have shown that liquorice root extract antioxidant activity enhances the photostability of other compounds when added to a topical dermatological cream (Morteza-Semnani et al. 2003). The aim of this work was to investigate the effect of a methanolic liquorice root extract on the photostability of some commonly used sunscreens, namely, 2-ethylhexyl-*p*-methoxy cinnamate (EHMC), benzophenone-3 (BP3) and *tert*-butylmethoxy dibenzoylmethane (BMDBM).

## **2.0 Experimental**

The effect of liquorice root extract on common sunscreen agents was investigated by firstly characterizing the constituents of the extract and then subjecting it to photochemical stability studies alone and when mixed with the sunscreen(s).

### **2.1 Materials**

The liquorice root extract was purchased from Warren Chem Specialities (Pty) Ltd, South Africa. The solvents used HPLC-grade acetonitrile (ACN) and methanol (MeOH) were purchased from Merck KGaA. The three chemical UV filters of analytical purity (99.9 %) were purchased as follows: 2-ethylhexyl-*p*-methoxy cinnamate (EHMC) and *tert*-butylmethoxy dibenzoylmethane (BMDDBM) were a kind donation from BASF, benzophenone-3 (BP3) was from Sigma-Aldrich and N,O-bis(trimethylsilyl)trifluoroacetamide (BSTFA) was purchased from Supelco.

### **2.2 Characterisation of liquorice root extract**

The liquorice root extract was characterised by gas chromatography-mass spectrometry (GC-MS), gas chromatography-flame ionisation detection (GC-FID), and high performance liquid chromatography-mass spectrometry (HPLC-MS) in order to identify the chemical components present.

#### **2.2.1 Sample preparation**

About 25 mg of liquorice root extract powder was soaked in 25 mL of methanol at 25 °C and placed in an ultrasonic bath for two hours and then left to stand for 24 hours protected from light by aluminium foil. The extraction mixture was then made up to 50 mL in a volumetric flask with methanol. The resultant solution was filtered through a 0.45 µm Millipore Millex-LCR membrane filter and then transferred to an aluminium foil cased glass vial for storage. A 20 µL aliquot of this solution was injected into a high performance liquid chromatography-mass spectrometer (HPLC-MS) for characterisation of the chemical components in the extract. The remaining solution was preserved for photostability studies.

The liquorice root extract samples for gas chromatography-mass spectrometry (GC-MS) characterisation were firstly derivatised to volatilise the polyphenols in the extract. This was achieved by dissolving a sample mass of about 2 mg of extract

powder in 1.0 mL of ACN in a clean, dry 3 mL reaction vial. To this solution 0.5 mL of N,O-bis(trimethylsilyl)trifluoroacetamide (BSTFA) was added, then capped tightly, mixed well, and heated at 70 °C for 45 min. The resultant derivatised mixture was filtered through a 0.45 µm Millipore Millex-LCR membrane syringe tip filter after cooling to room temperature. A volume of 0.1 µL of this derivatised sample was then injected into the GC-MS chromatograph.

### **2.2.2 The GC-MS experiment**

A 0.1 µL volume of the derivatised liquorice root extract sample was delivered into a Shimadzu GC-MS (QP2010 SE), with a column temperature set at 70 °C and injection port at 250 °C. Injections were in split mode at a ratio of 20:1. Components were separated in a GL Sciences InertCap 5MS/Sil 30 m × 0.25 µm quartz capillary column with a bound stationary phase consisting of 5% dimethylpolysilphenylene siloxane. The column was held 70 °C for 2 min, raised to 240 °C at 10 °C min<sup>-1</sup>, then held for 5 min followed by a rise to 270 °C at 10 °C min<sup>-1</sup> and held for 10 min. Helium was the carrier gas flowing with a linear velocity of 30.0 cm s<sup>-1</sup>. The MS ion source temperature was 200 °C and the interface temperature was set at 250 °C. The MS detector was programmed to run in scan mode in the *m/z* range 35-1000 at a scan speed of 3333. The total run time was 37 min.

### **2.2.3 The GC-FID experiment**

To check method interconvertability a GC-FID experiment was carried out on the same sample (derivatised liquorice root extract) with the same temperature program. The GC-FID used was a Shimadzu GC-2010, fitted with an autosampler AOC 20i and a flow unit type AFC-2010. Components were separated in a DB-5 (30 m × 0.25 µm) quartz capillary column with a bound stationary phase consisting of 5% phenyl polysilphenylene-siloxane. The make-up gas was nitrogen/air flowing at 10 mL min<sup>-1</sup>, the carrier gas was hydrogen with a flow rate of 40 mL min<sup>-1</sup> and oxygen/air flowing at 400 mL min<sup>-1</sup>. The injection port was set at 250 °C, operating in a split mode of 20:1 for an injection volume of 0.1 µL. The velocity flow control mode was adopted keeping the pressure at 61.9 kPa, the total flow rate at 5.0 mL min<sup>-1</sup>, the column flow of 0.68 mL min<sup>-1</sup>, and a linear velocity of 20.0 mL s<sup>-1</sup>.

#### 2.2.4 HPLC-MS analysis

The liquorice root extract dissolved in methanol (see Section 2.2.1) was characterised by means of HPLC-PDA-ESI-MS/MS. The analysis was carried out on an Agilent 1200 series LC MSD Trap, equipped with a photodiode array detector, a binary pump, a degasser, auto sampler, and an ESI Trap MS. This employed a G1312A binary pump, a G1316A autosampler, a G1322A degasser and a G1315D photodiode array detector controlled by ChemStation software (Agilent, v.08.04). The chromatographic separation was achieved on an Agilent Zorbax Eclipse XDB C-18 reversed-phase column (150 × 4.6 mm i.d.; 5 µm particle size). The mobile phase was composed of water:formic acid (99:1, v/v, solvent A) and acetonitrile (solvent B). The mixtures were resolved by a gradient elution as follows: 5–13 min, 16 % B; 13–18 min; 45 % B and held for 5 min; 23–28 min, 75 % B, held for 5 min; 33–40 min, 99 % B, then held 5 min and then dropped to 16 % B for 15 min. The experiment was performed at ambient temperature with a flow rate of 1 mL min<sup>-1</sup> and an injection volume of 20 µL. The chromatograms were collected at detection wavelengths of 275, 280, 286, 310, 320, and 358 nm with a bandwidth of 4 nm simultaneously in each of the 60 min run time. The photodiode array detector was set to collect the UV-vis spectra of the chemical species separated over the range of 190 to 800 nm. Analyses were interfaced to an Agilent-SL LC MSD trap equipped with an electrospray ionization source and operated in the negative-ion mode. The mass detector was a G2445A ion-trap mass spectrometer controlled by LCMSD software (Agilent, v.4.1). The nebulizing gas was nitrogen set at a pressure of 65 psi and flow rate adjusted to 116 mL min<sup>-1</sup>. A heated capillary and voltage was maintained at 350 °C and 4 kV respectively. The instrument was programmed to scan over a mass range from  $m/z$  90 to  $m/z$  2000. The target ion accumulation in the trap was put at 30000 counts for a maximum accumulation time of 50 ms. MS<sup>2</sup> data were acquired in the negative ionization automatic smart mode to obtain MS<sup>n-1</sup>; primary precursor ion. The target ion was set at  $m/z$  350, the compound stability at 100 %, and the trap drive level at 90 %. One precursor was selected in each cycle; and excluded after averaging 3 spectra; the release time was 0.3 minutes. All collision-induced fragmentation experiments were performed in the ion-trap with helium as the collision gas, and the voltage was increased in cycles from 0.3 up to 2 V. The fragmentation time was 20 ms at an activation width of 10 amu and the cut-off for the daughter ion range set at 30 %. MS<sup>3</sup> data were obtained by manual fragmentation, targeting the most abundant ions in the precursor ion in the MS spectra.



### **2.3 Photostability experiments**

The sunscreen mixture(s) with liquorice root extract were prepared by adding about 20 mg of the sunscreen agents to 25 mL of the methanol extract (see Section 2.2.1). This solution was then made up to 50 mL in a volumetric flask with methanol. To obtain working solutions, appropriate dilutions were carried out in order to obtain a sunscreen agent concentration of about  $200 \mu\text{mol dm}^{-3}$  in the extract before photostability studies were done. Samples of liquorice root extract with and without sunscreens added were exposed to simulated solar light in a Newport research lamp housing (M66901) fitted with mercury-xenon lamp, powered by an arc lamp power supply (Newport 69911). The power output of the lamp was controlled by a digital exposure controller (Newport 68951) maintaining the output at 500 W. The radiation from the lamp was passed through a 10 mm thick Pyrex filter to ensure that only wavelengths greater than 300 nm impinged on the samples. The exposure time was varied incrementally from 0 hour in steps of 30 min to 4 hours of continuous exposure. Each exposed sample was contained in a stoppered 1.00 mm pathlength quartz cuvette. After each irradiation interval a UV-visible spectrum of the sample was recorded on a Perkin Elmer Lambda 35 UV-visible beam spectrophotometer. A 20  $\mu\text{L}$  aliquot of these same solutions was then injected into a HPLC chromatograph to monitor the chemical transformations in the extract and the included sunscreen(s). Samples of the sunscreens alone dissolved in methanol were similarly irradiated and monitored by UV spectrophotometry.

#### **2.3.1 HPLC analysis of the irradiated samples**

The chemical transformations in the irradiated samples were monitored on a Shimadzu Prominence LC chromatograph with a PDA detector. The chromatographic separation was achieved on an Agilent Zorbax Eclipse XDB C-18 reversed-phase column ( $150 \times 4.6 \text{ mm i.d.}$ ;  $5 \mu\text{m}$  particle size). The mobile phase was composed of water (solvent A) and acetonitrile (solvent B). The mixtures were resolved by varying the concentration of B as follows: 5–13 min, 16 % B; 13-18 min, 45 % B and held for 5 min; 23-28 min, 75 % B, held for 5 min, 33-40 min, 99 % B then held 5 min and then dropped back to 16 % B for 15 min. The experiment was performed at ambient temperature with a flow rate of  $1 \text{ mL min}^{-1}$  and an injection volume of  $10 \mu\text{L}$ . The chromatograms were collected at detection wavelengths of 275, 280, 286, 310, 320, and 358 nm with a bandwidth of 4 nm simultaneously in each of

the 60 min run time. The photodiode array detector was set to collect the UV-vis spectra of the chemical species separated over the range of 190 to 800 nm.

### 3.0 Results and discussion

The components of liquorice root extract were first characterised before photostability studies were done on the extract alone and on its mixture(s) with the sunscreen agents.

#### 3.1 Characterisation of liquorice root extract

Most plant extracts contain polar N-H and O-H groups which are responsible for strong hydrogen bonding that makes them essentially nonvolatile. Hydrogen on these functional groups can be substituted with a trimethylsilyl (TMS) group in order to break the hydrogen bonding thus making them volatile. The presence of each TMS group on any GC-MS fragment is normally taken as 'acidic' hydrogen substitution by the TMS group during derivatization. The qualitative elucidation of the molecular ion can then be done by replacement of the TMS by a hydrogen atom. The chemical composition of the liquorice root extract was therefore identified by replacing the TMS group by H- on the phenolic and alcoholic GC-MS results. This is because a typical derivatization of hydroxylated polycyclic aromatic hydrocarbons into TMS ethers using BSTFA follows the scheme in Fig. 2 under hydrophobic conditions. The hydrophobic conditions must be attained because the TMS group substitutes exchangeable, 'acidic' protons and therefore hydrolysis of water may prevent any further derivatization of the analyte (Fig. 2 and 3).

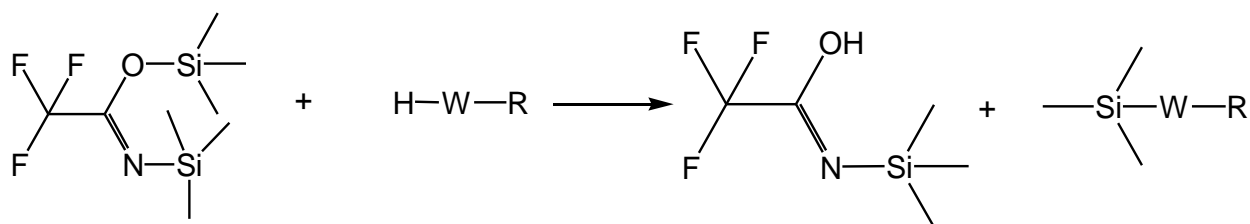


Figure 7: General scheme for silylation reaction using N,O-bis(trimethylsilyl)trifluoro-acetamide: TMS = Si(CH<sub>3</sub>)<sub>3</sub>, W = O, S, NH, NR', COO, R, R' = Alk, Ar.

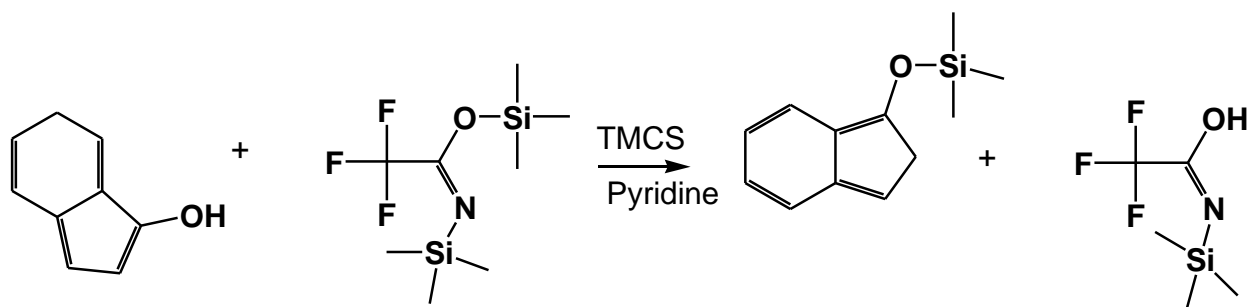


Figure 8: Typical derivatization reaction of a secondary metabolite by BSTFA.

However, the reconstructions of the parent secondary metabolites in the liquorice root extract pose a challenge owing to the complex composition of the extract. The total ion chromatogram from the GC-MS (Fig. 4) showed high intensities of the fructopyranose and fructofuranosesilylated fragments indicating high abundance of glycyrrhizin in these extracts (Fig. 5). The remaining less intense signals could be attributed to the fragmentation of glabridin giving rise to hydroxyl cinnamic acid moieties (Fig. 6).

The methanolic extract considered in this work is expected to have a high concentration of flavonoids. The major constituents in liquorice root extract are glabridin and glycyrrhizin (Fig.1). These compounds are known to dissociate upon electron impact through a limited number of assumed pathways. The origin of diagnostically valuable fragments can be explained by a retro-aldol fragmentation of the molecular ion and the daughter fragment (Denisova et al. 2006). The flavanolic cleavage forms a set of fragments including the A- and B-rings and cleavage of the pyran ring at the third C atom. The many alcoholic fragments observed in this work can be attributed to the high concentration of glycyrrhizin, whose sugar cleavage gives fructofuranose and fructopyranose moieties (Fig. 5). The hydroxycinnamic acid moieties could similarly be attributed to the fragmentation of glabridin, another known constituent of liquorice root extracts (Fig. 6). The successive cleavage of a silyl substituent as  $\text{CH}_2\text{SiMe}_3$  or  $\cdot\text{SiMe}_3$  gives rise to various identified chemical components (Fig. 9.7 and Fig.9.8).

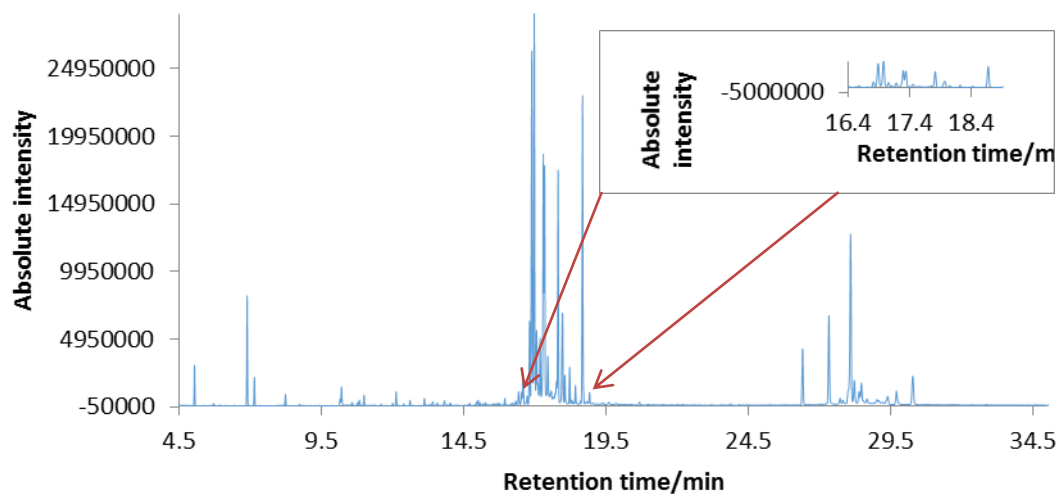


Figure 9: The total ion chromatogram of a derivatized sample of liquorice root extract on GC-MS. The separation was effected on a GL Sciences InertCap 5MS/Sil 30 m  $\times$  0.25  $\mu$ m quartz capillary column under the conditions described in Section 2.2.2.

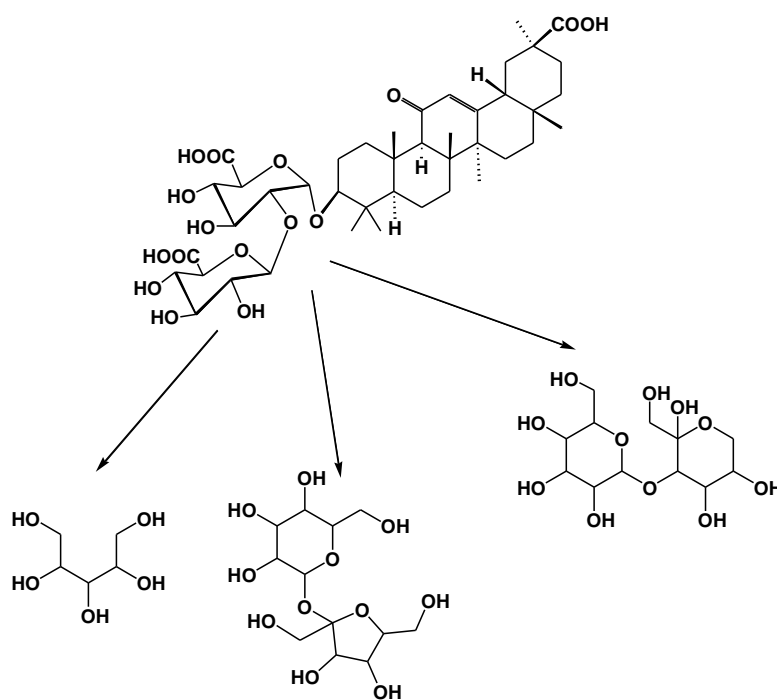


Figure 10: The proposed fragmentation scheme of the sugar moiety of glycyrrhizin.

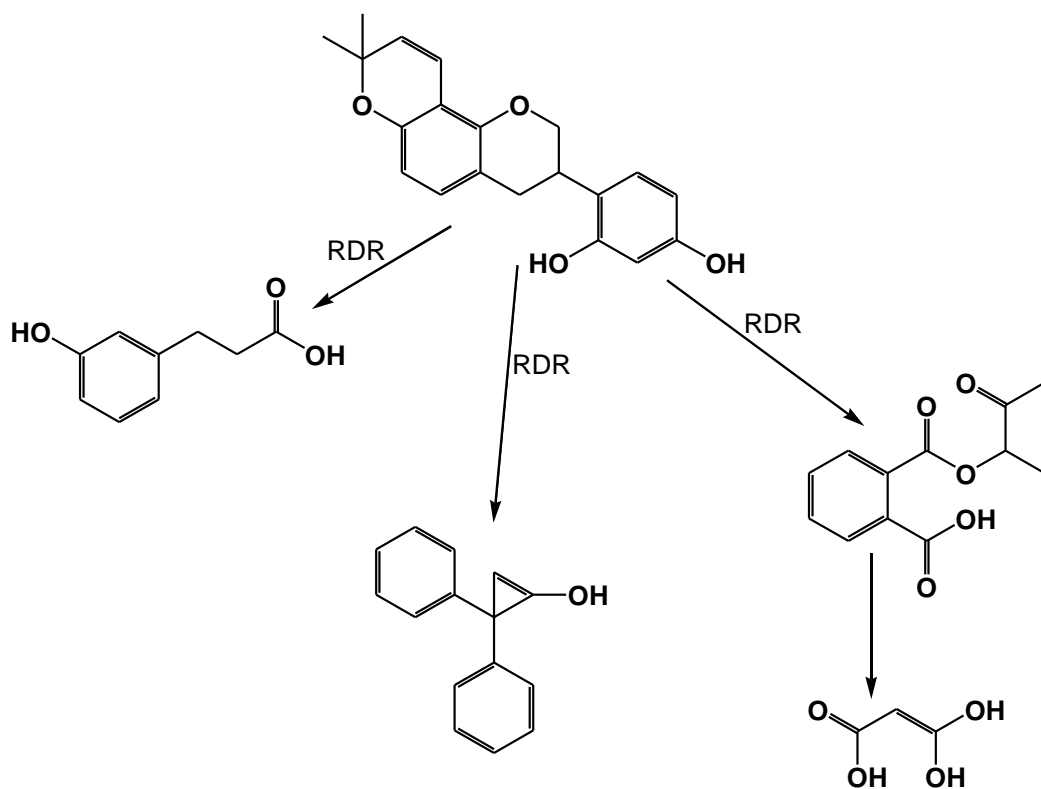


Figure 11: An anticipated fragmentation pattern of glabridin in a retro-diene reaction fashion modified by trimethyl silylgroups.

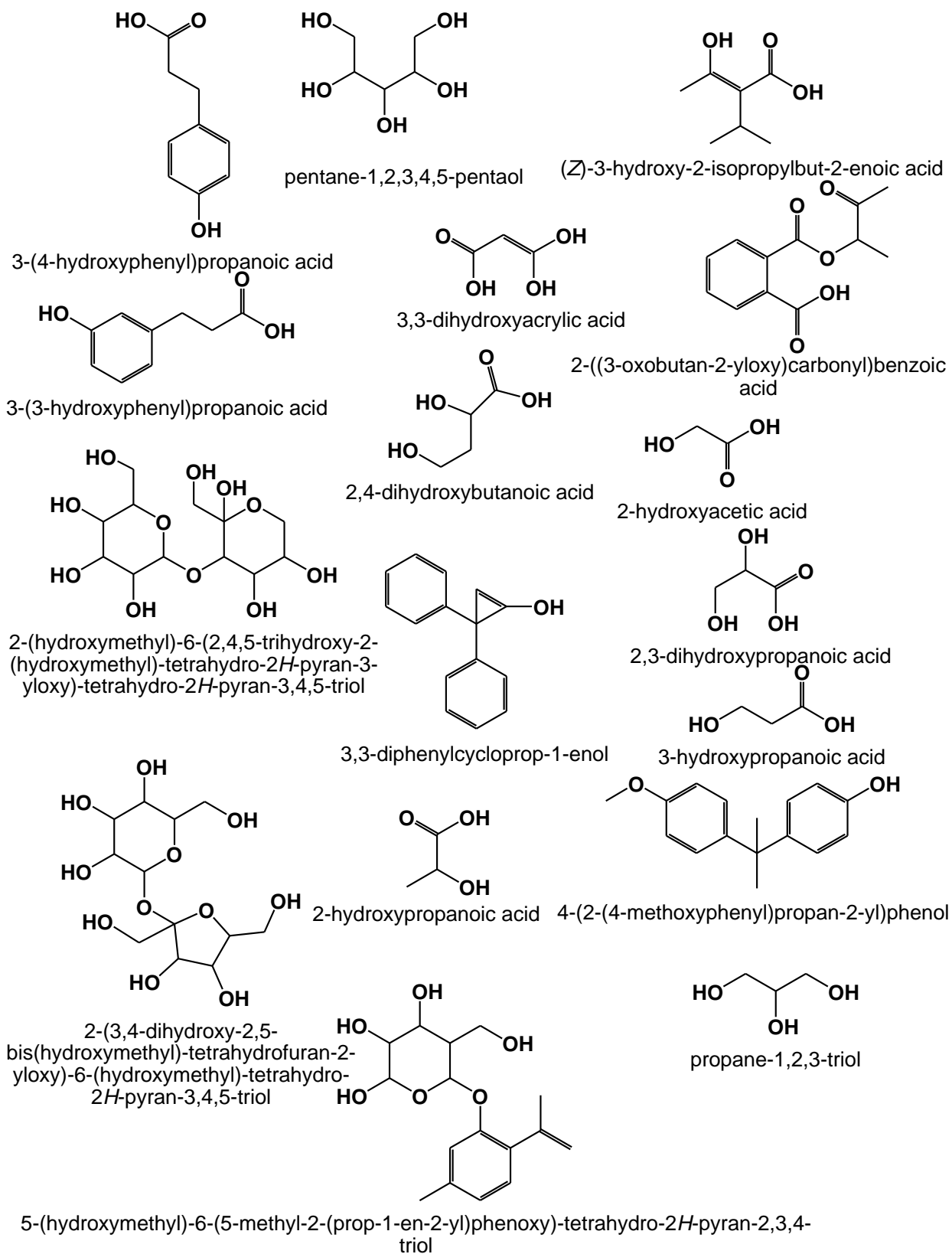


Figure 12: Some of the chemical constituents of liquorice root extract identified in this work.

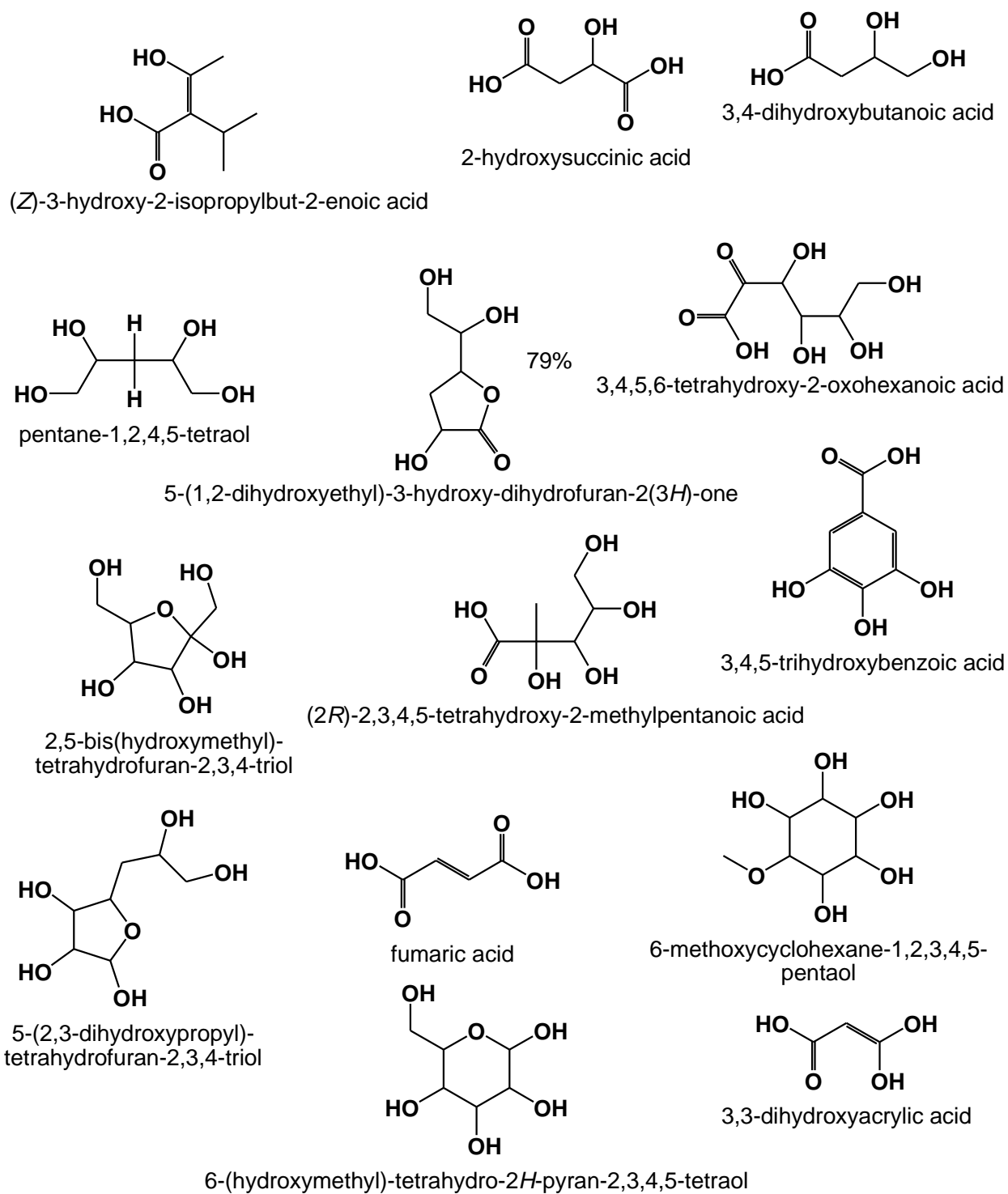


Figure 13: More constituents of liquorice root extract identified by GC-MS.



### 3.2 Photostability studies of the liquorice root extract

The prolonged exposure of a methanolic solution of liquorice root extract to simulated solar radiation showed a notable degree of photodegradation (Fig. 9). This photodegradation is observed mainly in the UVB region as the drop in absorption in the UVA1 (340-400 nm) region remains fairly stable. The HPLC chromatograms of the same samples show rearrangement of the two major constituents of the liquorice root extract initially present (Fig. 10). The photo-absorptive capacity observed with this extract can be attributed in part to the  $\alpha$ -enone,  $\pi$ -bond conjugation in glycyrrhizin and the  $\alpha$ -diene,  $\pi$ -bond conjugation in glabridin. The Woodward-Fieser predictive calculation for the glycyrrhizin chromophore gives a wavelength of absorption  $> 259$  nm. Imposing similar selection rules on the  $\alpha$ -diene system of the glabridin molecule gives a wavelength  $> 319$  nm (Fig. 11). However, it should be noted that these rules only give benchmark values. The actual absorbance may differ by about 5-6 nm or higher. These absorptions explain why the liquorice root extract shows good absorption in the UVB and fair absorption in the UVA (Fig. 9).

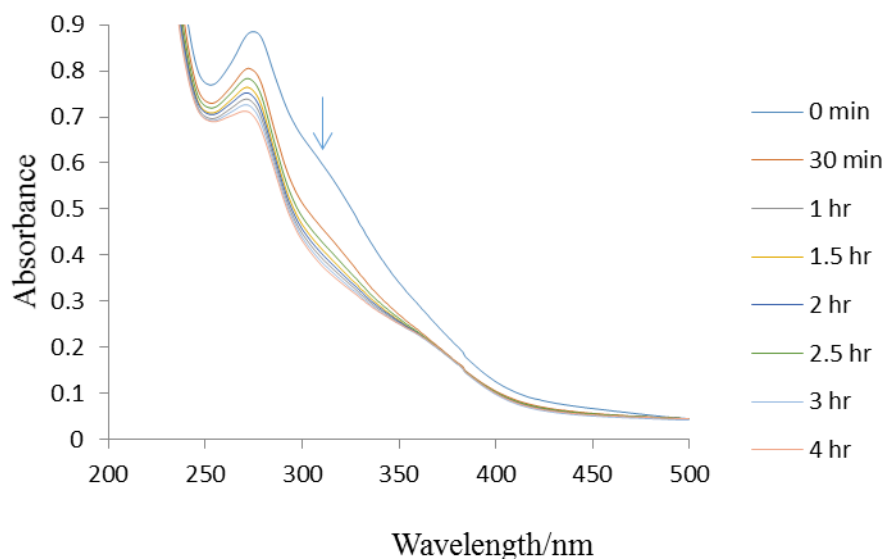


Figure 14: The photodegradation of the liquorice root extract dissolved in methanol exposed to simulated solar radiation, in a 1 mm pathlength quartz cuvette. Each exposure circle involved use of fresh sample extract. The spectra were recorded on a Perkin Elmer Lambda 35 UV-vis deal beam spectrophotometer.

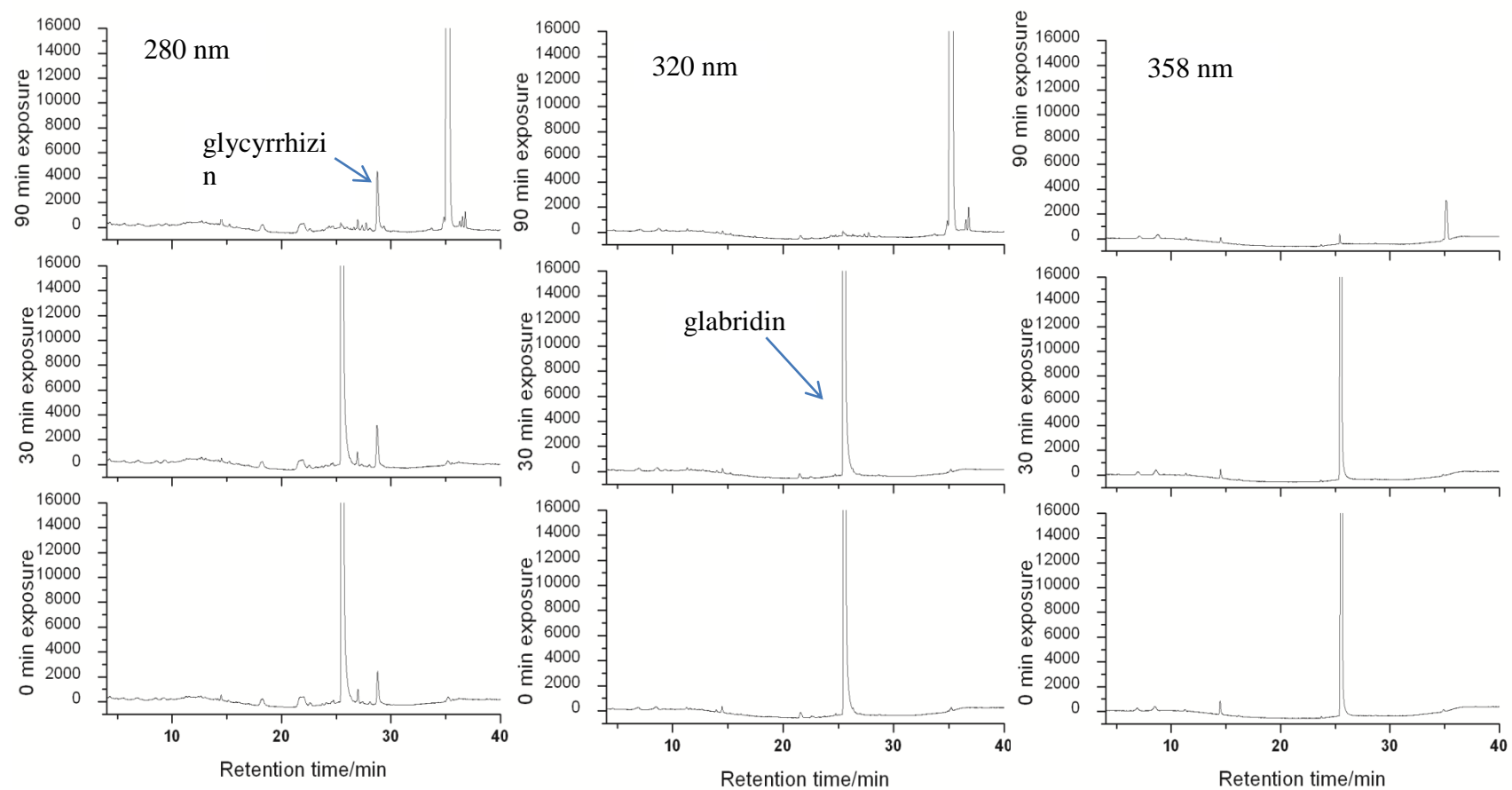


Figure 15: Photo-induced chemical changes in liquorice root extract secondary metabolites exposed to simulated solar radiation, monitored on a HPLC at 280, 320, and 358 nm. The separation was effected on a Zorbax Eclipse-XDB C-18 column (150 mm × 4.6 mm, i.d., 5 μm). The mobile phase was a gradient elution of acetonitrile-water with a flow rate of 1.00 mL min<sup>-1</sup> and the injection volume was 20 μL.

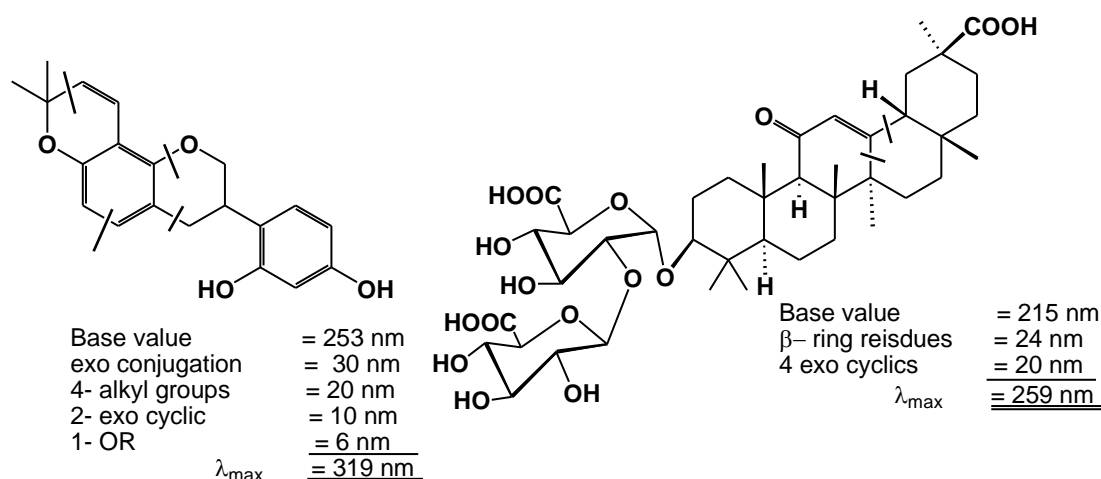


Figure 16: Predicted wavelengths of maximum absorption for glycyrrhizin and glabridin based on the Woodward-Fieser selectionrules.

The chromatogram of the unexposed sample at 358 nm shows a very small peak for the prominent peak observed at 280 nm (Fig. 10). This indicates that, this species does not absorb sufficiently at a longer UV wavelength (358 nm), consistent with the predicted value from Woodward-Fieser values calculated above (Fig. 11). The photochemical reactions are observed after 30 minutes of exposure for which a number of peaks appear and others disappear. These can be explained in terms of photo-induced, repeated Norrish type I processes yielding a range of substituted flavonols and other associated photochemical rearrangement products. These chemical species show the relative absorbance in the long wavelength region as indicated by the new peak observed at 358 nm (Fig. 10).

### 9.3.3 Effect of liquorice root extract on the photostability of BP3

The photochemical response of a methanol solution of BP3 irradiated with solar simulated radiation was firstly investigated. The UV spectra of BP3 showed photostability (Fig. 12). The HPLC analysis of these same solutions also showed only one peak at 286 nm indicating that BP3 did not photodegrade in the present conditions (Fig. 13). This could be attributed to hydrogen bonding between the carbonyl and *ortho*-hydroxyl group that interferes with the  $n, \pi^*$  excitation of the carbonyl chromophore. It is known that *ortho*-hydroxybenzophenone does not undergo

photoreduction(Placzek et al. 2013)and stabilises the chromophore, namely, the carbonyl group.

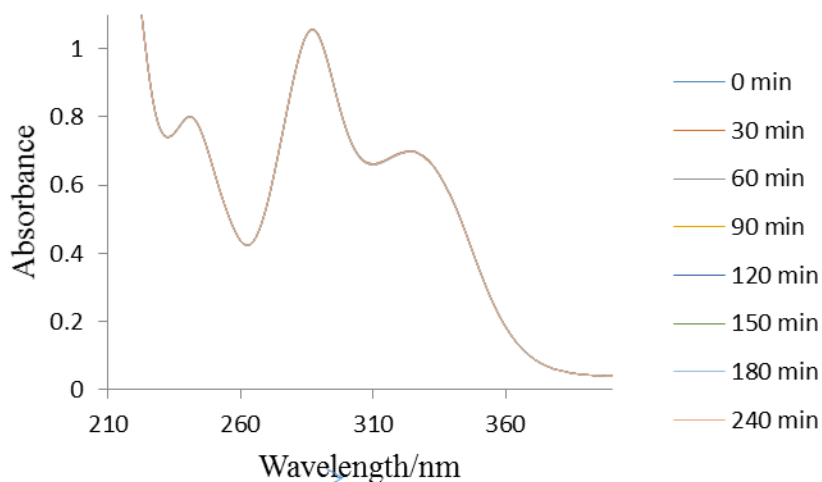


Figure 12: The spectral stability of BP3 in methanol irradiated by a solar simulated source. The spectra were acquired on a Perkin Elmer Lambda 35 UV-vis spectrophotometer in a 1 mm pathlength quartz cuvette with air as the reference.

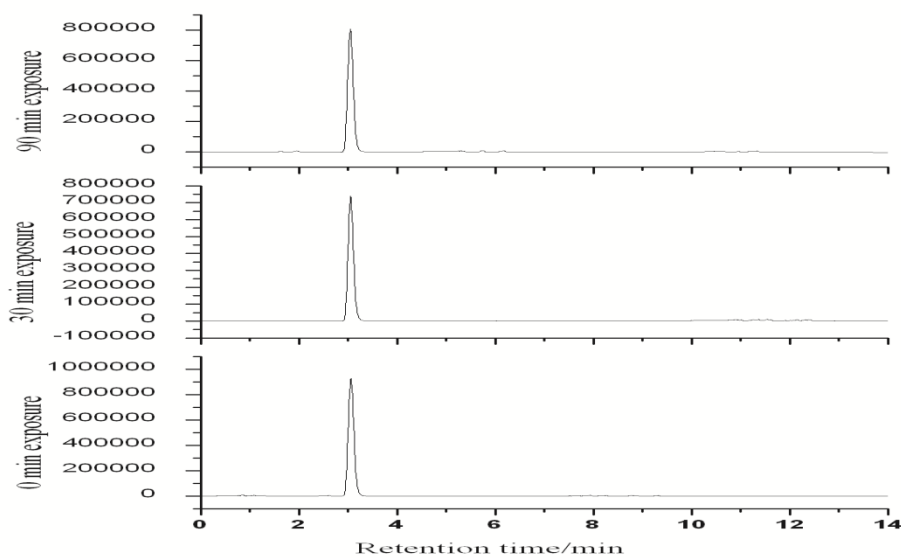


Figure 13: The photostability of BP3 monitored by HPLC at 286 nm. A reversed phase Zorbax Eclipse-XDB C-18 column (150 mm  $\times$  4.6 mm) column was used with mobile of methanol-water (84:16 % v/v). The injection volume was 20  $\mu$ L and the flow rate set at 1 mL min<sup>-1</sup>.

The irradiation of an ethanolic solution of BP3 and liquorice root extract showed a small photodegradation followed by a blue shift in the spectra of BP3 (Fig. 9.14). The HPLC chromatograms of the liquorice root-BP3 mixture gave rather interesting results. The retention time of the BP3 peak varied on the chromatograms and incremental exposure time gave varying retentions for various prominent peaks at various wavelengths of analysis (Fig. 15). We speculate that because the UV spectra remained essentially the same, then the carbonyl chromophore is not affected by the reactions and the attack is on the phenyl rings. These reactions could be responsible for the variation of the BP3 peaks and these reactions do not necessarily require light. This observation may in part agree with work by Schallreuter et al. (1996), who proposed possible photoreactions of BP3 culminating in the photo-oxidation of BP3 to semiquinone. But the HPLC analysis from the current work, however, suggests a possible dark reaction that may not necessarily lead to semiquinone formation. It can be further speculated that inclusion of BP3 in the solution containing liquorice root extract introduces proton-type photochemical reactions. We envisage ground state reactions of BP3 that could involve C-C coupling of a radical pair generated by H-abstraction on the BP3 phenyl ring with the fructopyranose moiety (Fig. 16).

It is known that BP3 is a derivative of benzophenone and absorbs UV radiation up to 360 nm. The intersystem crossing quantum yield of benzophenones is about 1, and the energy of its  $n, \pi^*$  lowest triplet excited state (TET) is about  $290 \text{ kJ mol}^{-1}$  (Cowley 1997; Murai et al. 1978; Cai et al. 2005). These compounds are known photosensitizers with singlet oxygen ( $^1\text{O}_2$ ) production quantum yields of about 0.3. We associate the peaks observed at 358 nm on prolonged exposure (at 90 min) with reactions of the triplet excited state, of BP3, with photosensitized liquorice root extract components. The chemical species formed therefore alter the retention time of BP3 without affecting the chromophore (C=O). The other observed peaks arise from various reaction pathways. Upon light absorption, the triplet-triplet energy transfer (TTET) initiated reactions together with both type I (hydrogen atom or electron transfer) and type II (singlet oxygen) processes take effect. These reactions are sustained by thermal population of the upper vibrational states of the excited triplet state of BP3. Both glycyrrhizin and glabridin may be photosensitized by the triplet excited state of BP3 and

therefore undergo a Paternò-Büchi [ $\sigma_2+\pi_2$ ] photo-cycloaddition giving rise to oxetanes (Fig. 17 and Fig. 18). These reactions are known to compete with TTET and are favoured for  $n,\pi^*$  triplets when the excited state of the alkene is comparable to or higher than that of the carbonyl compound.

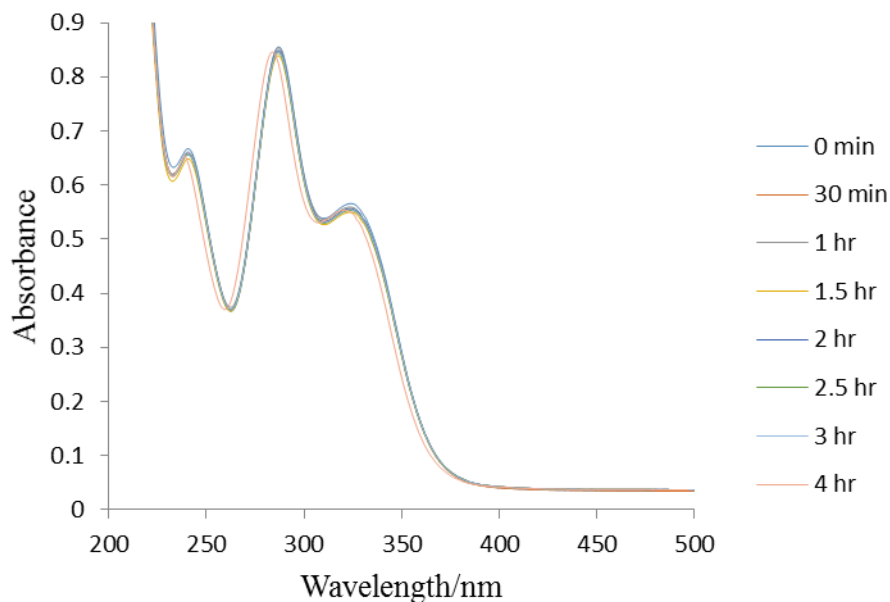


Figure 17: The photostability of BP3 incorporated in liquorice root extract dissolved in methanol when exposed to simulated solar radiation, in a 1 mm pathlength quartz cuvette. Each exposure event involved use of fresh sample solution. The spectra were recorded on a PerkinElmer Lambda 35 UV-vis dual beam spectrophotometer.

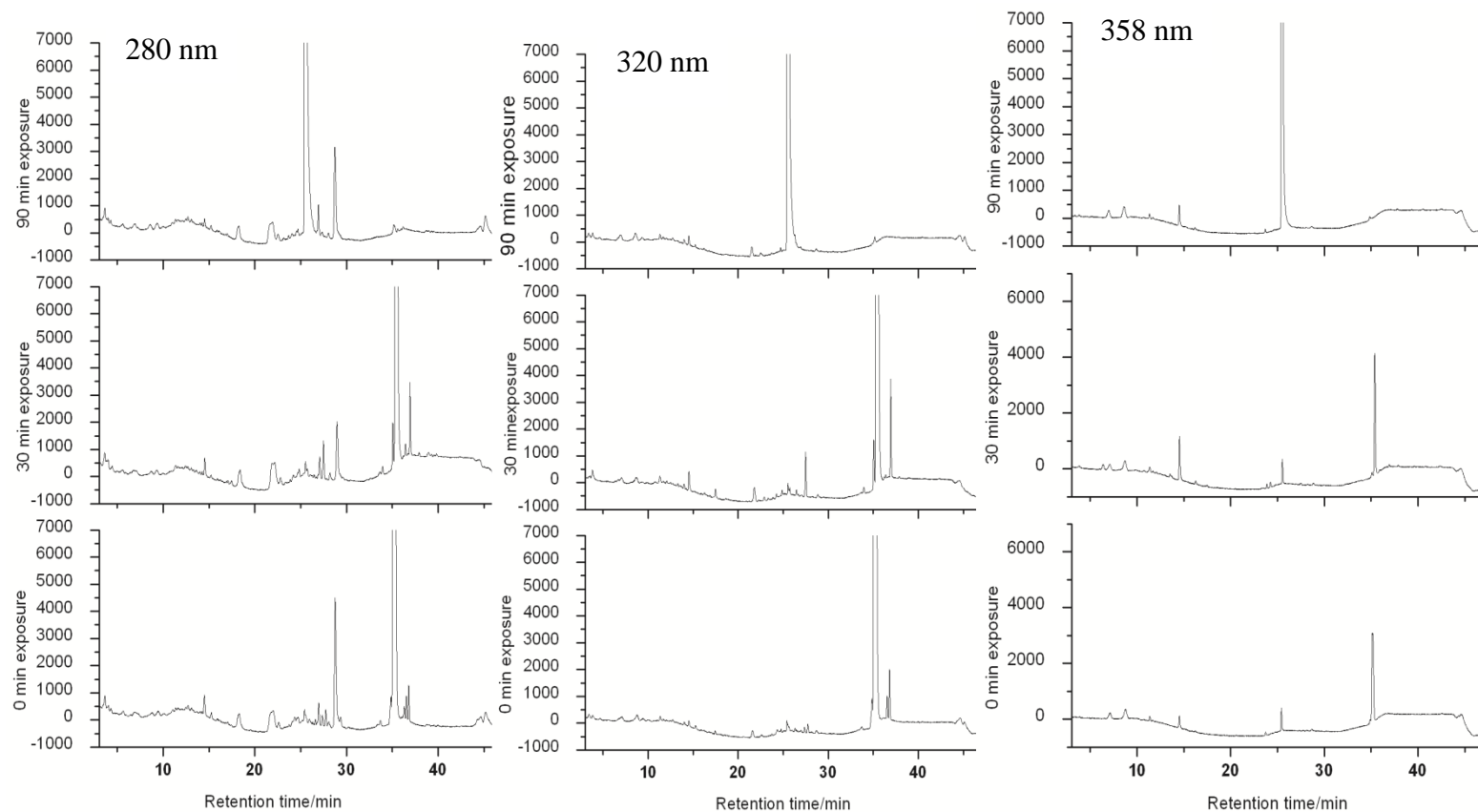


Figure 18: HPLC chromatograms of the photochemical changes when BP3 is incorporated in the liquorice root extract dissolved in methanol and irradiated by simulated solar radiation. The chromatograms were monitored at 280, 320, and 358 nm. The separation was effected on a Zorbax Eclipse-XDB C-18 (150 mm x 4.6 mm, i.d., 5  $\mu$ m) column. The mobile phase was a gradient elution of acetonitrile-water with flow rate of 1.00 mL min<sup>-1</sup> and the injection volume was 20  $\mu$ L. The BP3 could not be identified because the retention time changed from the one shown under this conditions.

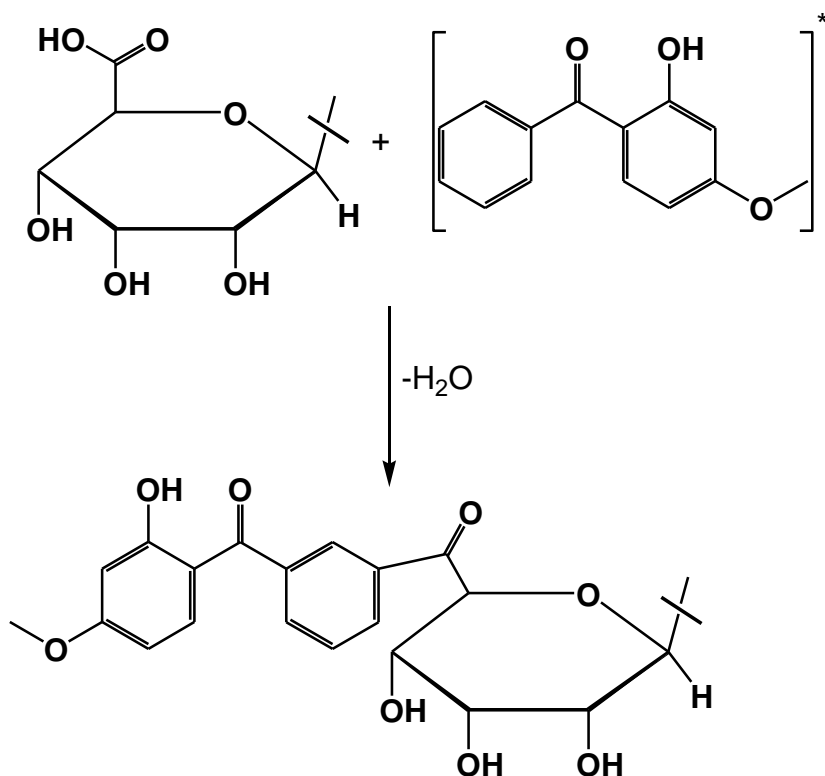


Figure 19: Proposed reaction of the excited state BP3 with the fructopyranose moiety of glycyrrhizin.

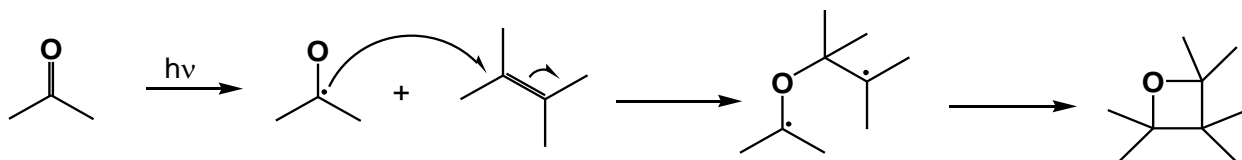


Figure 20: The Paternò-Büchi mechanism proposed for the photodegradation of BP3 and BMDBM in the liquorice root extract.



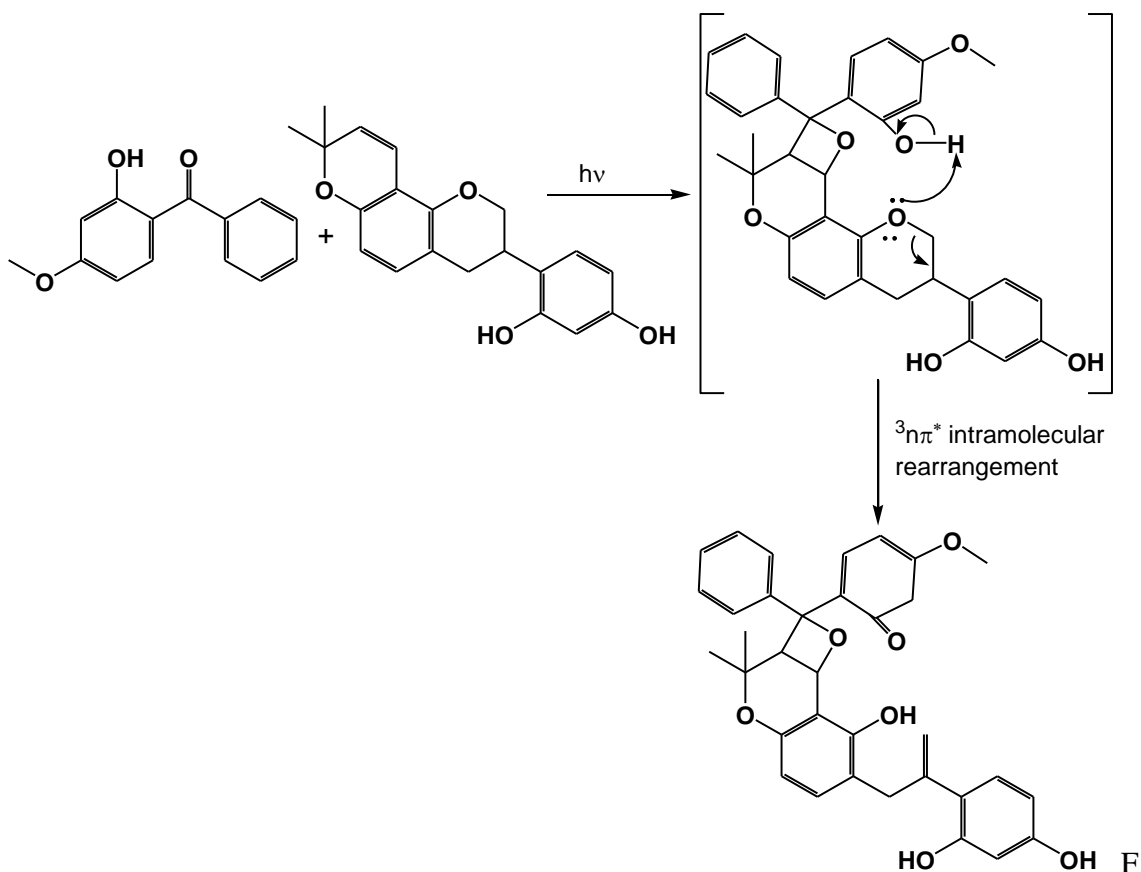


Figure 21: Proposed photo-induced reactions of BP3 with glabridin exposed to solar simulated radiation.

### 9.3.4 Effect of liquorice root extract on the photostability of BMDBM

The photostability of a methanol solution of BMDBM was first investigated by irradiation of the solution with a simulated solar source. The characteristic photodegradation of BMDBM was demonstrated by the spectral lability observed in the UV spectra (Fig. 19). A drop of 0.4 absorbance units was recorded in this work for a four-hour period of continuous exposure. The HPLC analysis did not show a sufficient decrease in the peak area of the *enol*-BMDBM at 358 nm (Fig. 20). Several working groups have demonstrated the photostability of *enol*-BMDBM in polar protic solvents (Mturi and Martincigh 2008). The UV spectra show an increase in the absorbance at 260 nm but the HPLC chromatograms monitored at 260 nm did not show an appreciable change. This could be attributed to the difference in the sensitivity of the instruments and the fact that *keto*-BMDBM formation is not favoured by a highly polar protic medium. The UV spectra of BMDBM in a mixture with liquorice root extract show

a drop in absorption capacity with increase in irradiation time (Fig.21). A comparison of the spectral changes under the same conditions with those of BMDBM alone (Fig. 19), shows that the absorbance drop is smaller. A notable difference is the reduction in the *keto*-form of BMDBM observed at 260 nm against the decay of the *enol*-form of BMDBM. The assumption here is that in this mixture the BMDBM *keto-enol* tautomerism may only occur to a limited extent but rather decomposition to other chemical species takes place. This indicates that, liquorice root extract diminishes the *keto*-formation but fails to completely protect against *enol*-BMDBM degradation. It can be concluded that liquorice root extract may only partially photostabilize BMDBM. BMDBM is known to photodegrade in UV light in a nonpolar solvent and to break into two radicals: the phenacyl and benzoyl radicals (Schwack and Rudolph 1995). The HPLC chromatogram shows chemical species absorbing in the UVA region, characteristic with the photo-rearrangement and radical disproportionation reaction of BMDBM (Fig. 22, Supplementary Materials Table S3). Here also we envisage the participation of BMDBM in Patternò-Büchi type reactions but preserving the *enol*-chromophore (Fig. 17).

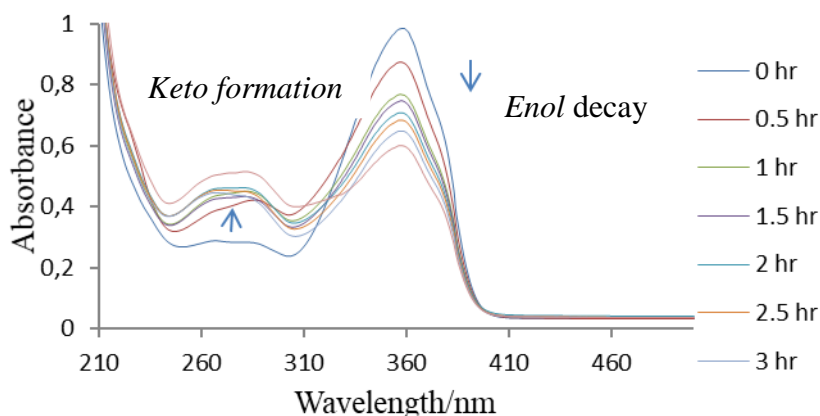


Figure 19: The spectral changes of BMDBM dissolved in methanol and irradiated by a solar simulated light source. The spectra were acquired with a Perkin Elmer Lambda 35 UV-Vis spectrophotometer in a 1 mm pathlength quartz cuvette with air as the reference.

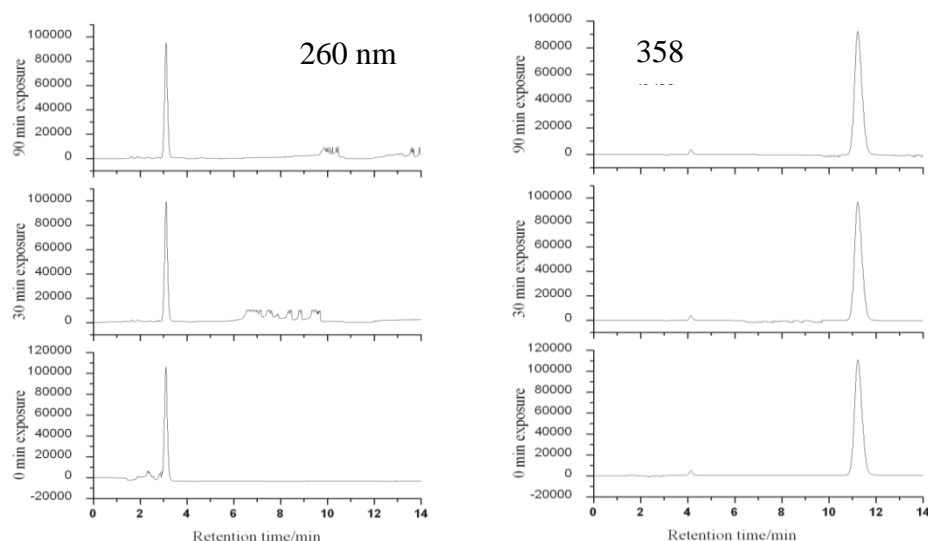


Figure 20: The photochemical changes of BMDBM monitored at 260 and 358 nm on a reversed-phase Zorbax Eclipse-XDB C-18 (150 mm x 4.6 mm) column with methanol-water (84:16 % v/v) mobile phase. The injection volume was 10  $\mu\text{L}$  and the flow rate set at 1  $\text{mL min}^{-1}$ .

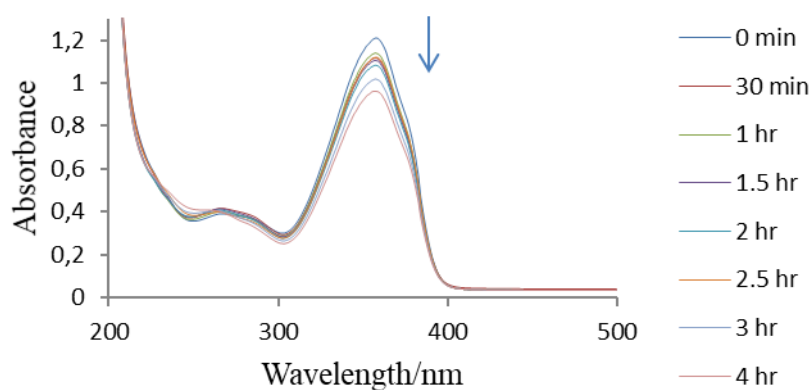


Figure 21: The photodegradation of BMDBM in liquorice root extract exposed to UV radiation in methanol, in a 1 mm pathlength quartz cuvette. Each exposure event involved the use of a fresh sample mixture. The spectra were recorded on a PerkinElmer Lambda 35 spectrophotometer.

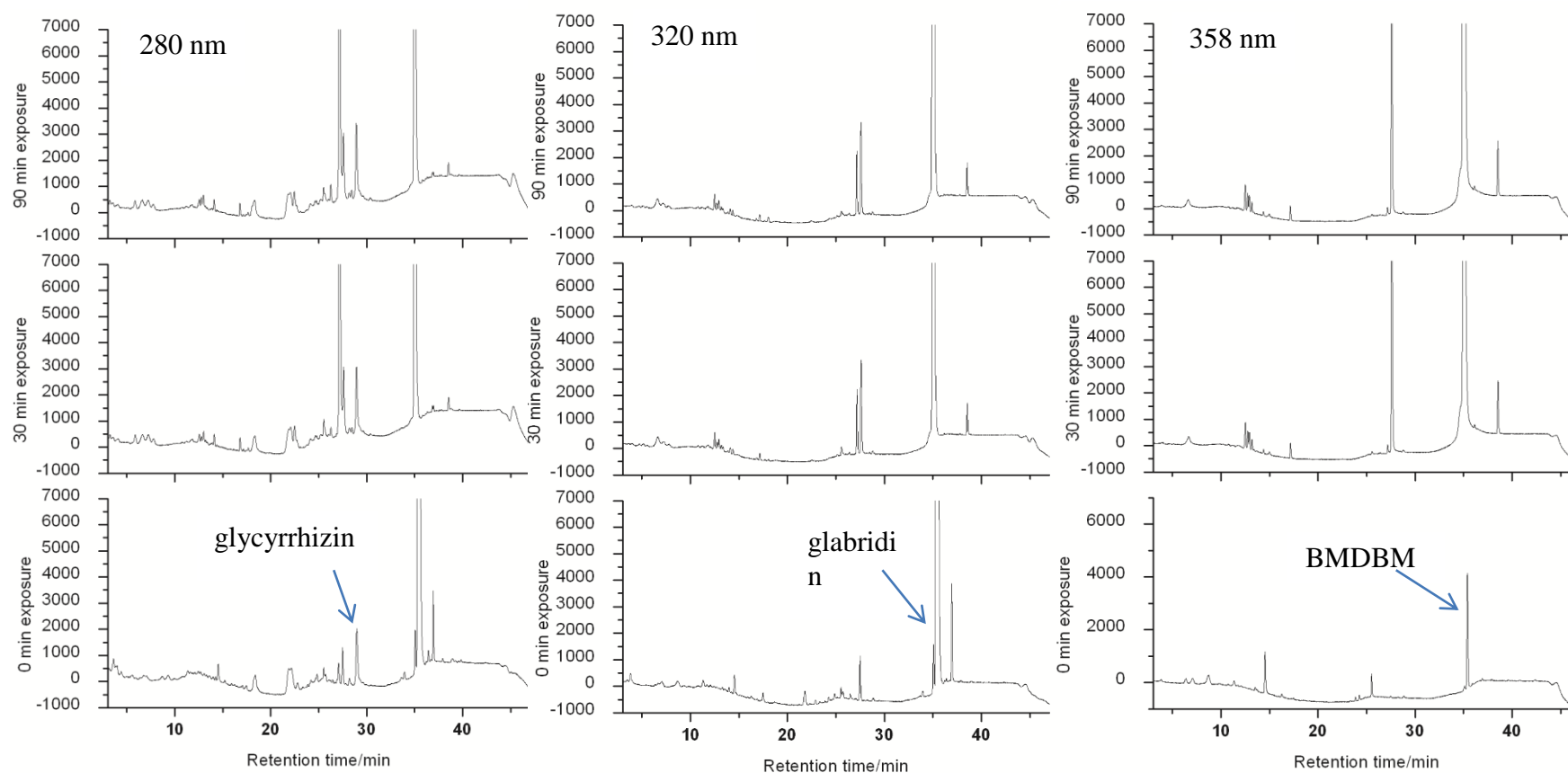


Figure 22: The photo-induced chemical transformations of a mixture of BMDBM and liquorice root extract in methanol. The HPLC chromatograms were detected at 280, 320, and 358 nm. The separation was effected on a Zorbax Eclipse-XDB C-18 column (150 mm × 4.6 mm, i.d., 5 μm). The mobile phase was a gradient elution of acetonitrile-water with a flow rate of 1.00 mL min<sup>-1</sup> and the injection volume was 20 μL.

### 3.5 Effect of liquorice root extract on the photostability of EHMC

The irradiation of a methanolic solution of EHMC with solar simulated radiation for an incremental period of time shows a spectral lability (Fig. 23). The HPLC analysis indicates formation of *cis*-EHMC which absorbs shorter wavelengths (Fig. 24). This could explain the spectral lability observed during the photo-isomerisation of *trans*-EHMC to *cis*-EHMC. Pattanaargson et al. (2004) and Broadbent et al. (1996) have previously reported the photoisomerisation of EHMC under UV irradiation.

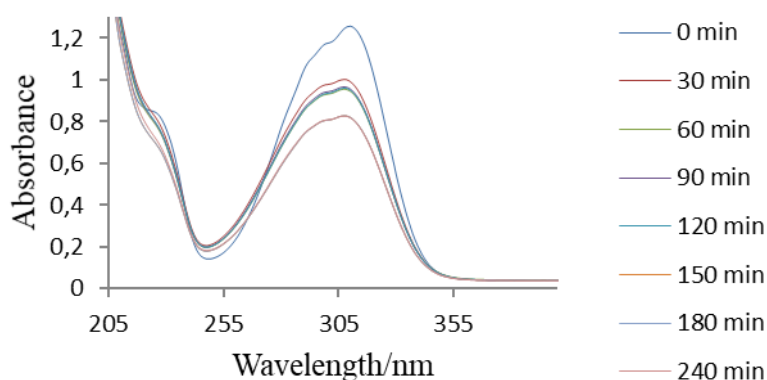


Figure 23: Photoinstability of EHMC dissolved in methanol under solar simulated irradiation. The spectra were acquired with a Perkin Elmer Lambda 35 UV-VIS spectrophotometer in a 1 mm pathlength quartz cuvette with air as the reference.

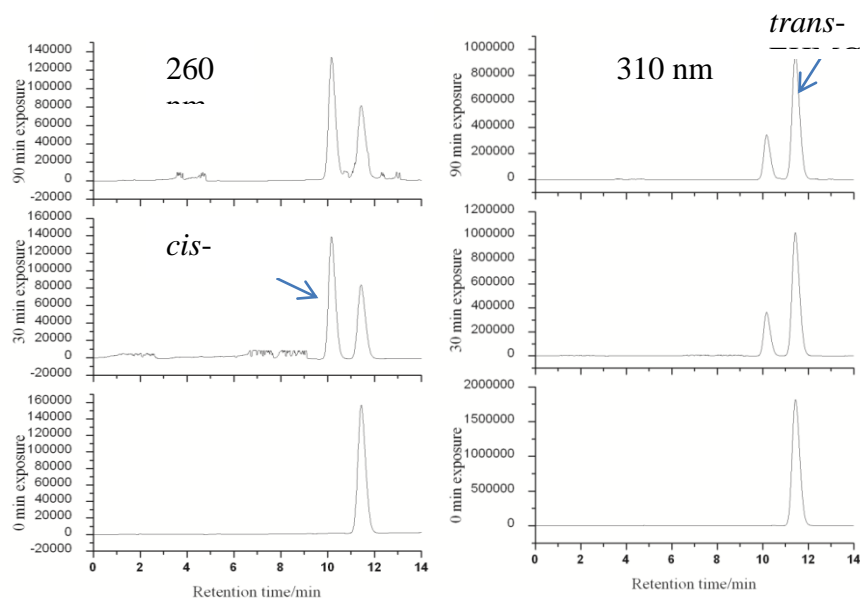


Figure 24: Isomerisation of EHMC under simulated solar irradiation monitored by HPLC at 260 and 310 nm on a reversed phase Zorbax Eclipse-XDB C-18 column (150 mm  $\times$  4.6 mm) with a methanol-water (84:16 % v/v) mobile phase. The injection volume was 20  $\mu$ L and the flow rate set at 1 mL

The photo-response of the mixture of EHMC with liquorice root extract was erratic with a sudden increase in the photo-absorption and then a fall (Fig. 25). This is unlike the cinnamate spectral decay observed when EHMC is dissolved in methanol (Fig. 23). The HPLC analysis of these solutions showed the formation of strongly absorbing chemical species on continued exposure above 30 min (Fig. 26). This could be attributed to [2+2] cycloaddition and Paternò-Büchi carbonyl-alkene reactions from the  $n\pi^*$  (Fig. 27).

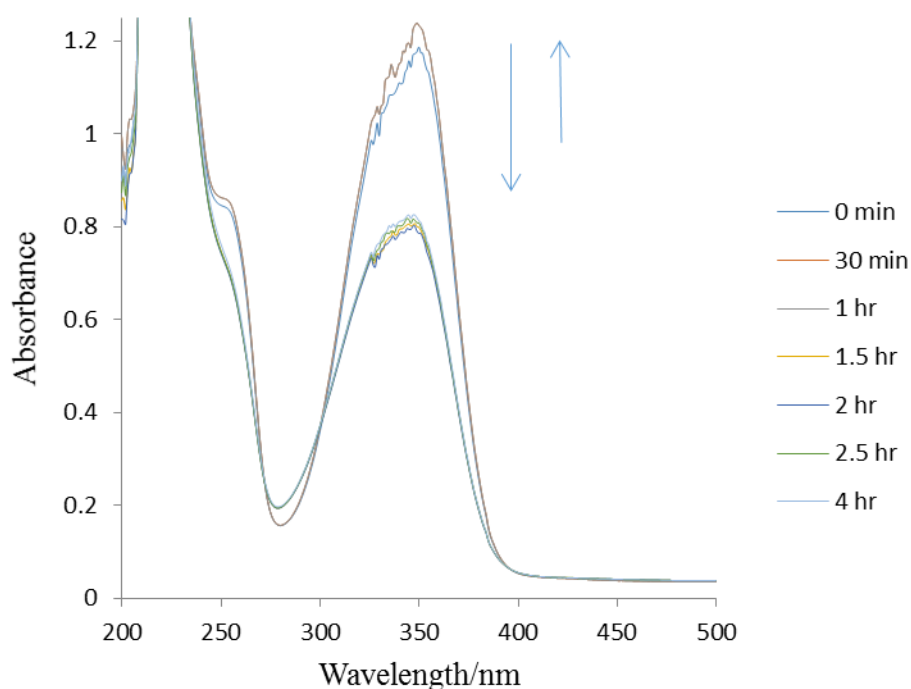


Figure 25: The photoinstability of EHMC in liquorice root extract dissolved in methanol when exposed to simulated solar radiation, in a 1 mm pathlength quartz cuvette. Each exposure event involved use of a fresh sample solution. The spectra were recorded on a Perkin Elmer Lambda 35 dual beam spectrophotometer.

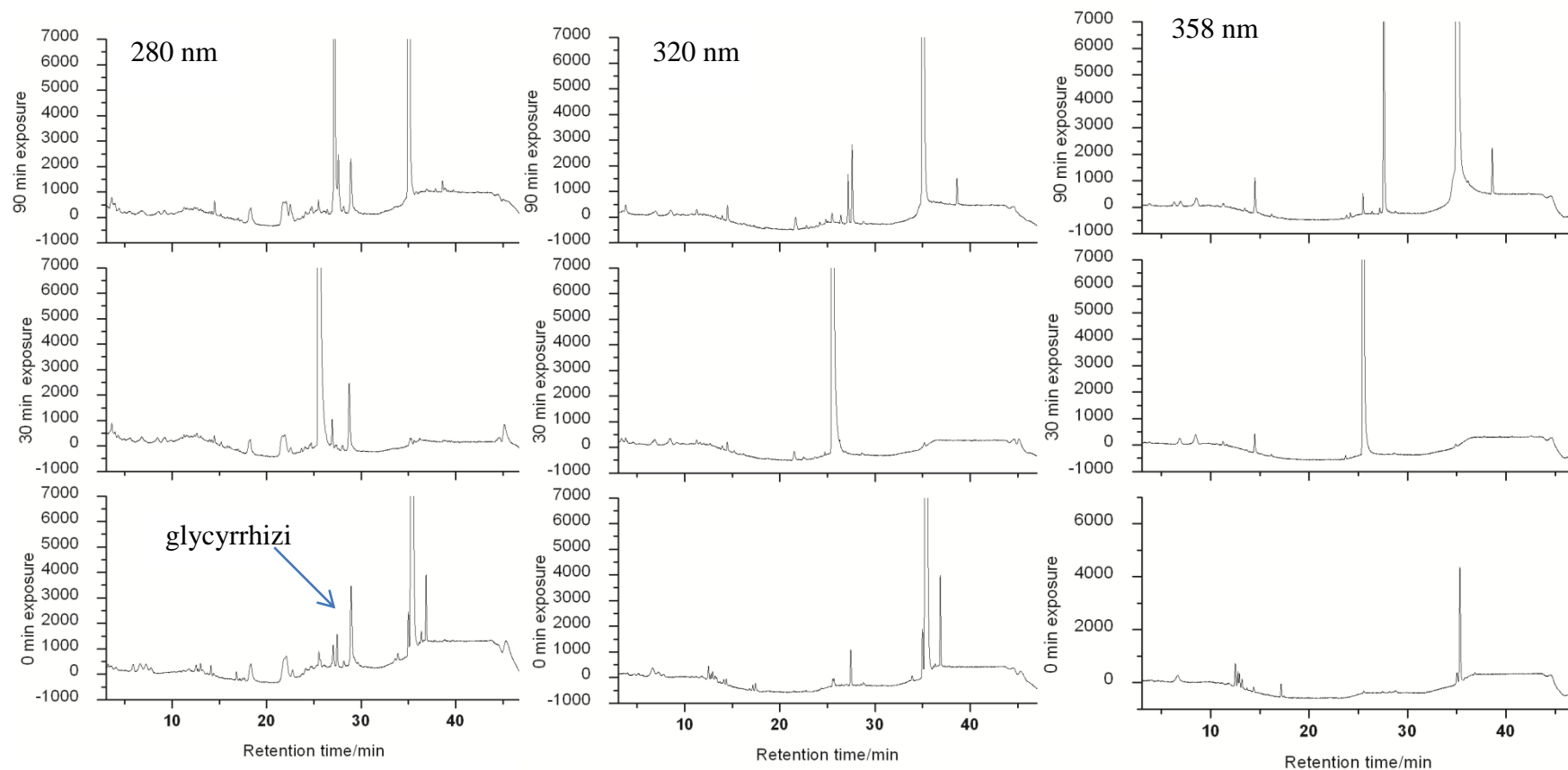


Figure 26: HPLC chromatograms of the photo-induced chemical reaction of EPMC with liquorice root extracts dissolved in methanol, irradiated by solar simulated radiation. The chromatograms were monitored at 280, 320, and 358 nm. The separation was effected on a Zorbax Eclipse-XDB C-18 (150 mm × 4.6 mm, i.d., 5 μm) column. The mobile phase was a gradient elution of acetonitrile-water with a flow rate of 1.00 mL min<sup>-1</sup> and the injection volume was set 20 μL. The EPMC peak and the glabridin could not be resolved under this conditions. .

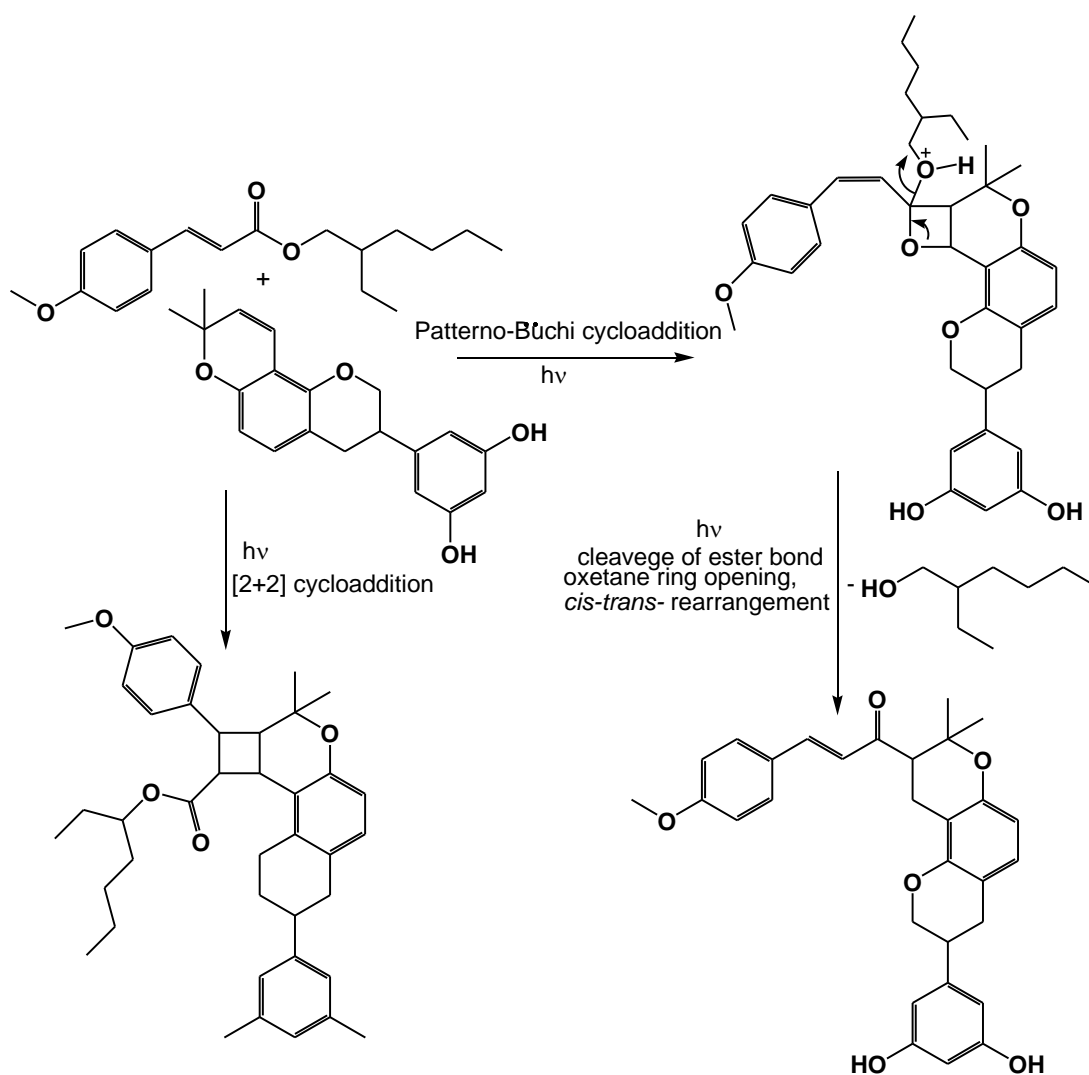


Figure 27: Proposed mechanism for the ethylhexylmethoxy cinnamate reaction of EHMC with glabridin.

The proposed mechanism is informed by the fact that the UV spectra of the mixture retain the same shape as the UV spectra of EHMC, and therefore the cinnamate moiety is assumed to be retained. The observed initial drop in the absorption of UV light can be attributed to competitive  $[\pi 2 + \pi 2]$  cycloaddition and Patterno-Büchi  $[\sigma 2 + \pi 2]$  cycloaddition involving glabridin which forms an oxetane. We propose that the Patterno-Büchi reaction dominates the  $[\pi 2 + \pi 2]$  cycloaddition upon UV light exposure, which would require a homolytic ring opening of the cyclobutane ring to retain the easily cleavable ester bond (Fig. 27). On prolonged UV exposure the oxetane assumes a *cis*-conformation, which absorbs at a longer wavelength for the cinnamic moiety but with a very low



absorption coefficient ( $\epsilon_0$ ). The oxetane becomes more strained leading to oxidative heterocyclic ring opening with cleavage of the ester bond. The overall result is the retained cinnamic acid moiety with higher  $\epsilon_0$ , and a bathochromic shift attributed to the proximity of the cyclic pyran ring of the glabridin moiety. This explains the observed stability of this mixture covering the entire UV spectrum and without further photodegradation (Fig. 25) and the source of the peaks observed at 358 nm (Fig. 26). We conclude that a mixture containing liquorice root extract and EHMC is likely to produce a broad spectrum sunscreen product owing to the photochemical reactions between EHMC and the liquorice root extract constituents.

### **3.6 Effect of liquorice root extract on the photostability of a mixture of EHMC, BP3 and BMDBM**

The three sunscreen absorbers investigated are frequently mixed together in a formulation in order to obtain a broad-spectrum photoprotective product. A mixture of the three sunscreen agents was prepared by dissolving the three UV absorbers in methanol and subjected to photostability studies. This solution showed photodegradation (Fig. 28), with absorption maxima in the UVB region. The HPLC analysis of this mixture showed the relative photostability of BP3 and BMDBM and photoisomerisation of EHMC (Fig. 29). This mixture, therefore cannot guarantee broad-spectrum photoprotection. Efforts were thus made to investigate the effect of liquorice root extract on a mixture of EHMC, BP3 and BMDBM. Most working groups have reported the inherent photoinstability of a BMDBM and EHMC mixture in which EHMC is reported to undergo photoisomerisation photosensitised by BMDBM occasioning photo-loss ([Dondi et al. 2006](#); [Pattanaargson et al. 2004](#)). These two may also undergo a [2+2] cycloaddition reaction that breaks down rapidly to give other less absorbing photoproducts. In this work the UV spectra of the three sunscreens combined with liquorice root extract showed a drop after 30 minutes and then stabilized (Fig. 30). The spectral decay of this mixture in methanol is accompanied by a blue shift (Fig. 28) a phenomenon that is reversed in this mixture containing liquorice extract. An inspection of the corresponding HPLC chromatogram showed the EHMC and BMDBM peaks only. However, the BP3 peak was again not seen on the HPLC chromatogram. This could be due to reactions explained in Section 3.3. A study by [Sayre et al.](#)

(2005) suggested that the photo-loss of EHMC may be enhanced by the free radicals formed in the photodegradation of BMDBM present in the mixture. The overall observed effect of these reactions is the emergence of one major absorbing species (Fig. 31). The HPLC chromatographic data reveal several other chemical species (Supplementary Materials Table S6.). This mixture achieves an improved absorption efficacy but does not stop the photo-degradation of BMDBM and photoisomerisation of EHMC as chemical entities but reaction occurs to produce long wavelength absorbing species.

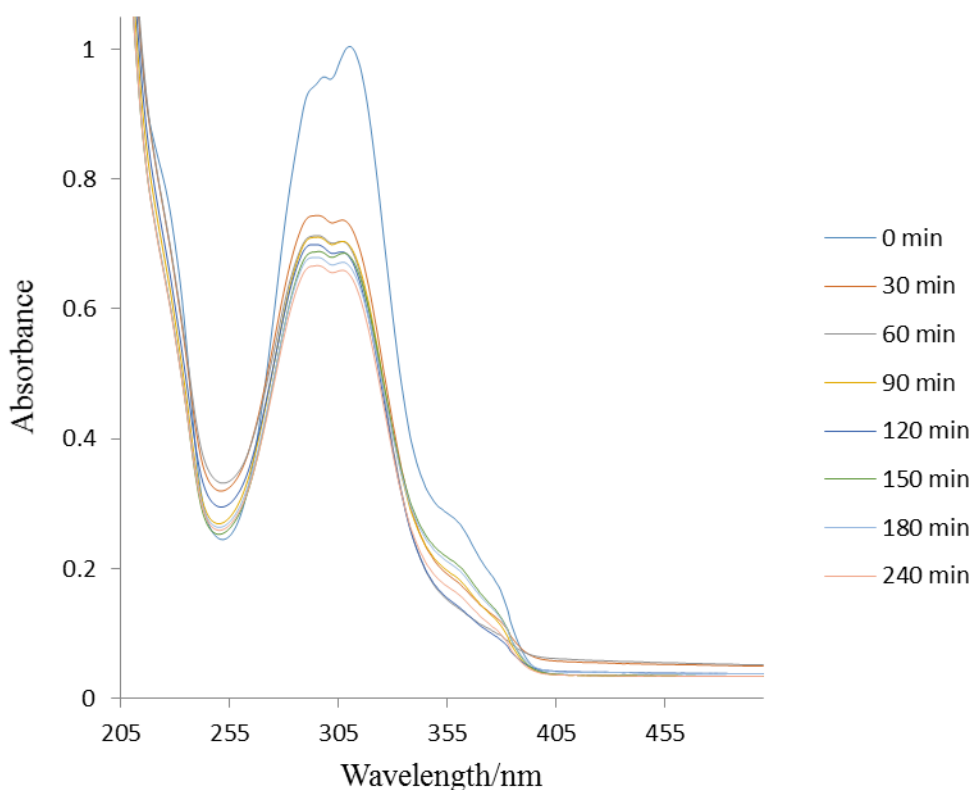


Figure 28: The spectral transformations of a mixture of the organic UV absorbers: EHMC, BP3 and BMDBM, under solar simulated irradiation, in a 1 mm pathlength quartz cuvette. Each exposure event involved use of a fresh sample solution. The spectra were recorded on a PerkinElmer Lambda 35 spectrophotometer.

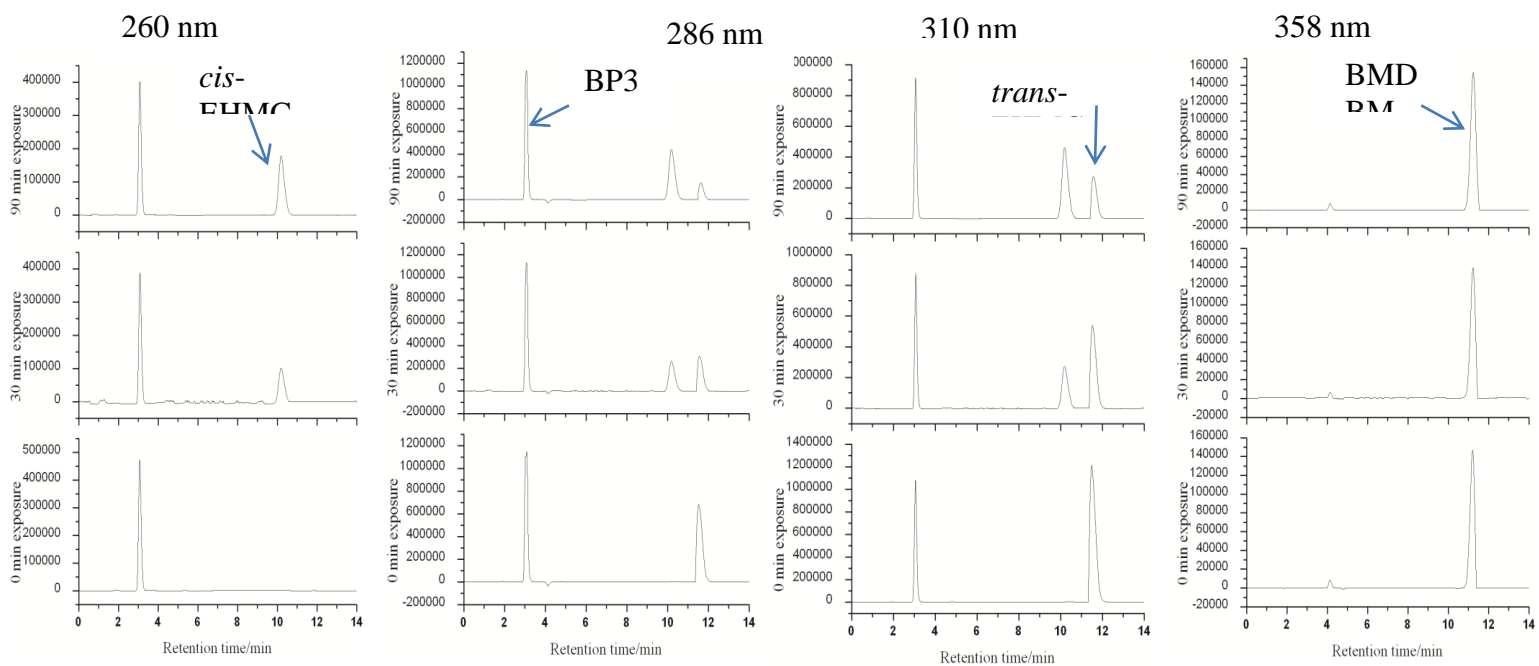


Figure 29: The photochemical transformations of a mixture of BMDBM, BP3, and EHMC dissolved in methanol monitored by HPLC at 260, 286, 310, and 358 nm. The separation was effected on a Zorbax Eclipse-XDB C-18 column (150 mm  $\times$  4.6 mm, i.d., 5  $\mu$ m). The mobile phase was a gradient elution of acetonitrile-water with a flow rate of 1.00 mL min<sup>-1</sup> and the injection volume was 20  $\mu$ L.

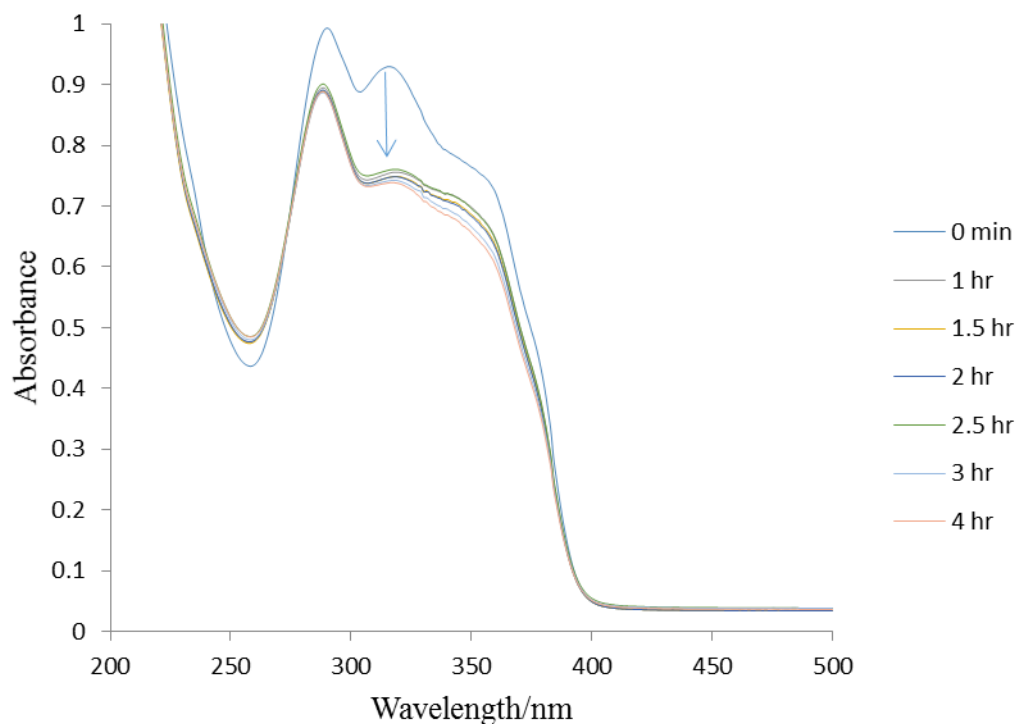


Figure 30: The photostability of a mixture of EHMC, BP3, BMDBM, and liquorice root extract dissolved in methanol when exposed to simulated solar radiation, in a 1 mm path-length quartz cuvette. Each exposure event involved use of a fresh sample solution. The spectra were recorded on a PerkinElmer lambda 35 UV-vis dual beam spectrophotometer.

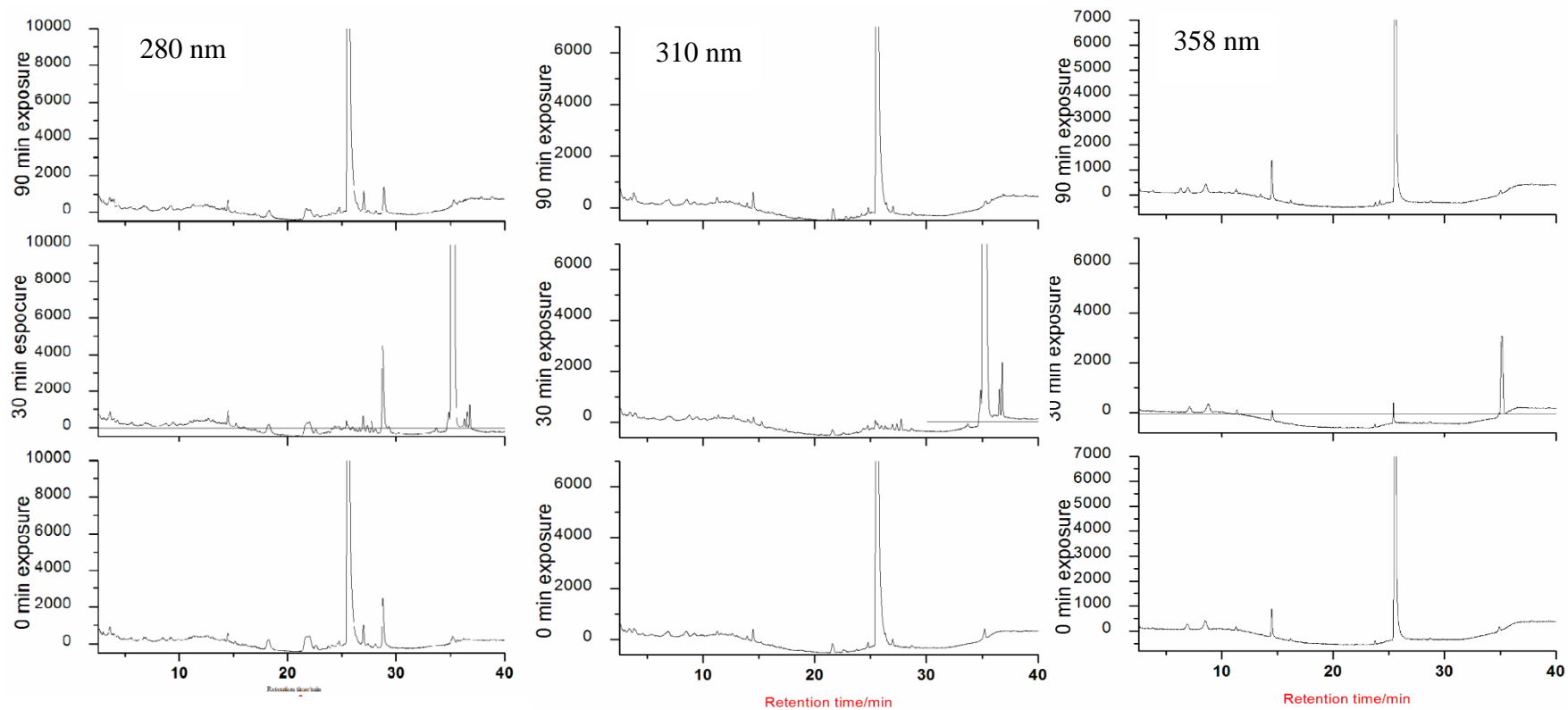


Figure 31: Photochemical changes when liquorice root extract is incorporated in a mixture of EPMC, BP3 and BMDBM in methanol, monitored by HPLC at 260, 286, 310, and 358 nm. The separation was effected on a Zorbax Eclipse-XDB C-18 column (150 mm x 4.6 mm, i.d., 5  $\mu$ m). The mobile phase was a gradient elution of acetonitrile-water with flow rate of 1.00 mL min<sup>-1</sup> and an injection volume of 20  $\mu$ L. No peak could be identified conclusively.

#### 9.4 Conclusions

The aim of this work was to investigate the effect of liquorice root extract on the photostability of some commonly used sunscreen absorbers. The liquorice root extract alone showed appreciable photo-absorption. However, irradiation of the extract with simulated solar radiation for increasing exposure periods showed a drop in UV-light absorption. We conclude that the photo-absorbing species in the liquorice root extract degrade upon exposure to UV light. The inclusion of common UV-absorbing agents into the liquorice root extract dissolved in methanol, showed different photo-degenerative responses depending on the agent. For example, a mixture containing BP3 in the liquorice root extract showed no appreciable change or drop in UV absorption. But a significant chemical transformation was observed from the HPLC data. No peak for BP3 could be detected on the chromatogram; the observed variation in the retention time indicates both dark and light-promoted reactions between the secondary metabolites of the liquorice root extract and BP3. We propose that the reactions between these metabolites and BP3 do not affect the carbonyl chromophore but rather add onto the phenyl rings. This causes the slight bathochromic shift observed suggesting that the added groups are electron-donating groups. These effects predominate even when all the three absorbing molecules are mixed together. The HPLC chromatograms of the mixture of the three sunscreen absorbers with liquorice root extract resemble those of BP3 along with the liquorice root extract. The UV spectra resemble those of BP3. These results indicate the stability of the *ortho*-hydroxybenzophenone moiety but do not rule out C-C and C-O linkages on the phenyl rings.

EHMC showed an unusual photodegradation response with a drop-increase and drop fashion. This is attributed to a photochemical reaction involving both Paternò-Büchi and [2+2] cycloaddition reactions followed by a rearrangement. The resultant species is stable or has a longer life-time. There is need to investigate, isolate and characterize this species due to its photostability and may provide a lead to a stable synthetic UV absorber.

The addition of liquorice root extract to a solution of BMDBM in methanol did not show significant change on its photostability. A steady drop in UV absorption was observed at 358 nm the wavelength of maximum absorption for the *enol* form of BMDBM. This indicates photo-induced degradation of this UV absorber. There was a slight increase in absorbance at about 260 nm on the UV spectra indicating a possible isomerization to the *keto* form but to a very limited degree. The *keto* form of BMDBM has maximum wavelength of absorption at 254 nm. A close inspection of the HPLC data shows that exposure to UV radiation of this mixture leads to photochemical reactions similar to those observed and proposed for EHMC. This could be true given that BMDBM can split down to a phenacyl radical and a benzoyl radical upon UV irradiation. The phenacyl radical may rearrange to produce the cinnamic acid moiety which is likely to react in similar fashion as EHMC.

The overall analysis of liquorice root extract is that it may not be a very good stabilizer for all the chemical absorbers investigated, but it reacts with the agents to yield products with varying absorption characteristics. We conclude that these photoreactions with the absorbers produce UV-active species which may photostabilize the absorption efficacy of the formulation and not the individual sunscreen agent. It is expected that the phenolic compounds in the liquorice root extract may also contribute to absorption and scavenging of radical species.

### **Acknowledgements**

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## Supplementary Materials

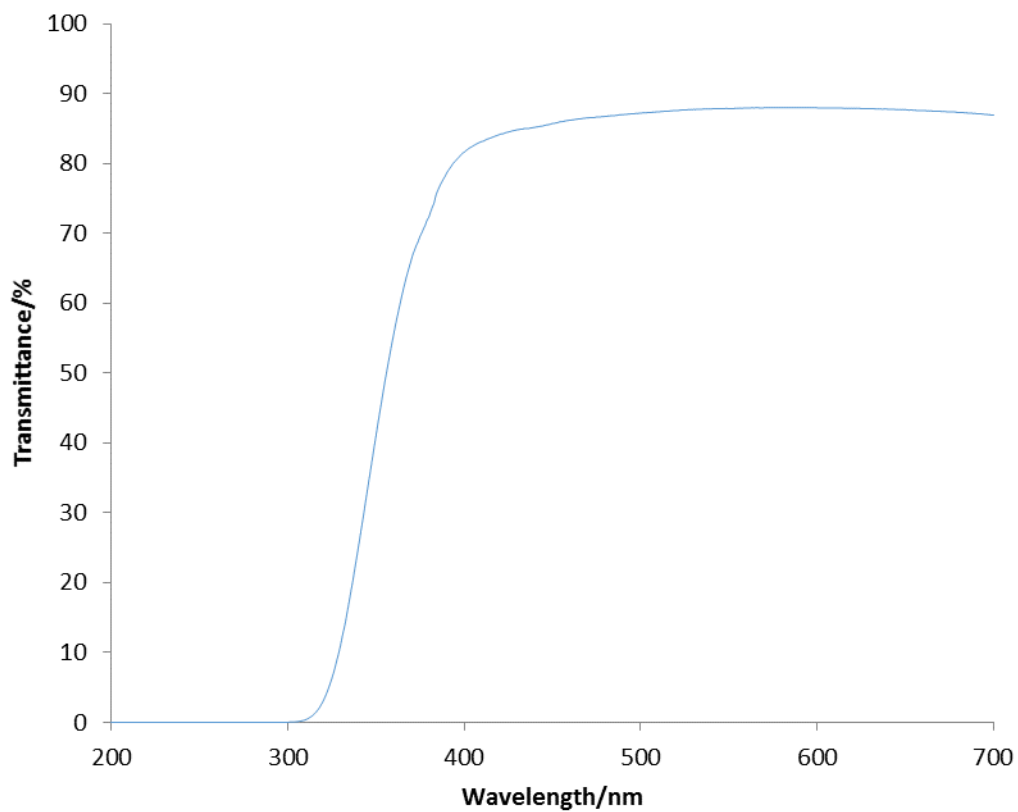


Figure S9.22: The transmittance spectrum of the 10 mm-thick Pyrex glass filter used in this work recorded on a Perkin Elmer Lambda 35 UV-vis dual beam spectrophotometer.

Table S9.1: The photochemical changes of the sunscreen(s) dissolved in methanol after irradiation with simulated solar irradiation monitored on HPLC-PDA at 260, 286, 310, 358 nm.

<b>Mixture of BMDBM, BP3 and EHMC</b>					
<b>Wavelength/nm</b>	<b>UV-filter</b>	<b>RT</b>	<b>Peak Area</b>		
			<b>0 min</b>	<b>30 min</b>	<b>90 min</b>
<b>260</b>	<i>keto</i> -BMDBM	3.072	474053	388025	402645
	BP3	3.08267	1149065	1127671	1136999
<b>286</b>	<i>cis</i> -EHMC	10.19733	0	261526	443856
	<i>trans</i> -EHMC	11.53067	683313	303745	148920
<b>310</b>	BP3	3.05067	1076471	879510	915656
	<i>cis</i> -EHMC	10.19733	0	272403	461590
<b>358</b>	<i>trans</i> -EHMC	11.488	1212199	538875	272829
	<i>enol</i> -BMDBM	11.21067	146473	139439	154766
<b>BMDBM</b>					
<b>260</b>	<i>keto</i> -BMDBM	2.368	5769	99334	95094
<b>358</b>	<i>enol</i> -BMDBM	11.232	110714	96556	92185
<b>BP3</b>					
<b>286</b>	BP3	3.06133	927540	738944	806767
<b>EHMC</b>					
<b>260</b>	<i>cis</i> -EHMC	10.16533	0	139036	133916
	<i>trans</i> -EHMC	11.43467	156696	83566	81385
<b>310 nm</b>	<i>cis</i> -EHMC	10.16533	0	362702	342873
	<i>trans</i> -EHMC	11.44533	1818585	1026119	965827

Table S9.2: The chemical transformations of liquorice root extract dissolved in methanol on UV irradiation monitored on HPLC-PDA at 275, 280, 286, 310 and 358 nm.

275 nm						280 nm					
RT	PA-0min	RT	PA-30min	RT	PA-90min	RT	PA-0min	RT	PA-30min	RT	PA-90min
1.309	78395	1.4	172727	1.394	161441	1.4	197880	1.4	164602	1.394	153166
1.4	125300	1.562	15298	1.555	15375	1.562	15560	1.562	15089	1.555	14317
1.562	16397	1.854	72975	1.845	71214	1.854	107730	1.854	88445	1.845	85167
1.854	88278	2.022	18149	2.011	19968	2.22	31271	2.216	37495	2.206	33554
2.027	21072	2.216	26449	2.205	36121	2.517	6452	2.757	20510	2.719	21933
2.221	39948	2.748	9341	2.724	22961	2.781	24284	3.25	14370	3.228	14328
2.784	25109	3.259	3330	3.248	16351	3.276	19671	3.496	5238	3.517	4502
3.282	23805	3.555	2439	3.533	5203	3.523	12519	4.154	1049	5.664	1227
3.567	14525	4.132	2395	4.092	1133	4.148	7474	5.95	6528	5.921	6458
4.021	4028	5.947	7197	5.643	1081	5.998	6965	6.798	13275	6.759	10975
4.144	3238	6.809	14776	5.917	6597	6.906	12869	7.418	12235	7.355	9499
6.001	6048	7.418	12488	6.737	14641	7.528	12518	7.953	6444	7.91	4403
6.898	14706	7.944	5997	7.352	11345	8.069	6043	11.912	1382	11.28	2137
7.536	13172	10.882	1058	7.901	4869	11.311	1672	12.583	4305	11.663	2106
8.088	5917	11.252	1807	10.832	1265	11.975	1877	12.787	1013	11.872	3793
11.326	1816	11.908	1927	11.233	1627	12.606	5577	13.045	4156	12.085	2076
11.731	1026	12.134	1207	12.577	4872	12.822	1807	13.76	1865	12.256	1214
11.934	2247	12.597	6939	12.769	1457	13.075	6156	13.905	2479	12.55	9860
12.625	6858	12.787	1817	13.025	6175	13.29	3862	14.154	5489	12.769	4199
12.818	1950	13.047	7418	13.221	2001	13.771	5782	16.83	9816	13.021	10183
13.074	7962	13.252	2553	13.76	6396	14.179	5678	17.191	6551	13.222	6476
13.29	4126	13.472	2591	13.869	2915	16.841	10004	24.191	3523	13.451	3681
13.837	6761	13.792	4757	14.133	6350	17.202	6637	24.405	1670	13.792	11063
14.179	7461	13.904	3411	16.805	11655	24.205	1850	24.661	2589	13.873	6130
16.833	12529	14.153	6518	17.161	5130	24.83	1939	24.836	2841	14.136	13546
17.202	5331	15.207	4589	24.17	1172	24.987	1565	24.987	2501	14.4	4997

23.819	1293	15.509	5854	24.821	1666	25.162	3014	25.158	4024	14.635	5925
24.195	3412	16.824	12017	24.966	1669	25.395	7132	25.389	8081	14.805	6105
24.448	2798	17.19	5209	25.109	1729	25.632	12822	25.626	14176	14.955	1342
24.683	2476	23.84	1075	25.373	8901	26.165	2388	26.161	2455	15.198	8253
24.839	3608	24.189	4524	25.613	15070	26.918	2545	26.907	2741	15.371	3716
24.992	2643	24.405	3611	26.141	1796	27.076	6111	27.067	6258	15.573	9162
25.153	3659	24.661	3171	26.887	2405	28.221	7975	28.209	8291	16.813	9160
25.401	10775	24.836	4015	27.054	6315	29.013	10996	29	11372	17.167	6391
25.634	16855	25.003	3933	27.544	1451	29.602	1315	29.575	1581	24.161	1822
26.162	3465	25.157	3808	28.198	9866	35.378	2199	30.503	1421	24.815	1377
26.916	2139	25.385	12948	28.99	11003	35.897	2802	30.916	1150	24.967	2037
27.077	5866	25.627	20643	29.581	1168	38.855	6493	35.365	2998	25.142	2773
27.567	1445	26.154	6365	30.471	1302	45.407	73254	35.884	2535	25.375	7305
28.222	8928	26.389	2930	30.845	1292			38.845	6575	25.611	12880
29.016	10101	26.707	3395	35.334	2613			45.425	76008	26.139	2533
30.511	1397	26.91	4040	35.877	2168					26.894	2939
30.906	1239	27.068	8430	38.825	7190					27.057	6602
35.264	1520	27.556	3550	45.519	70622					27.538	1414
35.385	1098	28.21	9439							28.198	8584
35.896	2256	29.003	11027							28.991	11378
38.852	6680	29.576	1145							29.581	1304
45.368	64862	30.501	1551							30.476	1148
		30.885	1639							30.925	1287
		35.364	3573							35.354	2604
		35.889	2018							35.877	2542
		38.844	6775							38.839	6253
		45.424	68933							45.503	80618
286 nm						310 nm					
RT	PA-0min	RT	PA-30min	RT	PA-90min	RT	PA-0min	RT	PA-30min	RT	PA-90min
1.4	179253	1.4	144361	1.394	132810	1.401	117829	1.401	79864	1.394	71480

1.562	15204	1.561	13259	1.554	12573	1.562	13061	1.562	7929	1.554	8089
1.854	101727	1.854	82722	1.845	76137	1.855	84946	1.854	61847	1.846	54745
2.22	21236	2.217	32451	2.206	27452	2.216	6871	2.213	7507	2.196	7721
2.56	4328	2.756	26603	2.716	17942	2.349	8470	2.349	9284	2.336	9731
2.786	6404	3.238	16707	3.217	5148	2.775	8876	2.746	8219	2.725	5312
4.154	1984	3.491	8919	5.643	1188	4.017	1233	4.072	1301	6.768	9748
6.009	4223	3.904	2751	5.928	3553	6.963	9592	6.819	10507	7.369	5435
6.936	9297	3.979	1225	6.778	8895	7.546	6491	7.417	6950	7.881	2298
7.537	9764	4.123	2278	7.356	7821	8.045	2733	7.972	3015	12.525	6607
8.047	4491	5.653	1261	7.928	3827	11.912	1878	11.857	1519	12.772	2124
11.929	1567	5.948	4067	11.864	1093	12.574	6022	12.546	6716	12.949	5481
12.594	4556	6.805	10757	12.537	4608	12.812	2142	12.788	2270	13.209	2647
12.814	1576	7.443	9768	12.773	1453	13.001	5722	12.973	5673	14.13	1932
13.066	4943	7.95	4520	13.02	4363	13.272	2977	13.233	3111	17.171	2284
13.291	2787	11.877	1403	13.209	1287	13.44	1600	14.152	2018	25.58	1703
13.792	2862	12.563	4593	13.884	3447	14.177	1915	14.396	1152	27.047	1207
14.178	3988	12.789	1475	14.131	3965	14.416	2061	17.199	2180	35.363	2979
16.858	6839	13.042	4163	16.827	6369	17.207	2240	25.601	1661	35.87	1616
17.213	6925	13.245	1138	17.169	7483	17.72	1029	35.365	3765	38.841	2344
23.861	2764	13.91	2463	24.159	4599	25.136	1011	35.88	1792	45.5	49753
24.203	3118	14.152	4127	24.658	3673	25.609	1752	38.856	2016		
24.683	3997	16.846	6847	24.808	2131	27.081	1242	45.456	50759		
24.822	2856	17.194	7124	24.974	2451	35.384	2736				
24.981	2489	24.174	1206	25.15	4571	35.896	1990				
25.175	5014	24.681	1339	25.369	7150	38.864	1909				
25.393	7027	24.824	1852	25.608	9505	45.388	46468				
25.631	10179	24.997	1691	26.14	1653						
26.166	2742	25.162	3970	26.896	2610						
26.923	2405	25.383	6244	27.056	6096						
27.077	6350	25.622	9680	28.202	6356						

27.557	1226	26.158	2270	28.987	8318						
28.219	5967	26.914	2449	29.602	2451						
29.014	7711	27.066	5979	29.978	1109						
29.624	1345	27.557	1073	35.347	2726						
35.38	2422	28.214	5937	35.868	2615						
35.896	2991	29	7985	38.842	6211						
38.846	5699	29.583	1419	45.5	86146						
45.403	78502	35.368	3412								
		35.883	2870								
		38.845	5464								
		45.464	83324								

Table S9.3: The chemical transformations of liquorice root extract mixed with BMDBM dissolved in methanol on irradiation with simulated solar irradiation monitored by HPLC-PDA.

275 nm						280 nm					
RT	PA-0min	RT	PA-30min	RT	PA-90min	RT	PA-0min	RT	PA-30min	RT	PA-90min
1.4	126755	1.408	119601	1.394	113945	1.4	122530	1.408	114605	1.394	109236
1.557	9811	1.565	9235	1.552	9863	1.557	9176	1.565	8650	1.552	9333
1.85	89030	1.858	65665	1.844	61528	1.85	84368	1.858	76589	1.844	72687
2.207	30723	2.027	17112	2.007	14993	2.203	29505	2.214	28474	2.202	22385
2.718	35299	2.215	34105	2.198	23068	2.731	13701	2.74	13763	2.696	6839
3.234	20722	2.731	27942	2.697	8490	3.225	4724	3.234	6005	3.225	1138
3.504	14930	3.241	20932	3.227	2086	5.849	3726	4.133	1643	3.553	1039
3.861	3225	3.558	14287	3.53	2058	6.59	4687	5.894	3285	5.869	3338
4.048	3878	3.947	3432	4.047	2006	6.688	3168	6.703	6355	6.661	7522
5.855	3712	4.097	2936	5.87	4163	7.224	7392	7.268	6666	7.215	7397
6.599	9010	5.9	4569	6.658	10175	7.765	3623	7.833	2836	7.75	3594
7.223	8096	6.668	9745	7.258	8271	12.528	2705	12.558	2752	12.525	2702
7.738	3618	7.311	8742	7.78	3739	12.989	3210	13.015	3101	12.987	3061
12.539	3191	7.844	3773	12.545	3251	13.214	1650	14.113	2754	14.082	2765
12.995	4141	11.816	1029	12.993	4105	14.088	2687	14.457	3412	14.428	5047
13.248	1798	12.561	2205	13.195	1079	16.788	2382	16.81	2431	16.777	2195
14.089	3479	13.016	3221	14.081	2985	17.443	1022	18.379	14586	18.323	14745
16.786	4171	14.114	2970	14.438	4911	18.325	14638	21.899	17976	21.856	15228
17.64	1315	14.46	3150	16.779	4085	21.824	16457	22.108	17745	22.045	19557
18.334	15988	16.809	4415	17.64	1127	22.06	19058	22.765	4373	22.72	4377
21.835	19066	17.679	1189	18.326	16192	22.726	4199	24.176	1733	24.12	1520
22.061	18172	18.374	15318	21.856	17094	24.133	1453	24.648	1124	24.608	1094
22.724	5368	21.899	19092	22.052	20446	24.645	1101	25.366	1539	25.28	1913
24.14	2006	22.113	18819	22.72	5131	25.341	1096	25.552	8189	25.517	7534
25.323	1921	22.756	5726	24.13	1689	25.52	5339	26.88	1145	25.982	1119



25.512	7826	24.17	3613	25.323	1913	25.685	2057	27.051	7959	26.837	1034
25.999	1254	24.373	2048	25.517	7283	26.848	1182	27.473	2877	27.015	7800
27.023	7353	24.655	1808	25.98	1573	27.023	7950	27.858	5661	27.432	2991
27.441	9214	24.813	1032	26.827	1003	27.44	10515	28.194	2314	27.816	5027
28.154	2444	25.376	1464	27.019	7511	28.158	2297	28.968	41965	28.145	2320
28.932	41921	25.549	7968	27.44	3184	28.932	42564	33.6	1522	28.922	42210
33.578	1423	26.036	1718	27.816	4592	33.557	1424	33.896	2263	33.557	1709
33.873	2593	26.88	1112	28.144	2749	33.865	2631	35.007	11086	33.856	2379
34.975	11024	27.054	7481	28.923	42344	34.975	13596	35.341	8216264	34.958	10618
35.312	7386906	27.479	3227	33.557	1443	35.312	9133380	36.392	3656	35.295	8038959
36.128	1744	27.856	5059	33.854	1974	36.356	4133	36.628	6055	36.349	3716
36.356	5402	28.187	2838	34.958	8836	36.587	1340	36.878	8626	36.588	5833
36.597	1731	28.968	42313	35.294	6759428	36.847	16705	45.326	31940	36.841	8511
36.847	14111	33.579	1330	36.352	3676	45.304	28032			45.298	31081
45.295	26970	33.893	1995	36.589	5099						
		35.007	9458	36.841	6588						
		35.339	6905276	45.295	25516						
		36.396	3995								
		36.626	5490								
		36.879	7039								
		45.262	20725								
286 nm						310 nm					
RT	PA-0min	RT	PA-30min	RT	PA-90min	RT	PA-0min	RT	PA-30min	RT	PA-90min
1.4	112075	1.408	102256	1.394	96685	1.4	74738	1.408	65625	1.394	61705
1.556	8708	1.565	8161	1.551	8888	1.557	8315	1.565	8129	1.551	8536
1.85	80083	1.859	70106	1.844	68414	1.851	65391	1.859	57246	1.844	48532
2.206	19056	2.218	21028	2.201	23449	2.208	6371	2.229	5495	2.208	4902
2.485	4015	2.714	6156	2.717	5581	2.332	8314	2.357	10290	2.338	1909
2.745	7023	4.097	1043	5.864	2564	2.706	7820	2.716	5026	6.64	4398
5.849	1940	5.893	2307	6.633	6905	6.626	4448	6.683	4291	12.484	3462

6.626	6289	6.706	5398	7.266	6233	7.236	2827	7.273	2425	12.906	2535
7.225	5991	7.309	5568	7.79	3443	12.488	3893	11.823	1163	14.08	1549
7.772	2961	7.826	3081	11.79	1050	12.735	1461	12.512	3401	14.358	1343
12.517	2761	12.53	2286	12.493	2626	12.914	3619	12.934	2243	17.136	1190
12.737	1050	13.01	2175	12.986	2831	13.183	1926	14.111	1448	25.548	2298
12.987	3224	14.113	2077	13.185	1068	13.355	1258	14.38	1107	25.675	1636
13.208	1952	14.463	3461	14.081	2177	14.085	1368	17.172	1155	27.013	1428
14.088	2141	16.808	1048	14.432	5026	14.359	1443	25.574	3269	27.431	1590
14.366	1154	18.36	10058	16.778	1035	17.139	1193	25.717	1512	27.818	3687
16.79	1065	22.086	21330	18.324	8705	17.425	2205	27.054	1833	33.854	1478
17.432	1155	22.75	2836	21.824	10558	25.552	1662	27.47	2010	34.962	14137
18.329	9176	24.175	1483	22.041	9983	25.674	2573	27.854	4221	35.298	10355312
21.856	11328	24.655	1081	22.694	2800	27.023	1662	28.825	1148	36.117	2738
22.052	9921	24.798	1111	24.143	1333	27.439	10742	33.905	1581	36.288	1778
22.722	3306	25.28	1906	24.62	1095	28.786	1006	35.01	14250	36.588	8264
24.125	1396	25.561	7717	25.205	1705	33.873	2660	35.343	10614079	36.841	14248
24.619	1123	27.05	7783	25.529	5188	34.977	19318	36.626	6644	45.296	17649
25.227	1107	27.47	2826	25.675	1162	35.311	13160482	36.879	13996		
25.533	4440	27.854	6030	27.012	7710	36.306	1330	45.299	17587		
25.664	2215	28.201	1552	27.445	2784	36.576	1197				
27.023	7838	28.966	27477	27.815	5305	36.848	25586				
27.44	11898	29.702	1557	28.127	1462	45.3	17600				
28.148	1519	33.568	1759	28.922	27003						
28.928	26690	33.894	1804	29.637	1387						
29.636	1301	35.007	13087	33.525	1557						
33.573	1521	35.342	9565410	33.853	1623						
33.874	2466	36.381	2268	34.96	12685						
34.976	16316	36.627	6663	35.296	9349185						
35.312	10934005	36.878	10448	36.117	2566						
36.345	2962	45.329	33436	36.342	3963						

36.597	1614			36.589	7647						
36.848	20108			36.841	11232						
45.317	31685			45.298	35132						
358 nm											
RT	PA-0min	RT	PA-30min	RT	PA-90min						
1.4	39570	1.409	33411	1.395	32197						
1.557	7811	1.565	7370	1.552	8203						
1.851	22731	1.859	21170	1.844	21167						
1.968	2217	1.983	2114	1.962	1889						
6.633	3633	6.703	4428	6.68	4639						
12.484	5464	12.508	5245	12.481	5775						
12.734	3458	12.759	3445	12.731	3634						
12.904	3294	12.926	3330	12.899	3531						
13.167	2010	13.192	2097	13.167	2018						
14.369	1311	17.165	3312	17.134	3339						
17.141	3307	35.039	4133	34.99	2363						
28.755	1006	35.318	44567	35.273	43048						
35.001	3397										
35.311	34877										

Table S9.4: The chemical transformations of liquorice root extract mixed with BP3 dissolved in methanol on irradiation with simulated solar irradiation monitored by HPLC-PDA.

275 nm						280 nm					
RT	PA-0min	RT	PA-30min	RT	PA-90min	RT	PA-0min	RT	PA-30min	RT	PA-90min
1.402	125182	1.395	120802	1.398	115884	1.402	121025	1.395	115669	1.398	110460
1.562	8783	1.553	9522	1.555	9587	1.562	8251	1.553	8844	1.555	8905
1.855	83159	1.846	78538	1.849	65079	1.855	82144	1.846	79598	1.849	74888
2.211	30904	2.203	24289	2.011	18245	2.211	32844	2.204	33705	2.206	20137
2.726	23112	2.714	7483	2.205	38274	2.744	24365	2.709	22169	2.716	8790
3.257	13213	3.242	1851	2.715	29243	3.239	17111	3.237	20006	3.22	1330
3.539	6379	3.535	2035	3.225	21267	3.507	11586	3.455	10733	3.523	1474
5.891	3607	4.076	1924	3.538	13977	4.086	7030	3.893	3622	4.059	1648
6.706	7255	5.891	3155	4.088	6841	5.898	3657	4.077	2354	5.872	4250
7.275	7262	6.678	8960	5.871	4801	6.712	6051	5.866	4587	6.608	8478
7.823	3376	7.28	7832	6.609	10881	7.27	6888	6.714	6983	7.238	8238
11.823	1083	7.832	3423	7.235	8922	7.826	3153	7.291	7175	7.749	3861
12.563	3160	12.56	2616	7.75	3774	11.802	1432	7.833	3467	11.809	1822
13.021	4192	13.016	3340	11.784	1184	12.56	2742	11.813	1038	12.545	3060
13.301	1695	14.108	2768	12.547	2908	13.019	3704	12.54	2833	13.002	3083
14.116	3108	16.8	3936	13.004	3580	13.222	1983	13.002	3399	14.102	2664
16.81	3897	17.658	1331	13.865	1114	14.116	3219	13.205	1475	16.798	2268
17.672	1244	18.362	14257	14.1	3156	16.812	2212	14.107	2603	18.344	14318
18.38	15678	21.867	18868	16.796	3989	18.361	15117	16.801	2184	22.067	35200
21.931	17058	22.088	19076	17.659	1460	21.888	14342	18.345	13734	22.742	4283
22.128	20824	22.74	5293	18.358	15504	22.123	21340	21.909	16297	24.15	1573
22.781	5285	24.144	2159	22.068	36988	22.786	4634	22.09	18854	24.641	1120
24.186	2034	25.355	1194	22.746	5070	24.186	1587	22.741	4199	25.269	1355
25.355	1861	25.555	3417206	24.154	1833	25.355	1133	24.141	1426	25.558	4233071
25.575	3348181	27.039	6564	24.634	1059	25.575	4148590	24.638	1334	27.043	7026

27.062	7117	28.167	2787	25.333	1556	27.062	7100	25.269	1198	28.168	2397
27.546	1838	28.953	42473	25.558	3415015	28.204	3130	25.555	4241154	28.958	43942
28.207	3335	35.323	2314	27.043	7140	28.544	1132	27.038	6727	35.338	4189
28.986	44812	45.296	25590	27.516	1544	28.985	47471	28.168	2639	45.305	30412
35.076	1127			28.173	2932	35.038	1120	28.953	43520		
35.365	2416			28.958	40055	35.362	2972	35.332	2723		
35.865	1126			35.035	1005	35.897	1464	45.309	27934		
45.308	23156			35.336	3334	45.326	31391				
				36.32	1089						
				45.304	20702						
286 nm						310 nm					
RT	PA-0min	RT	PA-30min	RT	PA-90min	RT	PA-0min	RT	PA-30min	RT	PA-90min
1.402	110184	1.396	103415	1.398	99198	1.403	74503	1.396	68054	1.398	63705
1.562	7756	1.553	8154	1.555	8689	1.562	7981	1.553	8323	1.555	8490
1.855	77095	1.846	70971	1.849	69845	1.856	60911	1.847	58359	1.849	56071
2.212	20411	2.204	20567	2.203	21204	2.208	3908	2.208	6563	2.205	7421
2.736	9198	2.709	6961	2.704	7082	2.357	1999	2.357	8703	2.333	6715
5.897	1714	4.11	1232	4.055	1156	6.724	4998	2.715	6185	2.689	8704
6.716	5433	5.892	2087	5.867	2255	7.326	2834	6.654	3644	6.62	5678
7.29	5916	6.685	4205	6.622	5973	11.826	1535	12.51	3433	7.224	3699
7.845	2899	7.294	3728	7.245	5568	12.515	3852	12.939	2251	7.789	1603
12.54	2897	7.84	1627	7.79	3173	12.764	1262	14.102	1292	11.803	1151
12.762	1198	12.521	2086	11.79	1438	12.946	3518	17.15	1189	12.496	3598
13.025	3553	13.005	2546	12.506	2514	13.227	2187	25.555	3276888	12.932	2557
13.221	2206	13.193	1332	12.997	2467	14.113	1292	27.035	1908	14.098	1388
14.115	2073	14.104	2000	14.103	2040	14.38	1378	28.795	1138	17.154	1135
16.829	1043	16.806	1056	16.805	1087	17.174	1095	35.33	3614	25.558	3267662
18.364	9903	18.229	3275	18.353	8517	25.575	3204247	45.296	16662	27.036	1348
21.888	8981	18.351	5432	21.867	10911	27.049	1381			35.044	1308
22.128	11241	21.92	10052	22.098	9956	28.83	1086			35.335	5459

22.761	2569	22.094	10499	22.737	2939	35.055	1216			45.307	12863
24.672	1076	22.717	2550	24.144	2730	35.364	3787				
25.575	4733540	24.162	1179	24.65	3197	45.337	14161				
27.06	7060	24.648	1252	24.794	1767						
28.195	1931	25.248	1302	25.269	3974						
28.984	28465	25.555	4839071	25.558	4835065						
29.702	1179	27.036	6852	27.039	7027						
35.373	3157	28.175	1857	28.17	1737						
35.869	1585	28.951	25752	28.955	28284						
45.351	28805	29.28	2353	29.666	1710						
		29.672	1161	35.046	1033						
		35.326	3379	35.341	4914						
		45.298	36714	45.311	34645						

358 nm

RT	PA-0min	RT	PA-30min	RT	PA-90min
1.403	37881	1.396	34813	1.398	34243
1.562	7570	1.553	7586	1.555	8389
1.855	20296	1.847	22269	1.849	21321
6.717	4036	1.975	4693	1.988	2240
12.512	5562	6.725	2899	6.638	4363
12.763	3525	12.504	5156	12.492	6030
12.934	3226	12.754	3350	12.744	3808
13.195	1916	12.925	3100	12.912	3689
14.388	1172	13.19	2008	13.178	2131
17.169	3448	17.155	3337	17.155	3340
25.575	793990	25.556	810399	25.558	809566
35.056	5055	35.016	4126	35.027	4963

Table S9.5: The chemical transformations of liquorice root extract mixed with BMDDBM dissolved in methanol on irradiation with simulated solar irradiation monitored by HPLC-PDA.

275 nm						280 nm					
RT	PA-0min	RT	PA-30min	RT	PA-90min	RT	PA-0min	RT	PA-30min	RT	PA-90min
1.402	138090	1.402	138410	1.395	131685	1.402	133501	1.402	133358	1.395	126014
1.562	9563	1.561	10240	1.553	9755	1.561	8963	1.561	9601	1.553	9099
1.853	91355	1.853	72024	1.845	68964	1.853	88965	1.853	83991	1.845	84000
2.205	36440	2.027	14754	2.016	14398	2.206	29917	2.209	22710	2.202	27777
2.713	26418	2.209	25969	2.2	23487	2.475	3784	2.721	9435	2.699	26977
3.224	23672	2.725	7154	2.68	8309	2.702	26585	3.218	1200	3.204	13706
3.526	14436	3.229	2335	3.21	2299	3.213	20085	3.557	1322	3.403	3273
3.84	2481	3.534	2269	3.537	2104	3.492	13279	4.088	1052	3.547	2289
4.039	5206	5.862	4023	5.836	3978	4.038	8047	5.862	4701	5.832	4050
5.844	3923	6.621	10312	6.587	10075	5.85	3917	6.62	9637	6.585	8068
6.573	10073	7.196	9267	7.189	9434	6.586	8702	7.21	9201	7.176	8484
7.185	8789	7.779	4449	7.722	4043	7.181	8190	7.761	4090	7.731	3747
7.765	4285	11.804	1447	11.763	1108	7.737	4283	11.803	1815	11.78	1024
11.762	1251	12.548	3677	12.537	3637	11.751	1156	12.533	3142	12.531	3220
12.526	3492	12.743	2731	12.739	5592	12.513	2946	12.742	1726	12.734	3166
12.976	4762	12.998	4771	12.98	5656	12.737	1154	12.996	3709	12.982	4560
13.216	1922	13.184	1216	14.077	3531	12.974	4083	14.101	3010	14.079	3255
14.074	3698	14.1	3614	16.774	6253	13.159	2202	16.792	3378	16.776	3305
16.767	6205	16.791	6463	17.419	2048	14.068	2931	18.349	13861	17.626	1067
17.624	2306	17.643	2321	17.636	1561	16.768	3298	21.867	15592	18.325	17266
18.312	16333	18.34	14434	18.326	18081	18.32	13988	22.067	16353	21.803	16307
21.867	18863	21.835	17921	21.824	20140	21.835	18226	22.472	12169	22.049	16265
22.031	16832	22.074	16403	22.024	15394	22.013	14432	22.741	3295	22.446	12640
22.426	11652	22.471	11780	22.444	11663	22.428	11830	24.15	1513	22.688	3130
22.709	4425	22.731	4402	22.684	4437	22.677	3428	24.627	1651	24.131	4965

24.13	2018	23.755	1420	24.115	1945	23.748	1278	24.79	1324	24.612	6379
25.323	2382	24.134	5859	24.606	1104	24.107	6291	25.184	3610	24.759	3220
25.495	6606	24.624	8681	25.227	3403	24.597	4098	25.523	9371	25.184	8688
26.005	1431	24.785	3761	25.499	5054	24.767	2911	26.021	1421	25.502	7237
26.22	1887	25.205	7457	25.628	3969	25.035	2198	26.256	4220	25.643	6816
26.837	1170	25.333	2706	25.984	2592	25.184	4651	26.848	1020	26.032	3893
27.138	499064	25.523	14780	26.247	7123	25.504	8890	27.157	480336	26.248	8557
27.566	26948	26.005	5105	26.645	1089	26.009	2688	27.589	28329	26.635	2620
28.136	5370	26.255	8385	26.837	1398	26.219	2658	28.177	4018	26.848	2057
28.448	1510	26.667	2615	27.14	504644	26.37	1406	28.426	3403	27.14	471925
28.914	44457	26.848	2316	27.569	28962	26.837	1308	28.934	35944	27.57	30604
29.632	1488	27.157	520028	28.153	5477	27.138	463262	29.643	1384	28.151	5211
34.977	1558150	27.588	32718	28.421	4998	27.567	26136	34.994	1672256	28.418	4903
38.519	3126	28.163	6371	28.914	43593	28.133	3015	36.829	1119	28.913	41484
45.275	21115	28.429	4488	29.611	2195	28.914	41718	36.954	1199	29.632	1641
		28.933	38964	30.371	1320	34.977	1599042	38.529	3644	30.377	1148
		29.653	1354	34.974	1590505	35.812	1180	45.295	34447	34.974	1631321
		34.994	1629840	36.937	1040	38.516	3080			36.94	1048
		36.835	1210	38.506	3827	45.277	24338			38.512	3517
		36.951	1294	45.253	26680					45.257	31373
		38.531	3847								
		38.768	1018								
		45.243	21792								
286 nm						310 nm					
RT	PA-0min	RT	PA-30min	RT	PA-90min	RT	PA-0min	RT	PA-30min	RT	PA-90min
1.402	122188	1.402	120685	1.395	113461	1.402	82238	1.403	79177	1.396	73738
1.561	8547	1.561	9137	1.553	8996	1.561	8248	1.561	8752	1.553	8702
1.853	81715	1.853	81453	1.845	76936	1.854	71013	1.854	66351	1.846	61640
2.205	22340	2.209	20973	2.202	21395	2.208	6552	2.219	6313	2.197	9752
2.715	6186	2.507	2026	2.703	8954	2.339	9552	2.336	8921	2.315	9253



4.057	1539	2.716	6594	5.859	1958	2.706	12762	2.724	5729	2.688	12227
5.852	2125	4.089	1381	6.584	7139	6.598	6084	6.617	5726	3.019	1328
6.562	6640	5.851	2093	7.224	6662	7.196	3234	7.216	3073	6.578	5671
7.194	6132	6.639	7613	7.731	3303	12.474	4192	12.499	4475	7.184	2792
7.737	3334	7.216	7027	12.505	3074	12.716	1557	12.747	1608	12.486	4497
12.477	3248	7.769	3415	12.733	1637	12.895	3958	12.931	3995	12.731	1589
12.721	1407	11.823	1490	12.97	4171	13.183	2153	13.187	1650	12.912	4320
12.979	3858	12.517	2925	14.086	2203	13.333	1226	13.361	1236	13.169	1632
13.187	2642	12.742	1072	16.779	1467	14.07	1461	14.09	1564	13.347	1415
14.067	2242	12.989	3289	18.011	4162	14.344	1502	14.37	1185	14.082	1376
16.773	1424	14.091	2235	18.197	2571	17.116	1295	17.144	1403	14.354	1089
18.311	10365	16.804	1619	18.322	4881	22.434	1284	22.478	1430	17.129	1356
21.835	9605	18.327	9085	21.781	10837	25.555	1129	25.554	4269	18.003	2963
22.042	9054	21.877	11511	22.049	7690	26.368	1130	27.157	41842	22.438	1572
22.426	11861	22.056	7232	22.44	13976	27.138	40423	27.592	20400	25.557	2906
22.709	2101	22.471	11983	24.122	1257	27.571	19537	28.777	1039	26.243	1197
24.117	2746	22.731	2014	24.614	1158	34.977	2016290	34.994	2107348	27.14	40681
24.633	2885	24.136	1255	24.761	1235	38.518	5054	38.53	5421	27.573	20217
24.764	2047	24.634	1399	25.201	3333	45.336	14390	45.266	18032	34.974	2056519
25.195	4478	24.767	1290	25.513	3991					38.513	5476
25.511	6710	25.212	2318	25.632	3466					44.527	2208
26.004	1694	25.535	9265	26.013	1723					45.286	14160
26.224	1274	26.021	1963	26.244	5364						
27.138	395911	26.254	3297	27.14	400165						
27.568	27209	27.157	409390	27.57	28229						
28.142	3898	27.59	28935	28.146	3211						
28.427	1162	28.167	3155	28.403	3815						
28.913	25384	28.44	2824	28.913	24638						
29.184	2961	28.932	21400	29.28	1463						
29.602	1581	29.237	2262	29.596	1552						

34.977	1637345	29.645	1266	34.974	1668522						
35.805	2417	34.994	1710141	36.93	1013						
36.107	1064	36.833	1034	38.517	3328						
36.288	1923	36.949	1105	45.298	33916						
38.516	2934	38.53	3554								
45.316	31101	45.293	38072								
358 nm											
RT	PA-0min	RT	PA-30min	RT	PA-90min						
1.402	42088	1.403	38772	1.396	38846						
1.562	7917	1.561	7986	1.554	7997						
1.853	23869	1.853	20587	1.845	22894						
1.968	2638	6.636	4702	1.961	2832						
6.587	4700	11.843	1077	6.595	5158						
11.868	1009	12.496	6769	12.482	6164						
12.469	6047	12.745	4406	12.734	3926						
12.723	3790	12.915	3964	12.902	3802						
12.89	3594	13.179	2354	13.169	2227						
13.157	2224	17.146	3942	14.357	1116						
14.345	1340	27.159	2192	17.128	3838						
17.123	3674	27.593	99325	27.146	2304						
27.148	2229	34.994	8593920	27.574	98791						
27.572	94559	38.529	14544	34.974	8401211						
34.977	8220439			38.512	14932						
38.518	13417										
44.496	2717										

Table S9.6: The chemical transformation of liquorice root extract with a mixture of BMDBM, BP3 and EHMC dissolved in methanol on simulated solar irradiation, monitored by HPLC-PDA.

275 nm						280 nm					
RT	PA-0min	RT	PA-30min	RT	PA-90min	RT	PA-0min	RT	PA-30min	RT	PA-90min
1.41	133174	1.402	132743	1.398	131131	1.41	129019	1.402	127941	1.398	125938
1.571	9152	1.561	9936	1.556	9099	1.57	8547	1.561	9340	1.556	8567
1.864	90514	1.853	83649	1.85	86510	1.864	79026	1.853	79070	1.85	85121
2.223	27602	2.128	45008	2.199	38439	2.224	10817	2.201	36363	2.203	35514
2.75	31214	2.71	25085	2.734	26796	2.755	1233	2.716	23264	2.705	22856
3.261	14820	2.993	13859	3.221	21549	3.257	1525	2.992	10043	3.215	20545
3.558	6296	3.229	12563	3.525	12840	3.486	1584	3.205	7930	3.508	12851
4.099	1034	3.539	13223	4.035	8653	5.91	3694	3.536	5376	4.031	8198
5.918	4004	3.851	3579	5.839	3868	6.775	8547	5.845	4214	5.867	3471
6.738	10327	4.042	3187	6.582	10587	7.288	8603	6.584	8580	6.618	7816
7.342	9043	5.833	3528	7.195	9167	7.871	3851	7.207	7880	7.199	8055
7.877	3972	6.562	8694	7.739	4331	11.825	1178	7.759	3365	7.741	3844
11.855	1139	7.173	8360	12.573	3509	12.579	3020	12.528	2756	12.545	3318
12.583	2799	7.76	4015	12.769	4341	12.783	1104	12.735	1302	12.772	2987
13.037	4442	11.787	2415	13.026	5435	13.034	4018	12.979	3349	13.015	5118
13.28	1747	12.529	4274	13.227	1252	13.269	1829	14.078	2781	13.232	1399
14.135	3276	12.73	2331	14.13	3137	14.137	3061	14.378	1845	14.131	3235
16.823	5840	12.98	5128	14.471	2969	16.825	3078	16.782	3087	14.468	3040
17.483	1161	13.173	1035	16.836	5830	17.68	1192	17.434	1067	16.838	3093
17.676	1454	14.078	3539	17.493	1466	18.392	15670	17.62	1148	17.5	1443
18.389	16071	14.384	1689	17.699	2027	21.931	16599	18.337	15271	17.701	1130
22.142	35751	16.781	5819	18.414	17199	22.133	17525	21.803	17278	18.406	16809
22.539	12531	17.408	1404	21.963	17545	22.54	13648	22.035	15671	21.92	16452
22.805	4205	17.619	1554	22.157	17550	22.805	3286	22.44	12985	22.141	16402
24.177	2069	18.339	16469	22.541	11959	24.205	1668	22.699	2909	22.54	12708

25.376	1917	21.824	18286	22.795	3603	24.815	1029	23.744	1032	22.773	3454
25.585	3868155	22.038	17528	24.154	1972	25.585	4798003	24.124	5179	23.691	1545
27.201	529829	22.444	11456	24.994	1988	27.201	493177	24.618	6084	24.156	4826
27.484	15370	22.72	4263	25.288	3383	27.485	16819	24.766	3784	24.651	6173
27.633	25748	24.114	2294	25.557	3985436	27.634	25291	24.967	2764	24.794	3089
28.2	2420	25.275	2939	26.255	3396	28.216	2196	25.152	2684	24.995	4411
28.997	41815	25.537	3875195	27.151	534477	28.996	41469	25.272	4551	25.284	6957
33.69	1523	26.236	1299	27.582	30889	33.666	1541	25.537	4839913	25.557	4966928
33.926	1919	27.149	522326	27.797	9553	33.947	1808	26.237	1156	26.253	2797
35.052	1677431	27.578	27040	28.146	5561	35.052	1722737	27.149	483037	27.151	492744
35.369	6786418	27.804	8916	28.416	7474	35.369	8404158	27.579	25719	27.582	28144
36.405	3927	28.146	4983	28.928	48654	36.406	3738	27.809	8324	27.799	8253
36.64	1085	28.425	4996	29.644	7941	36.64	1257	28.151	3536	28.142	3008
36.892	15850	28.927	46026	30.598	3581	36.893	18523	28.427	3855	28.423	4496
38.587	3484	29.632	3799	30.848	1348	38.59	3293	28.925	44247	28.927	41650
45.313	27993	33.6	1599	33.632	1488	45.34	30790	29.631	4345	29.638	5155
		33.86	1748	33.844	1050			33.589	1380	33.557	1461
		34.99	1631523	34.995	1644479			33.86	1712	33.851	1064
		35.296	6035815	35.219	2733896			34.99	1676243	34.995	1688954
		36.101	1046	35.287	3321049			35.298	7117289	35.293	7062640
		36.356	3803	36.08	1768			36.354	3688	36.1	1439
		36.596	6159	36.357	3890			36.597	6694	36.357	3602
		36.842	10240	36.596	6922			36.843	11316	36.596	7464
		37.309	6803	36.839	8970			37.309	6056	36.839	14840
		37.531	7452	36.949	5423			37.531	6105	37.309	11168
		37.747	6699	37.31	11870			37.748	5827	37.529	10517
		37.889	8195	37.53	12658			37.886	7494	37.745	11729
		38.531	3727	37.745	13356			38.531	3522	37.883	15045
		45.274	23866	37.882	16386			45.316	29383	38.532	3721
				38.532	4284					45.32	32358

				45.317	24454						
286 nm						310 nm					
RT	PA-0min	RT	PA-30min	RT	PA-90min	RT	PA-0min	RT	PA-30min	RT	PA-90min
1.41	117480	1.402	116590	1.398	113733	1.411	78585	1.403	76980	1.398	73711
1.57	8398	1.56	8880	1.556	8125	1.57	7916	1.56	8587	1.556	8324
1.864	80741	1.853	75284	1.85	80343	1.864	69593	1.853	59779	1.85	65105
2.223	19896	2.203	38338	2.204	30683	2.229	6953	2.193	4392	2.203	7993
2.755	8839	2.715	17142	2.692	21387	2.347	6452	2.347	2473	2.325	7190
5.915	2241	3	9325	3.216	10538	2.528	4240	6.57	5436	2.701	9409
6.772	6934	3.215	5558	3.429	2722	2.738	5680	7.171	2662	6.627	4697
7.354	6319	3.411	4879	3.605	2278	3.992	1137	11.792	1162	7.741	1033
7.875	3131	5.857	1916	5.847	2510	6.748	4440	12.479	3563	12.517	4161
11.866	1085	6.588	5597	6.601	6186	11.848	1408	12.91	2519	12.772	1524
12.557	3045	7.202	5707	7.218	6036	12.531	4032	14.079	1443	12.947	4075
12.783	1239	7.73	2676	7.736	2892	12.777	1496	14.351	1310	13.219	1618
13.035	3635	11.791	1390	11.791	1370	12.957	3897	17.133	1254	13.397	1146
13.263	2388	12.492	2676	12.537	3087	13.243	2388	17.415	1579	14.128	1542
14.133	2109	12.722	1058	12.773	1794	13.397	1002	22.464	1538	14.422	1439
14.396	1136	12.976	3024	13.012	4691	14.128	1319	25.272	1328	17.194	1224
16.828	1539	14.082	2168	13.218	1252	14.394	1472	25.537	3702028	17.471	1653
17.477	1131	14.383	1784	14.138	2245	17.178	1257	27.149	41317	18.079	1924
18.376	9688	16.784	1265	14.453	3056	17.471	2068	27.583	22721	22.551	1474
21.952	11741	18.338	9549	16.842	1368	22.543	1494	27.814	4369	24.997	1765
22.155	7422	21.792	9460	17.472	1246	25.585	3721421	28.45	1168	25.294	3101
22.541	12340	22.053	9136	18.414	11352	27.201	43081	28.769	1054	25.557	3808448
22.752	2775	22.446	12060	21.963	9993	27.49	9681	33.86	1123	27.15	41574
24.178	1983	22.709	1934	22.161	8757	27.638	21213	34.99	2103404	27.585	22446
24.661	1483	24.134	2446	22.543	14157	28.838	1459	35.302	8968159	27.816	4547
24.816	1005	24.632	2866	24.185	2437	33.938	2288	36.596	6977	28.431	1475
25.269	1016	24.77	1924	24.649	2819	35.052	2167809	36.848	10517	28.772	1002

25.585	5472912	24.977	2149	24.795	2013	35.369	12085707	38.531	5557	33.867	1462
27.201	421370	25.12	2006	24.997	3272	36.356	1163	44.538	2211	34.995	2120166
27.487	17701	25.271	2917	25.293	5535	36.651	1035	45.348	14185	35.302	8669005
27.635	26531	25.537	5482690	25.557	5635900	36.896	23569			36.596	7739
28.211	1783	27.149	406645	26.253	2448	38.586	5356			36.848	10341
28.995	27496	27.421	5824	27.151	421696	45.332	14320			37.887	1371
33.653	1636	27.58	26899	27.583	28257					38.533	5977
33.939	2248	27.81	8186	27.807	9086					45.312	13772
35.052	1764193	28.126	2185	28.138	2294						
35.369	10077322	28.43	3001	28.421	4084						
36.189	1051	28.924	25094	28.926	26708						
36.397	2609	29.259	1997	29.641	4059						
36.894	21629	29.636	2582	30.574	1380						
38.588	3256	33.589	1387	33.536	1262						
45.329	32129	34.99	1715995	34.995	1729985						
		35.3	8221614	35.297	8090041						
		36.348	2202	36.112	1180						
		36.595	7446	36.348	2233						
		36.845	12062	36.596	8002						
		37.309	5308	36.841	15166						
		37.53	4342	37.309	9887						
		37.748	4390	37.53	7428						
		37.888	6391	37.745	8884						
		38.533	3380	37.884	12891						
		45.32	30879	38.533	3581						
				45.327	35448						
358 nm											
RT	PA-0min	RT	PA-30min	RT	PA-90min						
1.411	40421	1.403	37652	1.398	36925						
1.571	7723	1.561	7647	1.556	8325						

1.864	23012	1.853	22650	1.85	23211
1.985	3273	1.969	2802	1.986	4106
6.77	5418	6.609	4534	6.638	5580
12.528	6201	12.477	5396	12.514	6398
12.777	4041	12.729	3632	12.773	4193
12.949	3679	12.898	3442	12.941	3807
13.218	2113	13.161	2162	13.216	2160
14.394	1225	14.359	1047	14.416	1069
17.181	3637	17.133	3656	17.193	3478
25.585	921858	25.276	1959	24.997	1019
26.419	1405	25.537	913296	25.295	2930
27.199	2453	27.15	2284	25.557	935616
27.64	102648	27.584	102185	27.154	2451
35.052	8927220	34.99	8839924	27.587	104278
38.586	14392	38.531	14900	30.818	1322
				34.995	8989042
				38.532	15854

## **Authentication of Herbal Products Traded in Nairobi County Using DNA Technology**

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At least 65 % of the population in developing countries uses medicinal plants as remedies. In Kenya it is reported that approximately 80% of the population have used herbal remedies at least once in their lifetime. Previous studies in Brazil estimated the frequency of mislabelling herbal products at 14 % to 33 % though based on limited data available then. In Kenya illegitimate remedies sold by herbalists as herbal contraceptive resulted in women having children display adolescence signs such as a menstrual cycle at the early stage of 3 years. There is therefore a gap in understanding the level of herbal products contamination, substitution and use of fillers in Kenya and the world at large. The aim of the study was to use DNA barcoding as the first screening step to authenticate selected herbal products on sale in selected markets. A questionnaire was administered to establish the commonly traded medicinal plants in selected Nairobi County markets. At least five individual plants of each selected species were collected from the wild and barcoded with a minimum of two markers to create the reference library. Blind sampling of available herbal products in Nairobi county markets were used to authenticate identification against a DNA barcode reference library of medicinal plants species collected in wild. The study established a baseline database of barcodes that can be used for herbal products identification. DNA barcoding technology is able to define species from ground herbal products. Over 30% of analysed products indicate adulteration and some had fungal contamination. Correct identification is mandatory to ensure correct labelling to avoid health risks that could arise from presence of other non-listed species. Therefore, there is need for more objective and scientific ways like DNA barcoding to authenticate individual herbs, as a way of monitoring quality of herbal medicines in Kenya.

**Key words:** DNA barcoding technology, herbal product, authenticate, Reference library, identification



## **Soliton Distribution in the Ball and Box Cellular Automation Model**

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### **Abstract**

Solitons are very important waves in Mathematical Physics. They help model many physical situations for instance tsunami waves, application in optical communication systems and in laser technology among others. Despite enormous application solving the non-linear equations which have soliton solutions is challenging. A remedy to this is to use cellular automation models to model soliton dynamics. In this work, an investigation of the distribution of the number of the solitons from the Ball and Box cellular automation model was examined. The distribution of the number of solitons from the two and three colour Ball and Box cellular automation is established. Using the online integer sequence, for the two colour, it was found that the distribution of the number of the solitons are indexed by the binomial coefficients. On the Other hand, for the three colour, it was found that only solitons of lengths one to four possesses the distribution while the other soliton lengths do not possess any distribution function.

Keywords: Solitons, Ball and Box Model, Cellular Automation, Integer Sequence, Binomial Coefficients



We observe that consecutive balls of length four, three and one proceed to the right with constant speed unless they are too close to each other. The ball of length four is faster than the remaining two balls. Also the ball of length two is faster than the ball of length one. We also observe that after some time,  $0 < t < 4$ , the balls collide. After the collision, there is phase shift; that is the balls have changed the orientation from four, three, one to one, three and four respectively. We note that the trajectory of the larger series have been shifted by four places to the right and the smaller one have been shifted by four places to the left.



Starting at any initial state, after a finite amount of time the system separates into basic solitons with non-decreasing length. Finally, if a soliton of length  $x$  passes through another soliton of length  $y$

where  $x > y$ , the phase shift of the longer soliton is  $+2y$  and that of the shorter soliton is  $-2y$ .

The BBS has been extensively investigated in the context of solitons and there is large literature on the subject. For instance Iwao (2009) studied the box-ball system with finitely many kinds of balls. The box-ball system was obtained from the hungry discrete Toda equation by ultra-discretization. They investigated the applications of the algebraic geometry and the tropical geometry to the ultradiscrete integrable system.

Also of significance notice on BBS is Mada et al. (2005) who investigated conserved quantities of periodic box-ball systems with arbitrary kinds of balls and box capacity greater than or equal to one. Finally, among the others, Fukuda et al. (2000) studied the BBS in the crystal theory formulation. New conserved quantities and the phase shift of the solitons scattering were obtained by considering the energy function in the combinatorial R matrix.

Despite all this enormous investigations carried out, none of the researchers investigated the distribution of number of solitons from the multi-colour ball and box model. In this paper, we study the distribution of the number of solitons in the multi-color BBS model.

## 2. Two Colour Ball and Box

In this section the extended two color BBS model is investigated. We suppose that the box can hold at most one ball and there are two kinds of balls which are indexed by integers one and two. Then the time evolution rule corresponds to taking the leftmost ball of index one out of its box and putting it in the first empty box to its right, then taking the new leftmost ball of index one as long as it has not already been moved at this time step and moving it to the first empty box to its right. We continue with this process until each ball of index one has been moved, then we repeat this process to balls of index two. This represents one time step.

For example consider the evolution of states below for four time steps.

$t = 0$  0 1 1 1 0 0 0 0 2 2 0  
 $t = 1$  0 0 0 0 1 1 1 0 0 0 2 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0  
 $t = 2$  0 0 0 0 0 0 0 0 1 1 1 0 0 2 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0  
 $t = 3$  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 1 2 2

0 0 0 0 0 0 t = 4 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 1 2 2 0 0 0 t = 5 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0  
 1 1 0 0 0 0 1 2 2

In the example above, we had started with two configurations of lengths 3 and 2. After time evolution,  $0 < t < 5$ , there is phase shift of the lengths into the lengths 2 and 3 respectively. We also observe a mix up of the type of the balls. The mix up 122 moves with speed 3 so it is considered as one ball of length three. Using Theorem 1.1 it is easy to see that the two color BBS describes soliton dynamics.

We now provide another example of the two color state. We start with the arbitrary state 0 1 2 2 0 0 0 2 1 1.

t = 0 0 1 2 2 0 0 0 2 1 1 0 t = 1 0 0 0 0 1 2 2 0 0 2 0 1 1 0  
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 t = 2 0 0 0 0 0 0 0 1 2 0 2 2 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 t =  
 3 0 0 0 0 0 0 0 0 0 1 0 0 2 2 2 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 t = 4 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 2  
 2 1 1 2 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 2 2 0 1 1 2 0 0 0 0 0 0 t = 6 0  
 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 2 2 0 0 1 1 2 0 0 0 t = 7 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0  
 0 0 0 2 2 0 0 0 1 1 2

---

From this example, it was observed that two unstable balls of lengths three unattained stability in the interval  $0 < t < 7$ . Using two unstable balls we had formed three stable balls of lengths 1, 2 and 3 respectively. Using Theorem 1.1, we conclude that the three stable balls formed are solitons.

From the results of examples above, it is easy to see that different initial conditions of the soliton configurations produces different number of solitons. This calls for investigation of the distribution of the number of the solitons given a particular soliton configuration. we examine the distribution of number of solitons when we involve all possible initial soliton configuration in the two color BBS.

### 2.1. Simulation of Two Color Ball and Box

On the 2 color BBS we simulated all the possible soliton configuration from the two color BBS model on the given n empty boxes. We started with two empty boxes then produce all possible ways of coloring the boxes with two colors. Each of these possible ways represent one initial configuration. Using the produced initial configurations, we carry out time update on each of the configurations until stable length of balls are obtained. We then count the number of stable balls. We repeat the process for boxes more than two.

Here, a sequence of length n shall represent coloring n boxes with n colors where the colors are the elements of the sequence, for instance the sequence 1212 shall mean color box one with color one, box two with color two, box three with color one and box four with color two.

As an example for the two boxes with two colors, we have four ways of producing initial soliton configuration, 11, 22, 21, 12. In the configuration each state represent a unique soliton arrangement which we can start with.

## 2.2. Results and Discussion

Trivially for the one box we have two ways to color it with two colors either 1 or

2. Both of these lead to 1 soliton. This means that the total number of 1 solitons is 2. Continuing the process to the other number of boxes we end up with Table 1 below

Table 1: Number of Solitons Generated from the Two color Ball and Box Model

n/k	2	3	4	5	6	7	8	9	10
1	0	0	0	0	0	0	0	0	0
2	1	0	0	0	0	0	0	0	0
3	4	0	0	0	0	0	0	0	0
4	10	1	0	0	0	0	0	0	0
5	20	6	0	0	0	0	0	0	0
6	35	21	1	0	0	0	0	0	0
7	56	56	8	0	0	0	0	0	0
8	84	126	36	1	0	0	0	0	0
9	120	252	120	10	0	0	0	0	0
10	165	462	330	55	1	0	0	0	0
11	220	792	792	220	12	0	0	0	0
12	286	1287	1716	715	78	1	0	0	0
13	364	2002	3432	2002	364	14	0	0	0
14	455	3003	6435	5005	1365	105	1	0	0
15	560	4368	11440	11440	4368	560	16	0	0
16	680	6188	19448	24310	12376	2380	136	1	0
17	816	8568	31824	48620	31824	8568	816	18	0
18	969	1162	50388	92378	75582	27132	3876	171	1
19	114	1550	77520	167960	167960	77520	15504	1140	20
20	133	2034	11628	293930	352716	203490	54264	5985	210
21	154	2633	17054	497420	705432	497420	170544	26334	1540
22	177	3364	24515	817190	135207	1144066	490314	100947	8855
23	202	4250	34610	130750	249614	2496144	1307504	346104	42504
24	230	5313	48070	204297	445740	5200300	3268760	1081575	177100
25	260	6578	65780	312455	772616	10400600	7726160	3124550	657800
26	292	8073	88803	468682	130378	20058300	1738386	8436285	2220075
27	327	9828	11840	690690	214741	37442160	3744216	21474180	6906900
28	365	1187	15607	100150	345972	67863915	7755876	51895935	20030010
29	406	1425	20358	143071	546273	11975985	1551175	11975985	54627300
30	449	1699	26295	201600	846723	20625307	3005401	26518252	14112052
31	496	2013	33658	280488	129024	34737360	5657227	56572272	34737360
32	545	2373	42720	385671	193536	57316644	1037158	11668031	81880920
33	598	2782	53796	524512	286097	92798376	1855967	23336062	18559675
34	654	3246	67245	706074	417225	14763378	3247943	45375676	40599289
35	714	3769	83476	941432	600805	23107896	5567902	85974965	85974965
36	7770		435897		10295472	3562467300		15905368	17672631
37	8436		501942		1262025654	14950296		28781143	35345263
38	9139		575757		1538093781	22425444		51021117	68923264
39	9880		658008		186435601	2033222880		88732378	13128240
40	41	10660	749398	22481940	350343565	3159461968	17620076360	63432274896	151584480450
									244662670200



From Table 1, by using the on-line integer sequence (<https://oeis.org>) we have the following result

Conjecture 2.1. Let  $n$  be the number of boxes and  $k$  be the number of soliton produced in the two color BBS. The two are related by the binomial coefficients;

$$a(n, k) = \begin{cases} \frac{n+1!}{k!} & \text{if } n+1 \geq 2k \\ 0 & \text{else} \end{cases} \quad (1)$$

provided that  $n, k \in \mathbb{Z}^+$

### 3. Three Colour Ball and Box System

We now extend the model introduced in previous section by introducing more species of the ball. We suppose that the box can hold at most one ball and there are three kinds of balls which are indexed by integers one to three.

The time evolution rule corresponds to taking the leftmost ball of index one out of its box and putting it in the first empty box to its right, then taking the new leftmost ball of index one as long as it has not already been moved at this time step and moving it to the first empty box to its right. We continue with this process until each ball of index one has been moved, then we repeat this process to balls of index two and index three. This represents one time step.

### 3.1. Simulation of Three Colour Ball and Box Model

As in previous section, we start with two empty boxes then produce all possible ways of coloring the two boxes with three colours. This represent initial soliton configuration. We then evolve all initial soliton configurations to count how many solitons of each kind results. We repeat this process for boxes more than two.

Let 1 denote colour number one, 2, colour number two and 3 represents colour number three. Then 12 denotes box 1 coloured with colour one and box two coloured with colour two. For the two boxes we have 9 ways of producing initial soliton configuration.

As before  $n$ ,  $k$  represents the number of boxes and number of solitons repectively. Table 2 gives the results for the numbers of solitons produced with different number of boxes coloured with three colours.

Table 2: Length and Number of Solitons for 3 colour ball and box

n/k	1	2	3	4	5	6	7	8	9
1	3	0	0	0	0	0	0	0	0
2	6	3	0	0	0	0	0	0	0
3	10	16	1	0	0	0	0	0	0
4	15	51	15	0	0	0	0	0	0
5	21	126	90	6	0	0	0	0	0
6	28	266	357	77	1	0	0	0	0
7	36	504	1107	504	36	0	0	0	0
8	45	882	2907	2304	414	9	0	0	0
9	55	1452	6765	8350	2850	210	1	0	0
10	66	2277	14355	25653	14355	2277	66	0	0
11	78	3432	28314	69576	58278	16236	1221	12	0
12	91	5005	52624	171106	201643	87802	12727	442	1
13	105	7098	93093	388752	616227	388752	93093	7098	105

### 3.2. Results and Discussion

Using the on-line integer sequence and data for the three colour BBS, the Conjecture 3.1 below gives the distribution of the number of solitons.

Conjecture 3.1. Let  $n$  be the number of boxes and  $k$  be the number of solitons produced in the three color BBS. The two are related by the binomial coefficients

$$\begin{aligned}
 & \binom{n}{k} = \frac{n!}{k!(n-k)!} \\
 & \binom{n}{k} = \frac{n!}{k!(n-k)!} \quad \text{if } k = 1 \\
 & \binom{n}{k} = \frac{n!}{k!(n-k)!} \quad \text{if } k = 2 \\
 a(n, k) &= \binom{n+3}{k} - 2 \binom{n+2}{k} + \binom{n+1}{k} \\
 & \binom{n+1}{k} \quad \binom{n+1}{k} \quad \binom{n+1}{k}
 \end{aligned} \tag{2}$$

+ 10 + 15 + 7 4+ 5 if  $k \neq 3$  7 8

□

□□No pattern else

No pattern in Conjecture 3.1 implies that there is no specific sequence which can fit the data.

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## DNA Barcoding of Fischer's and Yellow-Collared Lovebirds Traded as Pets

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Fischer's Lovebird (*Agapornis fischeri*) and Yellow-collared Lovebird (*Agapornis personatus*) are birds native to Northern and Central parts of Tanzania. They are colourful birds and have long been traded as pets through legal and illegal trapping. They are also found in Kenya mostly as hybrids after their introduction into the wild as aviary escapees. The population of *A. fischeri* has been reduced significantly due to their trade leading to a suspension of the legal trapping process. In addition, these two species are also known to hybridize, a phenomenon that is likely to lead to a decreased genetic diversity as well as genetic swamping of *A. fischeri*. The two species are listed under CITES in appendix II to closely monitor their trade which should not be a threat to their survival. The aim of this study was to generate a DNA reference library targeting a specific gene Cytochrome C oxidase subunit I that can assist in identification of illegally traded products of the said species. The study was carried out in Naivasha County and at least 5 individuals from every species were captured. Biometric measurements were recorded and every individual photographed for use as an electronic voucher. Blood was collected for DNA analysis. Following amplification and purification, amplicons were sequenced. The sequences were edited using the Geneious Research Software. Edited sequences were screened using BLAST for validation and submitted to the freely accessible online database GenBank. DNA barcoding is a molecular technique that has revolutionized the identification of species encountered in illegal wildlife trade; fast tracking the prosecution of wildlife criminals. The technique was able to differentiate the species as well as showed its ability to identify haplotypes and hence can be used to give insights on the variation of individuals in a population.

Key words: DNA barcoding; species identification; illegal wildlife trade; electronic voucher.

## **Routh's Hurwitz technique for linear control system and their application in analyzing stability motor-gear-alternator (MGA) system**

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### **Abstract**

Motor-Gear-Alternator (MGA) system is a device which may be used to amplify the usability of the solar energy for commercial and domestic purposes. One way of studying the stability of MGA is by using Routh's Hurwitz technique. This criterion can help in the development and implementation of MGA system. This paper presents step by step procedure for determining the nature of eigenvalues of the characteristic equation of the MGA transfer function. When the roots of the characteristic equation were computed, it showed that both roots are negative. Given that the signs of the entries on the first column of Routh's table did not change the sign, and fact that the real parts of the poles are both positive and nonzero the linear MGA system is stable.

Keywords: Routh's Hurwitz, Motor, Alternator and Stability.

## **Analysis of Delayed Pulse Vaccination Model of Infectious Diseases**

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### **Abstract**

This study concerns the theoretical determination of a mathematical model of delayed pulse vaccination of infectious diseases that affects children. In this study, a delayed SEIR epidemic model with impulsive effect and the global dynamic behaviors of the model will be analyzed. Using the discrete dynamical systems determined, it's shown that there exists an 'infection-free' periodic solution which is globally attractive when the period of impulsive effect is less than some critical value. The sufficient condition for the permanence of the epidemic model with pulse vaccination is given, which means the epidemic disease is to spread around. The study has concluded that time delay and pulse vaccination brings great effects of shortening 'infection period' on the dynamics of the model. The main feature of the study was to introduce time delay together with pulse into epidemic model, and investigate their effects on the dynamics of model. The results indicate that a large vaccination rate or a short period of pulsing leads to the eradication of the disease. Numerical simulation has been used together with the analytical results. The results shall be presented in tabular and graphical form.

## **Extraction of oil from tannery fleshing waste for potential tannage of ovine stomach**

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### **ABSTRACT**

The process of leather manufacturing produces vast amount of solid waste annually (8.5 million tons worldwide), and most of the solid waste (80%) is produced in pre-tanning operations. The fleshing operation to remove flesh, subcutaneous tissue and natural fat from the flesh side of hide/skin (fleshings) accounts for 50-60% of total solid waste generated. Attempts to extract oil from the fleshings have been made. However, the application of the oils from fleshings in tanning has not been explored. Oil tanning process takes about 12 days compared to chrome tanning which takes approximately 6 hours, and this explains why the technology is not commonly used. In this study oil was extracted from goat fleshings and characterized using Soxhlet method and chemical methods respectively. The percentage fat content, iodine value, acid value, saponification value of green fleshings was 26.16%, 73.00, 7.37 mg and 192.40 ml. N/meq respectively while that of limed fleshings was 16.81%, 65.87, 6.08 mg and 184.60 ml. N/meq respectively. The oil was used in oil tanning of the ovine stomach and produced quality exotic chamois leather with a grain, which has a different variety from the ordinary velvety chamois. This study also investigated the feasibility of turning the ovine stomach into novelty leather and then leather product which would add value to the chain of livestock. The stomach was taken through pre-tanning, tanning, post-tanning and finishing operation. Then mechanical operations like drying, toggling and staking were done. The physical test such as tensile strength, elongation at break, tearing strength and colour rub fastness were 16.5 N/mm<sup>2</sup>, 127.4%, 41.4 N/mm and 3 respectively. The physical and organoleptic properties of the leathers resulted by this study met the quality requirements for the chamois leather although the properties were poor compared to grain leather. The leather was used for making novelty leather product such as *coin purse, key case, purses and wallets*.

**Key words:** Chamois, Extraction, Fleshing, Novelty leather, Ovine stomach



## 1. INTRODUCTION

Tanning industry consumes biodegradable hide/skin and produces something noble and special. During leather processing, a series of chemical and mechanical treatments are employed to obtain desired effect or action. The pre-tanning operations are preparative stages of leather manufacturing before tanning which aim is to clean the structure of hide/skin and removal of non-structural proteins (Beghetto, Zancanaro, Scrivanti, Matteoli and Pozza, 2013). The leather manufacturing produces huge amount of solid waste (yearly 8.5 million tons worldwide), and most of the solid waste (80%) is produced in pre-tanning operations (Çolak *et al.*, 2005). Fleshing is a pre-tanning operation which removes flesh, subcutaneous tissue and natural fat from the flesh side of hide/skin where a substantial amount of solid waste (fleshings) is produced which is estimated (50-60)% of total solid wastes (Kanagaraj, Velappan, Babu and Sadulla, 2006). Fleshings consist of proteins, natural fats, and other constituents which pose high potentiality for utilization. Unfortunately, this waste does not find important usage and are currently being disposed into dumping sites or in open areas, consequently causing negative effect on the environment.

These fleshing waste has high amount of (4–18) % fat (Lupo, 2004) which could be a great source for manufacture of oil tanning agent. One way to recover these solid waste is using them as feedstock in tanning agent production. Fleshing is commonly used for the production of adhesives, gelatin, fatliquors and biodiesels (Gaidau, Niculescu, Stepan, Taloi and Filipescu, 2009) but attempts to use it as a tanning agent have not been made. The oil was used in oil tanning to produce chamois leather. Oil tanning is a traditional method that was used during the ancient times, the method involved the impregnation of the skin with oil in filling stock and then allow oxidation of oil to occur, with the products of the reaction having a tanning action. The oxidation process was done by hanging the tanned material in a warm stove for about 10-12 days. However, in the present study the leather was pretanned using glutaraldehyde and then tanned using fleshing oil, this method of tanning reduced the long oxidation period (Khan, 1997).

The oil-tanning process is based on the oxidation of oil. These unsaturated free fatty acids combine with oxygen to form oxidized form of fatty acids, aldehydes and peroxides which effect the tanning action on the pelt. The actual nature of the tannage is not known except for the following observations; the unsaturation of the oil decreases as the process progress, peroxy derivatives are formed, hydroxyl function appears and acrolein is produced (Sharpouse, 1985). The tannage is because of an aldehydic reaction since the procedure is joined by the release of acrolein,  $\text{CH}_2=\text{CHCHO}$  and polymerization of the oil, the availability of latter could represent the diverse between the qualities of oil-and aldehyde-tanned leather. The acrolein delivered amid oil tannage reaction can be utilized as an item like aldehyde-tanned calfskin however it is not utilized because of the harmfulness by the implication as a part of wood smoke (Laughlin, 2011).

The leather is best known for properties of holding water, cleaning and drying washed surface. This approach of oil tannage impacted softness, stretchability, washability and increased the thickness of the membrane. The thickness increased to a reasonable degree due to shrinkage effect of oil tannage. Production cost was minimized since fleshing, scudding, splitting and shaving operation were not involved in the

manufacture of leather. By tanning the ovine stomach into exotic chamois leather, the overall value of the animal product was increased. These exotic chamois leather meets the global demand for exotic leather which is highly valued. The leather processed from this non-conventional source is suitable for manufacturing of fancy small leather goods.

## 2. MATERIAL AND METHODS

### 2.1 Study site and samples preparations

Enough amounts of goat fleshings was collected from Sagana tannery. The limed fleshing was washed with water, delimed with ammonium sulphate. The delimed fleshings were cut into small pieces and dried in an oven.

### 2.2 Extraction of fat

Soxhlet method was employed for the extraction of fat from the fleshing. Measured quantity of the dried fleshing sample was placed in a thimble inside soxhlet glass chamber of the extractor. The extraction was carried out using the electrical manual. The sample was dipped in the solvent. Exactly 10 grams of dried powder was taken and petroleum ether was used as the solvent. The entire extraction process was carried out for approximately 8 hours (Kaviani, Darjani, Tomovska, Mazandarani and Shariati, 2015).

### 2.3 Oil analysis

The total fat content of goat fleshing was determined using A.O.A.C, 2005 method. Iodine value was analysed using Wijs method. Acid value was measured using AOAC method. Free fatty acid content was determined by converting acid value to free fatty acid content. Saponification value was also measured using an AOAC method.

### 2.4 Tanning

**Table 7 : Procedure of tanning using fleshing oil**

Process	Chemicals	Amount (%)	Time (hours)	Remarks
Pickling to 3.2	Water	150	2	The pH was adjusted
	Salt	10		
	Formic acid	0.8		
	Sulphuric acid	1		
Pre-tanning 8.5  12 hours	Glutaraldehyde	0.5	1	The pH was adjusted to  and the skin were pile for
Oil tanning drummed	Fleshing oil or	20	6	The skin was uniformly  along with oil for 6 hours
	Cod oil (control)			
Alkali wash	Water	400	1	The leather washed three

times		
	Soda ash	0.25
	Wetting agent	0.5

The leather was dyed, hooked to dry, toggled then snuffed and dedusted.

## 2.5 Leather analysis

The leather was condition using ISO 2419 test method. Physical properties such as tensile strength, elongation, tearing strength, colour rub fastness were analysed using SLP 6. Organoleptic properties such as softness, fullness, roundness, feel, colour uniformity and colour intensity were tested.

## 3. RESULTS AND DISCUSSION

### 3.1 Determination of fat content and yield

The fat content of green and limed fleshing from goat skins were determined and tabulated in Table 2. Petroleum ether was used as the solvent for fat extraction. It could be observed that the green fleshing from goatskin had the maximum fat content of 26.16 % while limed fleshing had lower fat content of 16.81%, animal fats contain 5-30% fat content suggesting that the obtained fleshing oil is in the range of literature values (Ananthakrishnan, 1982). It is obvious that during liming process, the fat gets saponified and hence lowering of fat content in the limed fleshing.

**Table 8 : The amount of fat content in percentage of fleshing waste of each species**

Sample code	Mass of fleshings (g)	Mass of oil (g)	Fat content %
GGF <sub>1</sub>	10.00	2.909	29.09
GGF <sub>2</sub>	10.00	2.257	22.57
GGF <sub>3</sub>	10.00	2.682	26.82
<b>Average</b>	<b>10.00</b>	<b>2.616</b>	<b>26.16</b>
GGF <sub>1</sub>	10.00	1.479	14.79
GGF <sub>2</sub>	10.00	1.857	18.57
GGF <sub>3</sub>	10.00	1.707	17.07
<b>Average</b>	<b>10.00</b>	<b>1.681</b>	<b>16.81</b>

It could be observed that green fleshing, which is devoid of any chemicals would be a suitable material for preparation of the product of higher quality. However, most of the tanneries carry out only limed fleshing. Hence, it becomes necessary to clean the limed fleshing devoid of chemicals, so that a quality product can be obtained. Hence, in the present work, the limed fleshing was washed, de-limed and used for fat extraction. The product obtained from green and limed fleshing are shown in Fig.1. It could be observed that the both products showed similar colour properties.



**Figure 23: The extracted oil from green and limed fleshings**

### 3.2 Saponification value

Saponification value of oil is a measure of the average molecular weight of the triacylglycerol in a sample. The smaller the saponification numbers the larger the average molecular weight of the triacylglycerol presents i.e. Saponification value is inversely proportional to the mean molecular weight of fatty acids was lower (Odoom and Edusei, 2015). Saponification value of green and limed fat extracted from goat fleshings have been determined and tabulated in Table 3. The saponification value of green fleshing  $GGF_{average}$  was 192.40, limed fleshing  $GLF_{Average}$  was 184.60 which is in good agreement with the reported works (Reda, 2014). The result shows that the green fleshing oil has higher molecular weight than the limed fleshing oil. All results fall under the standard value that is 184 -192 (Severin and Xia, 2005). Oils having saponification value “between” 180-233 have smaller molecules and so their penetration powers into the leather should be more, this in turn will improve the softness property of the final leather

**Table 9: Saponification value of fat extracted from goat fleshing waste**

Sample code	Mass of oil (g)	Saponification value (mg KOH/g oil)
GGF <sub>1</sub>	2.00	193.07
GGF <sub>2</sub>	2.00	186.27
GGF <sub>3</sub>	2.00	197.87
<b>Average</b>	<b>2.00</b>	<b>192.40</b>
GLF <sub>1</sub>	2.00	184.32
GLF <sub>2</sub>	2.00	186.27
GLF <sub>3</sub>	2.00	183.20
<b>Average</b>	<b>2.00</b>	<b>184.60</b>

### 3.3 Acid value

Acid value of the green and limed fleshing from goat raw material were measured in triplicate, the values are tabulated in Table 4. Acid value is a measure of rancidity. If the values are high, the fat or oil will become more rancid and vice versa. The acid value of oil used for making tanning oil should be below 8.0 mg/g (Thomas, 2012). It is observed from the table that the average acid value for the oil extracted from green

fleshing is 7.37 mg and that of limed fleshing is 6.08 mg/g. From the obtained result, it is very clear that acid value of the extracted oil from the fleshing is less than 8.0 mg/g.

The % free fatty acid can be calculated based on acid value and the following formulae was used and the values are tabulated in the above Table 4.

$$\text{FFA} = \text{AV} \times 0.503$$

**Table 10 : Acid value and %FFA of fat extracted from goat fleshing waste**

<b>Sample code</b>	<b>Mass of oil (g)</b>	<b>Acid value(mg KOH/g oil)</b>	<b>FFA %</b>
GGF <sub>1</sub>	2.00	7.17	3.61
GGF <sub>2</sub>	2.00	7.16	3.60
GGF <sub>3</sub>	2.00	7.78	3.91
<b>Average</b>	<b>2.00</b>	<b>7.37</b>	<b>3.71</b>
GLF <sub>1</sub>	2.00	6.09	3.06
GLF <sub>2</sub>	2.00	6.12	3.08
GLF <sub>3</sub>	2.00	6.04	3.04
<b>Average</b>	<b>2.00</b>	<b>6.08</b>	<b>3.06</b>

### 3.4 Iodine value

The main characteristics of oil from fleshing wastes that is required for preparing tanning oil is the iodine value. The iodine value (IV) gives a measure of the average degree of unsaturation of a lipid: the higher the iodine value, the greater the number of C=C double bonds. Table 5. shows the determined iodine value of fleshing oil. A low iodine number shows that the fat has a low quantity of unsaturated fatty acid and vice versa (Serrato, 1981). All the samples showed lower iodine value indicating that the fat/oil had lower level of unsaturation. A low iodine number also indicates a high melting point and soft lubricating value of the fleshing oil. The iodine value is used to determine the degree of unsaturation of the fatty acids. Fats and oils are usually classified, on the basis of their iodine value as drying oil 125 - 181, semi-drying oil 85-128 and non-drying 8- 129 (Dutta, 2008). All results are falling in the range of 65-73. Hence, based on the iodine values of extracted fleshing fat, they can be called non- drying oils and all types of fat can be used for preparation of tanning oil although the one that has low iodine will require more time for tanning to take place than the one with high iodine value. The chemical properties of the extracted fleshing oil are summarized in Table 6.

**Table 11: Iodine value of fat extracted from goat fleshing waste**

Sample code	Mass of oil (g)	Iodine Value
GGF <sub>1</sub>	2.00	73.09
GGF <sub>2</sub>	2.00	70.18
GGF <sub>3</sub>	2.00	75.72
<b>Average</b>	<b>2.00</b>	<b>73.00</b>
GLF <sub>1</sub>	2.00	65.72
GLF <sub>2</sub>	2.00	68.09
GLF <sub>3</sub>	2.00	63.81
<b>Average</b>	<b>2.00</b>	<b>65.81</b>

**Table 12: Physio-chemical properties of extracted oil from goat fleshing**

NO	Characteristics	Source of oil	
		GGF	GLF
1.	Colour	Light yellow	Light yellow
2.	Acid value	7.37	6.08
3.	Free fatty acid %	3.71	3.08
4.	Saponification value	192.40	184.60
5.	Iodine value	73.00	65.87

Comparison of the fleshing oil and cod liver oil chemical properties are given in table 7.

**Table 13 : Chemical properties of fleshing oil and cod liver oil**

No.	Chemical properties	Fleshing oil	Cod liver oil
1	Acid value	6 – 8	10 – 13
2	Fatty acid content (%)	3 – 4	5 - 6
3	Saponification value	185 - 193	199 - 204
4	Iodine value	66 – 75	80 - 120

### 3.5 Tanning

Developed oil from the goat skin fleshings was used in the process of oil tanning. Three trials were carried out; control process using commercial cod liver oil (T<sub>1</sub>), the developed oil was used alone (T<sub>2</sub>) and the developed oil was used in combination with the commercial cod liver oil (T<sub>3</sub>). From all the experiments, the leathers obtained had similar properties. Especially, the leathers did not show any oiliness on the surface. Hence, it could be inferred that the oil was stable during leather processing and had penetrated in to the leather matrix without any problem.



**Figure 24: Exotic chamois leather from the ovine stomach**

### 3.6 Physical properties

Chamois leather absorbs 4-5 times its weight of water, but the water absorbed depend greatly on the porosity of the tanned leather (OFlaherty, Roddy and Lollar, 1965). However, the exotic chamois leather from the ovine stomach showed poor water absorption. The stomach was snuffed to try to improve the water absorption capacity of the leather, but there was no increase in the amount of water absorption. The thickness of the ovine stomach was raised to the order of 0.7- 1.4 mm. This thickness achieved by the exotic chamois leather is suitable for fabricating small leather goods. Table 8 shows comparison of the physical properties of chamois leather from the flesh oil and cod liver.

**Table 14: Physical properties of exotic chamois leather**

Physical properties leather	Fleshing oil tanned leather	Cod liver oil tanned leather
Thickness (mm)	0.3 – 1.0	0.4 -1.0
Tensile strength (N/mm <sup>2</sup> )	16.00	17.25
Elongation at break (%)	127.5	127.30
Tearing strength	40.67	42.2
Colour rub fastness	3	3

From table 8, it can be seen that the physical properties of the exotic skin tanned by fleshing oil gave property close to those tanned using cod liver oil. The percentage elongation at break of chamois leather lies in the range of 120 - 163% (Herfeld and Konigfeld, 1963). The values ranged from 127-128% in case of grain chamois leather from the oil tanned ovine stomach. The results of physical tests were poor compared to the grain leather as the composition of raw outer coverings of animals and their stomachs are different.

### 3.7 Organoleptic properties

The softness properties of chamois exotic leather from fleshing oil and cod liver oil was similar. Fleshing oil tanned leather has better odour than cod liver oil tanned leather. Other organoleptic properties such as fullness, roundness, appearance and feel were similar.

**Table 15: Organoleptic properties of fleshing oil and cod live oil tanned leather**

Organoleptic properties	Fleshing oil tanned leather	Cod liver oil tanned leather
Softness	7 – 8	7 – 8
Colour	8 – 9	7 – 8
Appearance	8	8
Odour	7 – 8	4 – 6

On a 10-point scale, 0 = poor, 10 = excellent. The result was average results.

#### 4. CONCLUSION

This study shows that fleshing oil could find an application in processing chamois leather. Physical and organoleptic properties of fleshing oil tanned leather were similar to those of cod oil tanned leather. All of the parameters fulfilled the quality standard required. This study also produced new variety of exotic grain leather from the ovine stomach.

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## **Investigation of the quality of footwear produced by SMEs: case study of Kariokor market, Nairobi**

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### **ABSTRACT**

The increasing economic growth in Kenya has encouraged the growth of the leather and leather products sector. Kenya in its long-term vision to become an industrialized middle-income country by 2030, has identified the key role that the leather and leather products sector will play. There is a growing number of SMEs engaged in leather goods and footwear manufacturing around the country. A large number is involved in footwear manufacturing. This has been encouraged by local demand for affordable footwear. Even though production of leather footwear in the informal industry has increased over the years, the country's local footwear has low market position both at national and international level. The market share of the SME produced footwear has been attributed to the low quality of the products. A survey was carried out on the quality of leather shoes produced by SMEs in Kariokor market, Nairobi. Data was collected from 20 respondents who constituted owners and managers of footwear workshops to ascertain if they have adopted the use of quality standards in their shoe fabrication and if their products conform to laid down quality standards. The data was collected using simple random sampling method and analysed using Microsoft excel. The findings showed that none of the SMEs had adopted the use of quality standards and none of them had adopted Kenya Bureau of Standards (KEBs) standards. As a consequence, there was no mechanism of ensuring and maintaining conformity to footwear quality. It was therefore difficult to ascertain the quality of the shoes produced. This study recommends increased sensitization of SMEs on the importance of quality standards and quality manufacturing procedures in shoe fabrication for each type of footwear. In addition, KEBs should ensure its stakeholders adhere to set quality.

**Key words:** Footwear, Quality standards, SMEs, KEBs

### **INTRODUCTION**

Kenya has embraced the goal of industrialization of transforming the structure of economy into a newly industrialized country by 2030 (Government of Kenya, 2002a). In order to achieve this, its leather sector has been identified as a key driver towards achievement of Kenya's vision 2030 (Government of Kenya, 2002a). The leather footwear subsector offers an important opportunity for industrialization since the country has a unique comparative advantage in terms of availability of raw hides and skins required for the footwear sector (World Bank Group, 2015).

The Kenyan leather footwear industry is still young and developing comprising of the informal and formal sector. However, this industry is largely dominated by firms that target the domestic market through the artisanal production system (Mudungwe and Nicholas, 2012). Even though production of footwear in the informal industry has increased over the years, the country's local footwear has low market position both at national and international levels, as it still seems to have unmet potential (Kinyua,

2014). Kenya's once vibrant footwear sector is now choked by cheap imports from abroad which have significant share of the domestic market and the leather shoe industry is facing stiff competition from china and others (Okello, 2010). Although Kenya's ability to run a successful leather footwear industry is enormous as it produces huge amounts of hides and skins, the success of the footwear industry largely depends on quality of the shoe which unfortunately has been of great concern since the market share of the SME produced footwear has been attributed to the low quality of the products and most of the import shoes have attracted the local market (Muchie, 2000)

In fact, the second-hand market accounts for around 63% of footwear sold in Kenya. As a result, there is intense competition among the leather footwear industry players with emphasis laid on production of quality products in order to meet customers' satisfaction and be able to compete in the domestic and foreign market (Mwinyihija, 2014).

Research has shown that low price, high quality and attractive designs are strategies used by foreign competitors to influence the domestic footwear producers (Katende-Magezi, 2017). The domestic producers however, have considered competitive pressure from imports as an opportunity to improve performance. The toughness of the import competition can lead the domestic producers to upgrade quality.

Product quality is the most critical element for market success (Devaraj, Matta and Conlon, 2001). The quality of footwear is an important property and is evaluated based on whether the shoe meets set standards because a good quality shoe should meet the minimum quality requirements for it to compete favourably in the market (Goonetilleke,2001). It is against this background that this study provides an understanding of how the quality of the locally produced footwear has influenced domestic market access for the import shoes.

### **Footwear quality parameters**

A good quality shoe has to certify certain minimum quality requirements. It has to meet the requirements set by quality regulatory bodies. Such requirements include the chemical and physical properties of the shoes which include: Quality of raw materials and suitability of the materials for the product, quality of footwear accessories, quality of cutting patterns and lasting, quality of skiving and stitching, quality of sole attachment/ sole adhesion, finishing of the shoe, suitability of lining materials to its purpose, suitability of the insole, chemical composition of the shoe (presence of hexavalent chromium) and fit for purpose( Motawi, 2017). Based on the quality of raw materials in the case of leather footwear, a good quality shoe is required to certify the following physical parameters; tensile strength, tear strength, flex endurance, thickness of the sole, insole and upper material, adhesion of the sole, sole hardness, specific gravity of the sole etc. failure to certify these requirements implies that the shoe does not conform to quality( Footwear Distributors and Retailers of America, 2014)

## **RESEARCH METHODOLOGY**

### **Population**

In this study, the informal footwear industry was the population whereby the key respondents were footwear artisans in Kariokor market, Nairobi

### **Primary data collection**

The researcher used field survey to collect the data used for analysis. To carry out the study, simple random sampling technique was employed to collect data (Creswell, 2009). The study targeted small and medium enterprises in the leather footwear at Kariokor market. The chosen firms were leather footwear artisans in Kariokor market. The data was collected in form of questionnaires. During the sampling process, 20 questionnaires were administered whereby the key respondents were interviewed.

### **Secondary data collection**

The secondary data was taken through published and unpublished bibliographies, academic journals, conference proceedings, government reports and related studies.

## **RESULTS AND DISCUSSION**

### **Characteristics of the respondents and footwear production in kariokor**

The study sought information from the owners of the leather footwear production units and the producers of footwear in kariokor market. Questionnaires were developed to assess the quality of shoes produced by SMEs in Kariokor market, Nairobi. In accordance with the objectives of the research, the data was collected in six major thematic areas namely;

Education on leather related course; Raw material and production; quality tests, and Adoption and use of quality standards by SMEs. It was important to investigate the above-mentioned characteristics because the previous studies have highlighted them as crucial in determining the quality of a shoes (Okello, 2010)

### **Training in leather related course (owners and managers)**

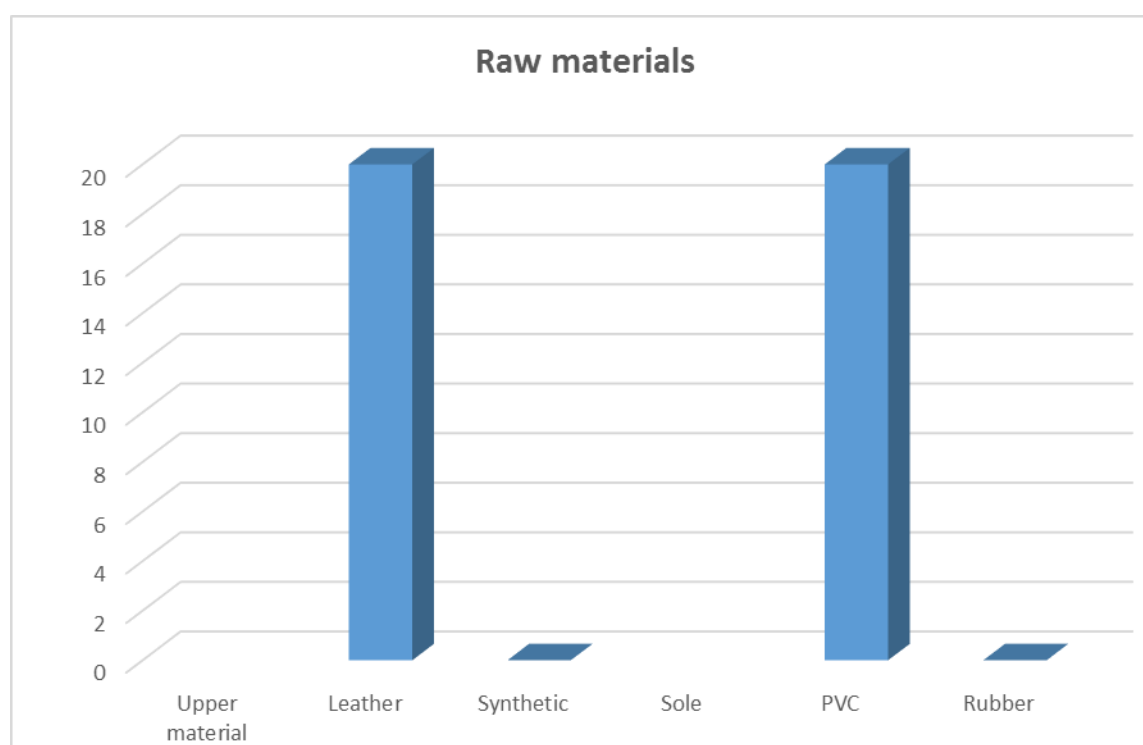
Based on training in leather technology, 20% of the owners/ managers had acquired training in craft level certificate in leather related field at KLDC. Majority of them had attained short courses on leather so as to understand its basics after their first degrees or diploma in other course while others had worked with BATA shoe company and had acquired the training through on job training. However, as shown in table 1, majority of the respondents (85%) had not attained training in leather related field. This implies that majority of the owners of leather footwear units had not acquired additional training skills on leather technology and shoe fabrication to enhance production and quality of the shoes.

**Table 16: Education in leather related courses**

<b>Training in leather related course</b>	<b>Frequency</b>	<b>Percentage</b>
Degree in leather related course	0	0
Diploma in leather related course	1	5
Craft in leather related course	2	10
No training in leather related course	17	85
<b>Total</b>	<b>20</b>	<b>100</b>

## Main raw materials and sources of local leather

From the respondents, it was noted that leather and PVC still remain the main raw material used in the production of shoes. From the 20 units studied, 100% rely on the local leather as their main raw material as shown in figure 1. Additionally, the main sources of leather included Aziz tannery, Leather Industries of Kenya and Industrial area. The findings from the study indicated that most of producers use tannery 'rejects' in form of wet blue to produce shoes. These materials are not finished and are therefore of poor quality. They therefore have a direct effect on the overall quality of the end product. The study also showed that leather material and other accessories are not subjected to quality testing before use. As discussed earlier in literature, the quality of the materials used determines the quality of the end product (Devaraj, Matta and Conlon). It was noted that the producers sought for poor quality leather because it is cheap and affordable.



*Figure 25: Main raw materials for footwear manufacture*

## Footwear quality parameters

Based on assessment of the quality tests and quality conformity of the shoes, it was discovered that all the firms do not subject their products to quality testing and they have no laid-out standard of ensuring quality is achieved and maintained. In fact, none of the respondents was aware of the potential of formation of hexavalent chromium in a shoe. According to table 2, none of them had the skills on how to perform quality testing and none of them had KEBS certification. It was therefore difficult to ascertain the quality of the shoes produced. The products from such said firms do not under go any quality testing and they do not certify any quality test once produced making them difficult to compete with other shoes both in the local or foreign markets.

**Table 17: Footwear Quality Parameters**

<b>Quality Test</b>	<b>Frequency</b>	<b>Percentage</b>
Test for fit	0	0
Tensile strength (leather)	0	0
Flex endurance (leather)	0	0
PH of leather	0	0
Thickness: leather, sole, lining, insole	0	0
Sole adhesion (PVC)	0	0
Sole hardness (PVC)	0	0
Specific gravity (PVC)	0	0
No quality tests	20	100
<b>Total</b>	<b>20</b>	<b>100</b>

**Awareness of, adoption and use of footwear standards- ISO and KEBS satisfaction**

In trying to further understand the quality of shoes, the study sought to assess the adoption and use of quality standards by footwear producers in Kariokor market.

From the respondents in table 3, 25% were aware of the quality standards. However, none of them had adopted the standards. Lack of conformity to quality standards was the key reason why most SMEs cannot attract international market. This could be seen as the main reason as to why most of the Kenyan leather footwear SMEs cannot attract international market. This could also be the reason why the local consumers prefer second hand shoes at the expense of the locally manufactured shoe (Okello, 2010).

**Table 18: Adoption and use of Footwear Quality Standards**

<b>Characteristics of Respondents</b>	<b>Frequency</b>	<b>Percentage</b>
Aware of existing quality standards	4	25
Aware and adopted existing quality standards	0	0
Aware, adopted and conform to quality standards	0	0
Not aware, not adopted, not conform to quality standards	16	75
<b>Total</b>	<b>20</b>	<b>100</b>

**KEBS and ISO certification**

This study established, none of the firms was ISO certified and none of them had KEBS certificate. As shown in table 4, the study also revealed that most of the SMEs in Kariokor, did not have certificates of quality conformity from any established organization. It was established that 100% of the firms did not have such said certification. According to the respondents, it was expensive to acquire certification from regulatory bodies since their businesses did not have high yields. In addition, some of the respondents did not see the necessity for certification. Lack of KEBS certification clearly indicates that their products do not conform to any quality standards. It is my considered opinion therefore, that their products are of unknown standards.

**Table 19: KEBS and ISO Certification**

<b>Certificate</b>	<b>Frequency</b>	<b>Percentage</b>
Have ISO certificate only	0	0
Have KEBS certificate only	0	0
Have both ISO and KEBS	0	0
Have no certificate at all	20	100
<b>Total</b>	<b>20</b>	<b>100</b>

### **Consumer complaints**

From this study, majority of their consumers complain about poor quality of soles as the soles wear out easily. Further study reveals that the duration of their soles takes about 3- 4 months. Some of them complain about poor sole adhesion which means bond between the sole and upper material is weak. It was therefore discovered that majority of the respondents use poor quality of adhesives in the attachment of the sole and upper material. Others complain of shoes not fitting them properly. All the above complaints indicate that the overall quality of their shoes does not conform to quality

**Table 20: Consumer complaints**

<b>Characteristic of Respondents</b>	<b>Frequency</b>	<b>Percentage</b>
Ill-fitting shoes	4	20
Non-durable soles	11	55
Weak sole attachment	3	15
No complaints	2	10
<b>Total</b>	<b>20</b>	<b>100</b>

### **CONCLUSION**

This study reveals that the leather footwear SMEs in Kenya haven't adopted the use of quality standards and hence they have no mechanism of ensuring quality is achieved and maintained. Lack of awareness was the main reason as to why the

producers do not have quality standards. Lack of conformity to footwear quality was found to be one of the significant variables that influence consumer preference and choice. In order to withstand stiff competition in the market, firms should use quality control standards to improve their products so as to attract more sales and to achieve superior performance. Having KEBS certification is considered the best way to achieve this. With regard to human resource skills, it was noted that human resource technical skills have significant effect on overall quality of the product. The artisans need to be trained on basic shoe fabrication techniques. Availability of staff with these necessary skills may influence a firm's decision to adopt the use of quality standards. Further research calls for laboratory analysis of the shoe samples to ascertain if they meet the minimum required quality standards set by the regulatory bodies.

## **ACKNOWLEDGEMENT**

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# Zeolite Materials Derived From Water Hyacinth and Rice Husk Ashes Clear Turbidity And Remove Lead Ions From Contaminated Water

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## Abstract

Water hyacinth plant is known to jam water bodies with thousands of tons of floating plant matter. In order to help in its control, it is important to explore ways to create value in its products especially the ones that can find use in water remediation. On the other hand rice husk is not waste anymore for its ash is rich in active silica. Thus, the present study determined the capacity and efficiency of water hyacinth ash, its insoluble residue, and rice husk ash to remove lead ions and turbidity from contaminated water. Mixtures of the two ashes were used to prepare zeolitic materials A and B by hydrothermal reactions. Material A was prepared using rice husk ash and the soluble fraction of water hyacinth ash while for material B, a mixture of equal amounts the two ashes including the insoluble residue of water hyacinth ash were used. The efficiency of the material was investigated by varying the effect of initial lead ions concentration, pH, contact time, temperature and adsorbent dose. Adsorption data for lead ions on rice husk ash, water hyacinth ash residue and materials A and B best fitted the Langmuir model and gave adsorption capacities of 37.04, 83.33, 142.86 and 278.6 mg/g respectively while water hyacinth ash best fitted Freundlich model and gave an adsorption capacity of 61.69 mg/g. The findings herein indicate that incorporating the residue of water hyacinth ash in the synthesis of the zeolitic material enhances its adsorption capacity and efficiency for lead ions and also imparts ability to remove turbidity.

Key words: Adsorption Isotherms, Heavy Metals, Water Remediation, Zeolite.

## INTRODUCTION

In Kenya where the population is estimated to be about 40 million people, 43 percent (17.2 million) has no access clean water. The major factors contributing to this water crisis include; rapid population growth, recurrent droughts, forest degradation, poor management of water supply and water contamination. This water crisis may worsen as industrial development and population grows as projected if drastic measures are not taken immediately. The rapid population growth both in rural and urban areas has stressed the existing water supply systems (Vorosmarty *et al.*, 2000). This accompanied by unsuitable water supply infrastructure has hindered access to water by the poor in many developing countries (Rosegrant and Cai, 2002). There has been remarkable growth in light and informal (Jua Kali) industries like textiles, leather, paper, plastics, electroplating, cement, metal processing, wood preservatives, paints, pigments and steel fabricating industries (Cheng, 2003). These industries discharge large quantities of toxic wastes (Chen *et al.*, 2007). Recent studies in Kenya have shown that the unregulated open-air mechanical workshops are significant sources of mobile and bioavailable heavy metal contaminants (Chengo *et al.*, 2013a, b). Several studies suggest that among the heavy metals, pollution associated with lead ions is of key concern in Kenya (Muiruri *et al.*, 2013; Muinde *et al.*, 2013; Nasiebanda *et al.*, 2014) and Africa (Yoshinori *et al.*, 2010; Akoto *et al.*, 2008). More so because lead is a non-essential element and toxic even at very low levels of exposure. Even low doses can impair the nervous system and affect fetus, infants and young children. Low level lead exposure leads to encephalopathy, ischemic heart disease, abnormalities in children, testicular atrophy, anemia and interstitial nephritis (Tong *et al.*, 2000). The maximum allowed levels of lead ions in drinking water is capped at 15 µg (Levin *et al.*, 2008). Turbidity is a key physical characteristic that expresses water's optical property to scatter and absorb rather than transmit light. This is caused by suspended matter or impurities that may include clay, silt, microscopic inorganic and organic matter, soluble colored compounds, plankton and other microscopic organisms. Excessive turbidity in drinking water is visually unpleasant and may also symbolize a health concern. Turbidity promotes growth of pathogens in water systems leading to waterborne disease outbreaks. Although it is not a direct indicator of health risk, many studies have shown correlation between removal of turbidity and removal of protozoa (Herson *et al.*, 1984; Gauthier *et al.*, 2003). Several processes used to remove turbidity and dissolved heavy metals include ion exchange, precipitation, ultra filtration, reverse osmosis, electro

dialysis and adsorption (Tchobanglous and Burton, 1991). Many of these approaches demand high energy, advanced operational requirement or difficult to treat and do not enable recovery of metals or material.

Water hyacinth is one of the most stubborn weeds of the world (Gopal and Sharma, 1981). Water hyacinth infestations are symptoms of eutrophication. Indeed studies have identified high concentrations of nutrient in water as the overriding factor affecting growth parameters of water hyacinth plants. Work done by Coetzee *et al.*, 2007 established that the growth rate of water hyacinth leaves and daughter plants at high concentrations levels was more than double their production at low concentrations. At high nutrient levels, the plant promptly covers water bodies and surrounding marshy regions at an average growth of one ton of dry matter per day per hectare (Mailu, 2001). Consequently such colonized wetlands decline in the quantity and quality of water they provide (Wilson *et al.*, 2005). This affects aquatic ecosystems health and the biodiversity of the water bodies (Greenfield *et al.*, 2007).

Due to increased contamination of the already scarce clean water, there is need to explore ways of developing relatively simple and cheap water filtration materials that can be used at household level for its remediation. In an attempt to develop cheap adsorbents using water hyacinth as one of the raw material as a means of aiding in curbing or putting it under maintained control, the present work aimed at developing adsorbents from water hyacinth and rice husk waste. Indeed findings herein suggest that water hyacinth and rice husk waste can be used as raw materials for synthesizing adsorbent materials for heavy metal removal from contaminated water. This work was done between the months of October 2012 to September 2013 at Kenyatta University, Chemistry department, research laboratory.

## MATERIALS AND METHODS

**Chemicals:** The stock solutions of lead with a concentration of 1000 mg/L were prepared by dissolving 1.600 g lead nitrate in 1000 mL distilled water in volumetric flask. The solution was then diluted to obtain standard solutions containing 0.1 mg/L, 0.2 mg/L, 0.4 mg/L, 0.8 mg/L, 1.6 mg/L 3.2 mg/L. Nitric acid and sodium hydroxide solutions were used in all experiments to adjust pH of the solution.

**Rice husk ash, water hyacinth ash and water hyacinth ash residue preparation:** Water hyacinth plants were obtained from Nairobi dam. They were then transported to the laboratory where they were extensively washed with tap water to remove soil and dust, sliced into pieces and then air dried for one week using a procedure already documented by (Kruatrachue *et al.*, 2004). Ashing was done using an oven at a temperature of 950 °C for 5 hours. The resulting ash was mixed to obtain a composite water hyacinth ash, WHA. Samples were sieved to obtain particles of the same size. Water hyacinth ash residue, WHAR was obtained after 50 g of water hyacinth ash were dissolved in 250 cm<sup>3</sup> of distilled water, shaken for five minutes and allowed to settle. Filtration was done using Whatman No.1 filter paper and the residue was sun dried for five hours. Rice husks were provided by Euros rice millers in Kirinyaga County, Mwea west district. They were then washed several times with distilled water to remove soil and dust, followed by filtration and then dried at 100 °C. The clean and dry rice husks were burnt in an oven at 500 °C for 3 hours to obtain rice husk ash, RHA.

**Potassium hydroxide solution:** 1M potassium hydroxide was generated from water hyacinth ash by dissolving 50 g of WHA and filtering off the residue. Titration experiments were done to determine the concentration of the alkaline solution using 0.1M hydrochloric acid.

**Synthesis of zeolitic material, ZMA:** About 25 g of rice husk ash was put into a stainless steel digestion bomb. A 250 mL potassium hydroxide solution was added to the ash. The bomb was closed and introduced into a pre-heated oven at 200 °C for a period of 24 hrs. The contents were then allowed to cool and filtered. The solid residue was then washed with distilled water to remove the excess alkali and dried at 105 °C for 12 hrs. The solid residue was designated as ZMA.

**Preparation of zeolitic material B, ZMB:** For the preparation of ZMB, 50 g of rice husk ash and 50 g of water hyacinth ash were put in a digestion bomb and 250 mL of distilled water added to the mixture. The bomb was put in a pre-heated oven at 200 °C for 12 hours. The resultant solid was washed with hot distilled water to remove the excess alkali and then dried at 105 °C for 12 hrs. The sample was designated as ZMB.

**Instrumentation:** Lead concentrations in the various solutions were determined using atomic absorption spectrophotometer model AAS 4141, ECIL, India at wave length 283.3 nm in flame mode

using air-acetylene flame. The pH meter, model PHEP, Hanna instrument, Italy, was used in this study between pH ranges 2-12 at a temperature of 22.7 °C. Turbid meter, model 2100P (HACH) was used to determine the turbidity of water. The concentration of the Pb<sup>2+</sup> was assayed in triplicates by use of an AAS with air-acetylene flame. The accuracy of the instrument was checked by triplication of samples. A series of standards were prepared for instrumental calibration by serial dilution of a working solution (100 mg/L) they were prepared from analytical grade stock solution (1000 mg/L) from Alpha Chemika and S.D. Fine- chem ltd. A standard and blank sample was run after every seven samples to check instrumental drift. Calibration curve method was used to quantify the heavy metal concentration.

**Batch experiments:** In the batch experiments a water-bath temperature controlled shaker (DKZ-1 NO.1007827) was used for the batch adsorption study. The experiments were performed at a constant shaking speed. For each experimental run, 50 mL aqueous solution of the known concentration of lead solution was taken in 120 mL plastic bottles containing a known mass of the adsorbent. These bottles were agitated at a constant shaking rate of 150 rpm in a temperature of 25 °C. 0.1 g of RHA, ZMA, ZMB, WHA and WHAR were used for adsorption of Pb<sup>2+</sup>. Triplicate solutions and 100 mg/L Pb<sup>2+</sup> ion solutions was mixed with 0.1 g of adsorbent and shaken for 24 hours at a temperature of 25 °C, centrifuged and filtered. The concentrations of Pb<sup>2+</sup> ions in the resultant filtrates were measured using flame atomic absorption spectrometry. The amount and percentage of Pb<sup>2+</sup> ions adsorbed were calculated using the equation 1 and 2 respectively

$$qe = \frac{(C_0 - C_e)}{m} V \rightarrow \quad (1)$$

$$R = 100 \left( \frac{C_0 - C_e}{C_0} \right) \rightarrow \quad (2)$$

Where,  $qe$  = Amount of metal ion removed at equilibrium

$C_0$  = Initial concentration of sorbate

$C_e$  = Concentration of sorbate at equilibrium

$m$  = mass of adsorbent used

$V$  = volume of solution used

**Effect of adsorbent dosage:** The effect of adsorbent dosage on the percentage of Pb<sup>2+</sup> ions adsorbed was investigated by agitating Pb<sup>2+</sup> solutions at various dosages ranging from 0.02 to 2.5 g at fixed contact time, initial metal ion concentration and pH. Initial concentrations of the aqueous metal solution of Pb<sup>2+</sup> were kept constant at 10 mg/L for WHA, RHA and ZMA and 100 mg/L for WHAR and ZMB. The initial pH of each metal ion solutions was adjusted to its respective optimum pH. The experiment was conducted in triplicates and agitated for 2 hrs on the water bath shaker. At the end of the contact time, the samples were centrifuged and filtered using Whatman No.1 and Pb<sup>2+</sup> concentrations of the filtrates determined using flame atomic adsorption spectrometry.

**Effect of contact time:** The percentage of Pb<sup>2+</sup> ions adsorbed at various contact time was investigated using 50 mL of 10 mg/L sample solutions in eight plastic bottles. 0.1 g of WHA, RHA and ZMA were added to each bottle. The concentrations were adjusted to 100 mg/L for WHAR and ZMB. The pH of the sample solutions were adjusted to 5. The bottles were shaken at 120 rpm for times ranging from 1min to 24 hrs. The solutions were then filtered and the filtrates were subjected to atomic absorption to record the absorbance of lead and determine concentrations of Pb<sup>2+</sup> ions.

**Effect of initial concentration of Pb<sup>2+</sup>ions:** The effect of initial concentration of Pb<sup>2+</sup>ions on the percentage of Pb<sup>2+</sup> adsorbed was investigated by agitating 50 mL samples of leads solutions of 10 mg/L in 120 mL plastic bottles with 0.1 g of ZMA, WHA and RHA adsorbents in a water bath shaker at 25°C. Pb<sup>2+</sup> ion concentrations were adjusted to 100 mg/L for WHAR and ZMB. The contact time was kept constant at 2 hours and initial pH of solution set at 5 using sodium hydroxide solution and nitric acid. Samples were withdrawn after 2 hours, filtered using Whatman No. 1 and measured for Pb<sup>2+</sup> ion concentrations. All tests were conducted in triplicate.

**Effect of pH:** The effect of pH on the percentage of Pb<sup>2+</sup> ions adsorbed was studied by varying the pH from 2 to 12. The adjustments were done using concentrated nitric acid and concentrated sodium hydroxide solution. 0.1 g of RHA, WHA and ZMB were added to 50 mL aqueous solutions containing 10 mg/L lead ions. The concentrations of lead solutions were adjusted to 100 mg/L for WHAR and ZMB. All tests were conducted in triplicates.

The samples were agitated using the water shaker at constant speed of 150 rpm and contact time of 2 hours. At the end of the contact time, the samples were filtered using Whatman No.1 and the concentrations of Pb<sup>2+</sup> ions in the filtrates determined using flame atomic absorption spectrometry.

**Suspended particles in water:** Turbid water was prepared by adding clay materials to tap water. About 25 g of the clay materials was added to 1 litre of tap water. The suspension was stirred for about 1 hour to achieve a uniform dispersion of clay particles. Then it was allowed to settle for at least 24 hours for complete hydration of the clay material. The effect of doses of WHA, RHA, WHAR, ZMA and ZMB was investigated by agitating 50 mL of turbid water with 0.1, 0.2, 0.3, 0.4, and 0.5 g of adsorbents for 2 hrs. The solution was then filtered using Whatman No. 1 filter paper and turbidity of the filtrate determined using a turbid meter. All these studies were conducted at room temperature and at a constant speed of 150 rpm.

## RESULTS AND DISCUSSION

**Characterization of Materials:** The XRD scattering pattern of ZMA is shown in figure 1 and its subsequent theoretical phase chemical composition given in table 1. As shown, all the zeolites contained aluminosilicates minerals similar to those of naturally occurring zeolites. ZMA which was synthesized from RHA and the soluble part of WHA gave phase matches shown in table 1. The matches indicate that the material comprises of a zeolite framework mainly neutralized by Fe ions along Mg and Ca ions. This agrees with XRF data of ZMA presented in table 2. As shown the percentage oxides in descending order were SiO<sub>2</sub>, Fe<sub>2</sub>O<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>, K<sub>2</sub>O, CaO, TiO<sub>2</sub> and MgO at 75, 10.45, 7.8, 3.3, 1.1, 1.3 and 0.45 % composition respectively. Fig 2 shows the XRD scattering pattern of ZMB which was synthesized from RHA and WHA including the insoluble portion. The pattern was almost identical to the one for ZMA suggesting that the structures were very similar. However, phase matches indicated that the material comprises of a zeolite framework mainly neutralized by Mg and Ca ions. In addition phase matches of aluminum phosphate and iron silicide were obtained as shown in table 3. This concurs well with XRF data of the percentage oxides in descending percentage composition of 76.22, 10.52, 4.63, 2.7, 2.08, 2.01, 1.76 and 0.04 % for SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O, MgO, Fe<sub>2</sub>O<sub>3</sub>, CaO and TiO<sub>2</sub> respectively as indicated in table 4.

**Effects of initial metal concentration:** Figure 3 shows how the percentage of Pb<sup>2+</sup> ions adsorbed at saturation varied as the initial concentrations were varied from 10 to 100 mg/L for RHA and ZMA and 100 to 500 mg/L for WHA, WHAR and ZMB when 0.1 g of adsorbents were used under same conditions. Variation of the initial concentration from 100 to 500 mg/L decreased the % removal by ZMB from 99±12.6 to 75±9.6 %. The percentage removal by WHAR increased as the concentration increased from 100 mg/L to 300 mg/L. Further increase in concentration decreased the percentage removal to 99.2±0.6 % at 500 mg/L. The high and gradual increase in the percentage removal of lead ions as initial concentration increases for WHAR suggest it has large number of active sites and equilibrium constant, ( $K_{eq}$ ) than the others. The decrease indicates that saturation of active adsorption sites occurs at initial concentration levels of above 300 mg/L. The percentage removal of lead ions by WHA remained unchanged as initial concentrations were increased to 500 mg/L.

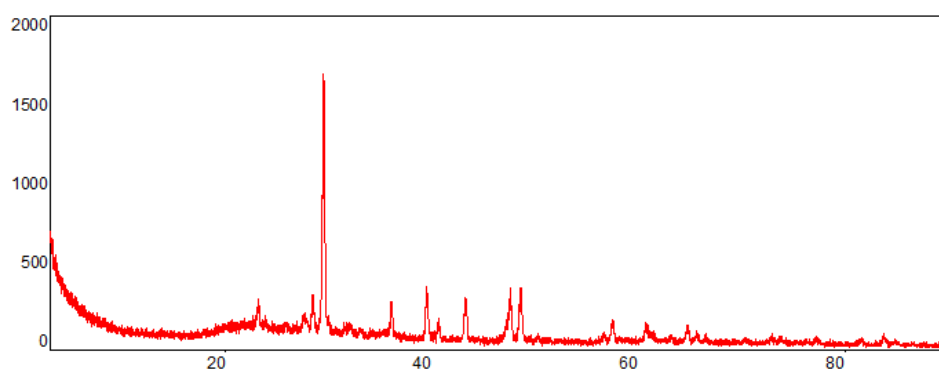


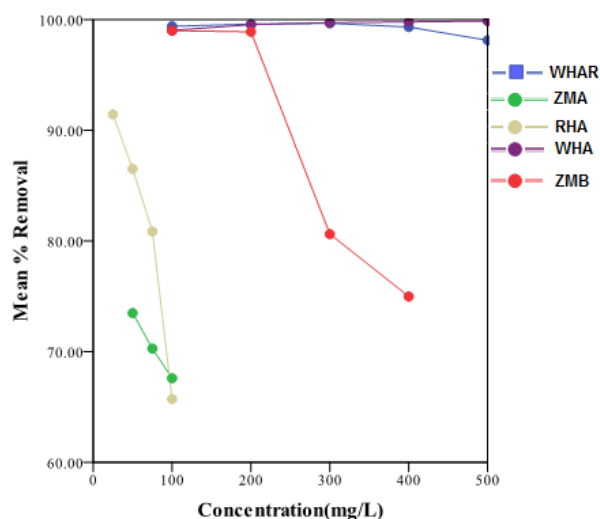
Figure 1. XRD scattering pattern for material ZMA

Table 1. Phase matches for XRD scattering pattern of material ZMA

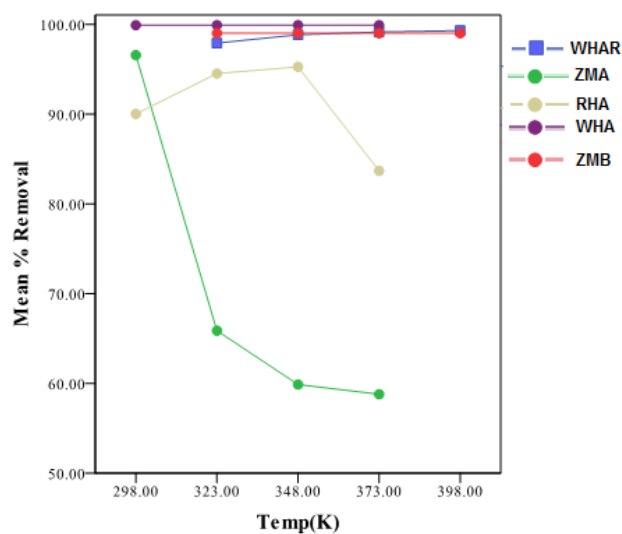
Phase name	Mineral	% content
Magnesioferrite	Aluminosilicate	83.48915
Iron silicon oxide	Aluminosilicate	4.704745
Magnesium Iron AluminiumOxide	Aluminosilicate	9.212560
Zeolite 4A	Aluminosilicate	2.593544

**Table 1. XRF percentage oxides data of material ZMA**

Compound	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	K <sub>2</sub> O	CaO	TiO <sub>2</sub>	MgO	Fe <sub>2</sub> O <sub>3</sub>
% oxide	7.8%	75%	3.3%	1.1%	1.3%	0.45%	10.45%



**Figure 3. The percentage removal of Pb (II) at saturation using 0.1g of water hyacinth ash, rice husk ash and zeolite at various initial concentrations (amount of biosorbent = 0.1 g, contact time = 24 hours and agitation speed = 120rpm)**



**Figure 4. Effect of temperature on the removal of Pb (II) by water hyacinth ash, rice husk ash and zeolite (initial solution concentration = 10 mg/L for RHA, WHA and ZMA and 100mg/L for WHAR and ZMB, amount of biosorbent = 0.1 g and contact time = 120 min agitation speed = 120rpm)**

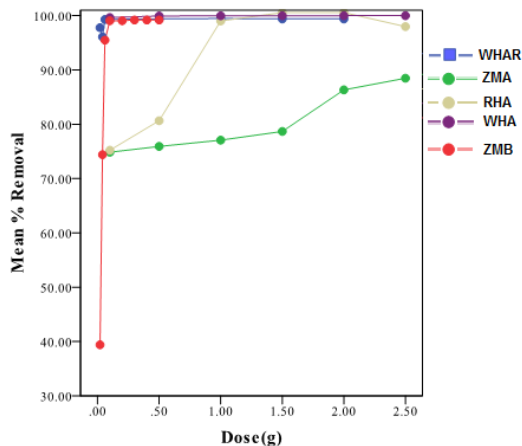


Figure 5: Effect of adsorbent dosage (g) variation on lead ion adsorption at pH of 6, agitation period of 120 min at 120 rpm and initial metal ion concentration of 10mg/L for RHA, WHA and ZMA and 100mg/L for WHAR and ZMB

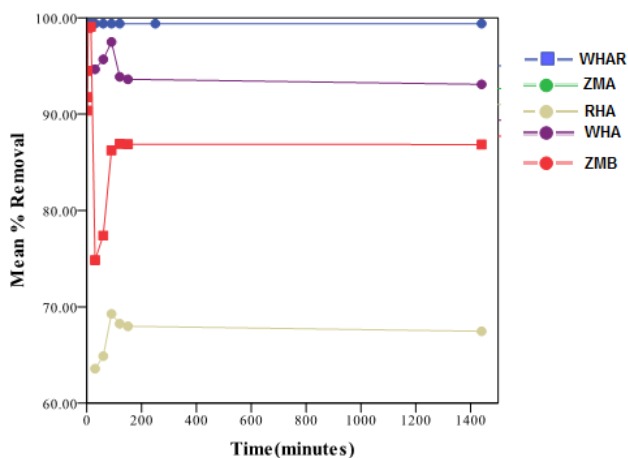


Figure 6. Effect of contact time on the adsorption of Pb(II) ions at pH 5.0, agitation speed 120 rpm, temperature 25 °C and initial metal ion concentration of 10mg/L for RHA, WHA and ZMA and 100mg/L for WHAR and ZMB

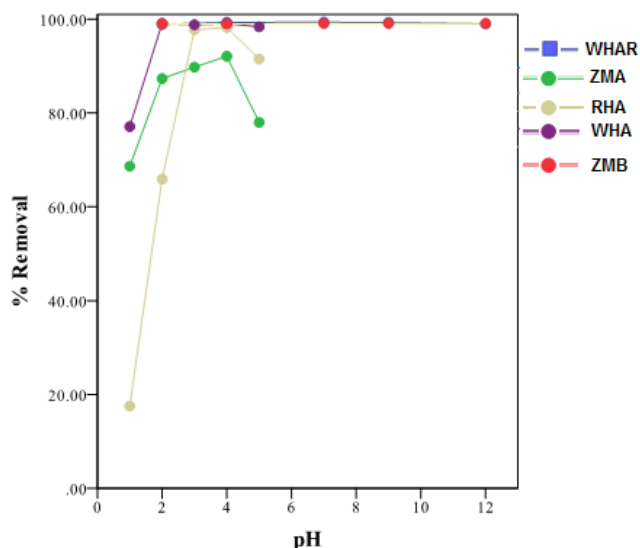
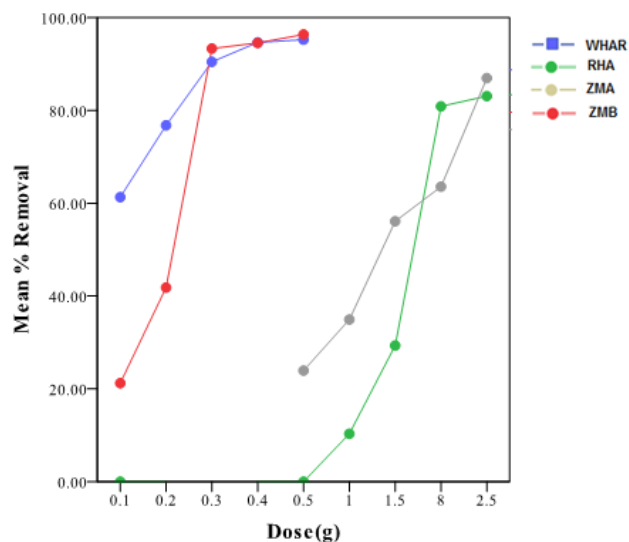


Figure 7. Effect of pH on the adsorption of Pb(II) ions using 0.1g of adsorbent at contact time 2 hours, agitation speed 120 rpm, temperature 25 °C and initial metal ion concentration of 10mg/L for RHA, WHA and ZMA and 100mg/L for WHAR and ZMB



**Figure 8. Removal of suspended particles from water using different adsorbent dosages and agitation period of 120min at 120rpm, Temperature 25°C for WHAR, RHA, ZMA and ZMB**

However, since WHA contains  $35.8 \pm 0.1$  %  $K_2O$ , it is possible that precipitation of  $Pb^{2+}$  ions at the higher pH contributed to the high percentage removal. The percentage removal of  $Pb^{2+}$  ions by rice husk ash reduced drastically from  $93 \pm 12.8$  to  $65 \pm 8.9$  % as concentration increased from 10 mg/L to 100 mg/L. In ZMA, a gradual decrease of percentage removal as initial concentration was varied from 10, 25, 50, 75 and 100mg/L was observed. The decrease is so gradual that variation of initial concentrations from 10 to 75 ( $7\frac{1}{2}$  times) corresponds to a decrease in percentage removal from about  $75 \pm 3.1$  % to about  $71 \pm 2.9$  %, indicating that all the number of binding sites decreased with increase in concentration of the  $Pb^{2+}$  ions.

**Effects of temperature:** The variations of percentage removal of lead ions adsorbed by WHA, WHAR, RHA, ZMA and ZMB were investigated as a function of temperature and the observations summarized in figure 4. The experiments were done at temperatures of 25, 50, 75, 100 and 125 °C using doses of 0.1 g / 50 mL, pH of 6 and initial concentrations of 10 mg/L for RHA, WHA and ZMA while initial concentration of 100 mg/L was used for WHAR and ZMB. The percentage removal of  $Pb^{2+}$  ions by water hyacinth ash residual, WHAR increased from  $97.00 \pm 0.61$  % to  $99.30 \pm 0.63$  % when the temperature was increased from 50 to 125 °C. Percentage removal of lead ions by RHA increased from  $90.01 \pm 5.27$  % to  $95.25 \pm 5.57$  % when the temperature was increased from 25 to 75 °C. Thereafter, the concentration of lead ions removed by RHA decreased to  $83.67 \pm 4.91$  %. This implies that at temperatures above 75 °C, the  $Pb^{2+}$  ions possess sufficient energy to overcome the enthalpy of adsorption on RHA. Percentages of  $Pb^{2+}$  ions removed by ZMA gradual decreased from  $96.56 \pm 2.44$  to  $58.78 \pm 1.49$  % when the temperature was increased from 25 to 100 °C suggesting that the ions are weakly held. The percentage removal of  $Pb^{2+}$  ions by ZMB and WHA remained constant with increase in temperature suggesting that ZMB and WHA  $Pb^{2+}$  adsorption was not affected by increase in temperature.

**Effect of adsorbent dosage:** Figure 5 shows how the percentage removal of  $Pb^{2+}$  ions varied as adsorbent doses were increased from 0.02 to 2.5 g. The experiments were done at pH of 6, agitation period of 120 min at 120 rpm and initial metal ion concentration of 10 mg/L for RHA, WHA and ZMA and 100 mg/L for WHAR and ZMB. The results showed that as the adsorbent doses were increased, the percentage removal of  $Pb^{2+}$  ions increased for all the five adsorbents. A gradual increment in percentage removal of 10 mg/L metal ion concentration by RHA was recorded as doses were increased from 0.1 to 0.5 g and a steeper one between 0.5 to 1 g. This plateaued between 1 and 2 g and decreased at 2.5 g. Reduction in capacity is due to overlapping of adsorption sites as a result of overcrowding of adsorbent particles as reported by Tumin *et al.*, 2008 leading to a concentration gradient between solute concentration in the solution and the solute concentration in the surface of the sorbent. Moreover, a high adsorbent dosage could impose a screening effect on the dense outer layer of the cells, thereby shielding the binding sites from metals (Bishnoi *et al.*, 2004). For ZMA, a gradual increase in percentage removal of  $Pb^{2+}$  ions was recorded at 0.1 and 1.5 g and a steeper one beyond 1.5 g. There was no significant change in the amount of lead ions adsorbed as the doses of WHA was increased. A rapid increments in the percentage removal of  $Pb^{2+}$  ions by ZMB and WHAR were observed as their doses were increased from 0.02 g to 0.06 g and then remained constant beyond 0.1 g. The initial



increment in percentage adsorption with increments in adsorbent dosage was due to increments in available adsorption sites for metal attachment (Abdel *et al.*, 2007).

**Effect of contact time:** The variations of percentage removal of  $Pb^{2+}$  ions as contact time was increased to 24 hours as represented in Figure 6. The percentage of the adsorbed  $Pb^{2+}$  ions increased as the time increased similar to literature reports (Meena *et al.*, 2005). RHA showed gradual increment of adsorbed  $Pb^{2+}$  ions in the first 30 min followed by a rapid metal ion adsorption for the first 60 min. This was followed by a gradual decrease beyond 60min and remained constant beyond 150 min. The percentage removal by WHAR and ZMB remained constant beyond 30 and 15 min respectively. The fast adsorption at the initial stage was probably due to the initial concentration gradient between the adsorbate in solution and the number of vacant sites available on the surface at the beginning. The progressive increase in adsorption and consequently the attainment of equilibrium was due to limited mass transfer of the adsorbate molecules from the bulk liquid to the external surface of the adsorbents.

**Effects of pH:** The effects of pH on the percentage removal of  $Pb^{2+}$  ions by the various adsorbents are represented in figure 7.

As observed from figure, RHA performs its best between pH 7-9 at percent removal of close to 100. ZMA gave best percentage removals of 83-86 % at pH values of between 4 and 9 while WHA performed best above pH values 4. The percentage removal of  $Pb^{2+}$  ions by WHAR and ZMB remained fairly constant as the PH was increased from 2 to 12 with percentage removal of close to  $100.00 \pm 0.01$  %. At low pH ( $< 4$ ), there was excessive protonation of the active sites at the adsorbents surface and this hinders the formation of bonds between  $Pb^{2+}$  ions and the active site. Further increase in pH above 4 led to decreased adsorption of  $Pb^{2+}$  ions by ZMA and RHA. At pH 7-9, removal of the lead ions remained almost constant in all the five adsorbents. At moderate pH values, linked  $H^+$  is released from the active sites and adsorbed amount of metal ions is found to increase. Generally, metal ions are more soluble at lower pH values and this enhances their adsorption as observed (Olayinka *et al.*, 2009). Removal of metal ions at higher pH values could be attributed to the formation of their hydroxides which results in precipitates, this is consistent with the observation of Lisa *et al.*, 2004. Therefore, removal of  $Pb^{2+}$  ions at higher pH values may be due to the formation of precipitates rather than adsorption. (Patnukao *et al.*, 2008) concluded that adsorption experiments for  $Pb^{2+}$  ions are better performed at moderate pH to avoid precipitate formation. Decrease in adsorption at higher pH ( $> 7$ ) is associated to the formation of soluble hydroxyl complexes (Amuda *et al.*, 2007).

**Percentage removal of suspended particles:** The percentage of turbidity removed in different adsorbent dosages by water hyacinth ash residue, rice husk ash water hyacinth ash and ZMB, in different dosages is described in Figure above. The highest removal was indicated at adsorbent dosage 0.5 g water hyacinth ash residue with removal efficiency of  $95.0 \pm 2.1$  %, 0.5 g ZMB with removal efficiency of  $96.0 \pm 2.2$  %, 2.5 g, rice husk ash with removal efficiency of  $83.0 \pm 1.9$  % and 2.5 g water hyacinth ash with removal efficiency of  $86.0 \pm 2.0$  % while the minimum removal was  $0.0 \pm 0.0$  % recorded at 0.1g and 0.5 g rice husk ash,  $61.0 \pm 2.8$  % at 0.1g water hyacinth ash residue,  $21.0 \pm 0.9$  % at 0.1 g ZMB and  $23.0 \pm 0.5$  % at 0.5 g water hyacinth ash. The removal efficiency remained fairly constant when the adsorbent dosage was increased above 0.4 g ZMB, 0.4 g water hyacinth ash, 2.0 g rice husk ash and 2.0 g water hyacinth ash.

**Adsorption isotherms:** The data obtained from the batch adsorption experiments were fitted to Langmuir and Freundlich isotherms at a constant temperature of 25 °C and important thermodynamic data obtained as shown in Table 3.

As implied by  $R^2$  values of 0.997, 1, 0.996 and 0.983 and  $1/n$  values of less than one for RHA, WHAR, ZMA and ZMB respectively, the data best fits into Langmuir isotherm model. This indicates a monolayer sorption onto adsorbent surfaces that contain finite number of identical active sites. The adsorption capacities of the adsorbents,  $q_{max}$  were  $37.04 \pm 0.18$ ,  $278.60 \pm 3.66$ ,  $83.33 \pm 0.86$  and  $142.86 \pm 1.48$  mg/g for RHA, WHAR, ZMA and ZMB respectively. WHAR gave the highest adsorption capacity of  $278.6 \pm 3.66$  mg/g, a value close to the one reported for nanocrystalline zeolite of 270.27 mg/g (Muhammad and Munawar, 2007). This is despite that it contains 54.8 % of CaO which is likely to cause water hardness. ZMA had an adsorption capacity of 83.33 mg/g, a value higher than the one obtained for natural zeolite tuff in single and binary systems of 68 mg/g (Wang *et al.*, 2008) and montmorillonite-illite type clay of about 52 mg/g (Oubagaranadin and Murthy, 2009). The adsorption capacity of ZMB was found to be  $142.86 \pm 1.48$  mg/g which is about twice the value reported for natural zeolite. This value is much higher than most values reported for bio-sorbents (Saeprasearsit *et al.*, 2010) and activated carbon (Lalhrwaitluanga *et al.*, 2009) The adsorption data for WHA best fitted into Freundlich isotherm as indicated by the  $R^2$  value of 0.772 versus Langmuir's value of 0.732. Its adsorption capacity,  $K_f$ , and  $1/n$  values were  $61.69 \pm 0.81$  mg/g and  $3.78 \pm 0.05$  respectively. The  $1/n$

value of greater than 1 indicates cooperative adsorption thus supporting that precipitation of  $Pb^{2+}$  ions at basic conditions brought about by WHA may be contributing to precipitation of  $Pb^{2+}$  ions.

## Conclusion

This study shows that WHA and RHA can be used to produce zeolitic materials which are good adsorbents for  $Pb^{2+}$  and suspended particles removal from water. Biosorption in RHA, WHAR, ZMA and ZMB are best described by monolayer Langmuir isotherm model WHAR and ZMB gave the highest  $q_{max}$  of  $278.6 \pm 3.66$  mg/g and  $142.86 \pm 1.48$  mg/g respectively. These findings imply that incorporating the water hyacinth ash residue into the zeolitic material enhances adsorption of  $Pb^{2+}$  ions and also imparts ability to remove turbidity.

**Conflict of Interests:** The authors declare that there is no conflict of interests regarding the publication of this paper.

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### **Microplastic in the environment - sources and recycling technologies**

Herzog, T. M.\*, Langat, K. H. and Dimitrov V. K.

It is a simple experience of modern societies that plastic is an indispensable part of everyday life.

Whereas plastic itself is non-toxic, microorganisms are not able to break down plastic into a cycle of materials. The impact of plastic refuse on an organism when it decays into tiny particles has yet to be established. But numerous studies showed considerable numbers of microplastic particles in maritime and terrestrial environments.

Mostly the source of microplastic is the lack of an effective waste management system but also state of the art environmental technologies may liberate it, origin e.g. as component of some sanitary products.

The authors give a statistically based insight to the problem and show principle strategies to overcome the problem. The simplest and most cost-effective way of stemming the flow of refuse into the oceans is obvious – restrict consumption and increase the recycling rate. But technical solutions by chemical design in non-perishable polymers during use and perishable after use are sophisticated attempts as well.

Our latest R&D project work results promised us a renaissance of recycling technologies for standard polyolefines and sustainable recirculation of postconsumer plastic waste of technical polymers.

Accompanying research on life circle assessment showed that the ecological footprint of a responsible, technically based daily life of an enlightened consumer is within the capacity of our resources.

#### **Key words**

Microplastic, Recycling, Sustainability, Ecological Footprint

## **Understanding movements of molecular shuttles driven by biomolecular machines under external forces**

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Motor proteins, such as myosin and kinesin, are biomolecular machines which drive muscle contractions and intracellular transports, respectively. Due to their small size and biocompatibility, integration of the motor proteins may offer a new way of powering biosensors. Led by this expectation, so-called molecular shuttles driven by biomolecular machines have been developed. The external forces induced by the electric field and fluid flow are used for directing gliding movements of the microtubules. However, mechanisms of propulsion of molecular shuttles under external forces are not yet fully understood. Here, by developing and using computer simulations, we are revealing mechanisms of the propulsion. In our simulations, microtubules, which are components of molecular shuttles, were modeled as inextensible elastic rods. Time evolutions of conformations of the microtubules were computed with a Brownian dynamics simulation. Kinesin motors were modeled as linear springs. Once bound, motor heads were assumed to move toward designated ends of the microtubules. The microtubules were also subjected to external forces. The simulations reproduced movements of the molecular shuttles driven by kinesin motors under external forces, which validated our simulation methods. With using the simulations, detailed mechanisms of the propulsion has been revealed. Our results would provide insights on interpreting experimental results on control of molecular shuttles.

## Contact Force Control of Flexible Manipulator Using Neuro Controller

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In this paper, we discuss a force control problem for a constrained one-link flexible arm. To solve the force control problem, we propose a simple boundary feedback controller that consists of the bending moment at the root of the flexible arm and its time derivative. In recent years, demands for reducing the weight of the robot arm are increasing in order to realize high speed operation and energy saving. As the rigidity decreases accordingly, the influence of the elastic deformation due to the flexibility of the arm increases, so that the position error and the elastic vibration cannot be ignored. Against such a background, researches on control of flexible manipulators have been actively conducted. Further, nursing robots and welfare robots because it advanced the use of an environment which interact with people is required even higher safety. Therefore, it is considered that control of contact force is necessary in addition to positioning control for safely performing work on people. In this paper, a gain auto tuning neuro controller is designed for a force control problem of a constrained one-link flexible arm. Numerical simulation is performed using FILT (Fast Inversion of Laplace Transform) method that is high-speed numerical inverse Laplace transform algorithm, and its control performance is examined and compared with the fixed gain results. After learning rate  $\eta = 0.1$  and learning number of 5000 times, the error from the target value was 0.088%, while the error with the target value was 0.134% only with the fixed gain control law, the difference of about 0.046% was I was able to reduce it. From the above, it was confirmed that the control system of the flexible arm using the neural auto gain tuning controller shown in this research is effective.

## Investigating The Effect Of Fiber Size And Fiber Content On Flexural Strength Of Rice Husk Fiber Reinforced Polyester Composites

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### Abstract

Environmental awareness campaigns throughout the world have awakened interest in exploring the potentiality of natural lignocellulosic fibers as reinforcements in composite materials - made of thermoplastics and thermoset matrices - for various applications. Natural fibers like bamboo, coir, sisal, and rice husks are plenty in Kenya and the rest of the world. Rice husk is conventionally regarded as an agro-waste product having no use. Thus, it is often disposed by incineration, heaping, or dumping in water bodies. In this present work, an attempt has been made to develop polyester based composites using rice husk fibers (RHF), and to investigate the effect of fiber content and fiber size variation on flexural strengths of the composites. Rice husks were milled and classified into three grades of various sizes (small, medium, and large). Polyester resin and methyl ethyl ketone peroxide (MEKP) catalyst were used as matrix. Composites were fabricated by hand layup method and fiber content was varied in steps of 5% from 0% (lowest) to 20% (highest). Sample specimens were sized from the cured composites for flexural testing in accordance with ASTM D790-10 standards. Flexural tests were conducted at relative humidity of 65% and ambient temperature conditions of 23±2 °C. Analysis of variance (ANOVA) conducted at 5% level of significance showed that both fiber size and fiber content influenced the flexural properties of rice husk fiber reinforced polyester composites.

**Keywords:** Rice husks, Fiber size, Fiber loading, Polyester resin, Flexural strength

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## 1. INTRODUCTION

The utilization of synthetic fibers in the manufacture of thermoplastic and thermoset based composite materials has been a common practice in manufacturing. This has been regarded as an inevitable requirement for obtaining material characteristics required in actual application such as longevity, high strength, ease of manufacture, and light weight. Since early 1960s, interest had been awakened towards the quest for stiffer, stronger, and lightweight materials for use in construction, transportation and aerospace industries (Kenechi, Linus, & Kayode, 2016). However, there is a more pressing need for the utilization of non-toxic, biodegradable materials in the 21<sup>st</sup> century, to minimize environmental pollution caused by synthetic fibers. Researchers have therefore plunged into the exploration of the feasibility of lignocellulosic fibers to substitute synthetic fibers and inorganic substances - metals, non-metals and alloys - as reinforcements in composites (Yang et al., 2004). Natural fibers are found to be affordable, readily available and friendlier to the environment than synthetic fibers, due to their non-toxicity and biodegradability. The fibers are obtained from plant wastes and processed with polymeric matrices using methods such as hand layup, compression molding and vacuum bag molding, to produce composites. Typical examples are polymer-based composites made from jute, hemp, kenaf, bamboo, saw dust, sisal, banana, Sodom apple, eucalyptus, and rice husk fibers.

Rice husk is among the most promising and readily available agro-waste product around the globe. It is not only cheap, but also easy to process. The husks contain 75-90% organic matter, which include lignin, hemicellulose and cellulose (Deka & Samanta, 2015). In Kenya, rice husk producing regions are located in areas such as Mwea in Kirinyaga county, and Ahero in Kisumu county. Conventionally, rice husk is often regarded as an agro-waste product having no economic value. Thus, it is often disposed by incineration, heaping, or dumping in water bodies. Alkaline treatment of natural fibers such as rice husks can improve thermal and mechanical characteristics of the composites. Surata et al., 2014 also pointed out that optimal mechanical strength of composites materials can be obtained by adjusting fiber content proportion in the composite.

Several researchers have examined different aspects of performance of composite materials made of rice husk fibers and polymer matrices. Abdullah et al., 2016 studied the effect of adding rice husk fibers of different proportions on mechanical performance of high-density polyethylene (HDPE). From their findings, composites with fiber ratios of 10% and 15% gave best mechanical strength results. In comparison with HDPE, all composites had lower elongation at break values. HDPE content of 25% yielded the best proportional limit of 155 N.

In a work published by Hameed, Prasanth, & Suseela, 2017, hardness and flexural properties of polyester-based composites made of rice husk, rice husk ash and coconut fibers were investigated. They found out that rice husk ash and coconut fibers had better strength properties, making them suitable reinforcements for several structural and non-structural applications. The composite specimen sample with 5% rice husks, 1% coconut fiber, 5% rice husk ash and 89% polyester gave better flexural strength results. The work did not examine the effect of fiber content on flexural characteristics of the composites.

Joshi, Chaudhary, & Upreti, 2015 studied thermo-mechanical characteristics of rice husk composites. Epoxy resin was used as the matrix material, and rice husks of random sizes in the range of 4-8 mm were used as reinforcement at various weight fractions. Results showed that epoxy resin had the highest ultimate strength values,



which decreased sharply upon addition of rice husks. As the fiber weight fraction was increased from 0% to 20%, the ultimate flexural strength correspondingly decreased. The effect of fiber size variation on mechanical strengths of the composite was however not examined.

Prithivirajan, Jayabal, & Bharathiraja, 2015 examined the mechanical and morphological characteristics of bio-based composites made from rice husk and coir pith particulates in epoxy matrix. Compression molding technique was used, and particulate weight fraction was varied from 10% to 50%. It was observed that adding rice husk and coir particulates improved mechanical properties of the composites. Unreinforced epoxy matrix recorded a flexural strength of 15 MPa. Coir pith-epoxy composites recorded maximum flexural strength of 23 MPa at 30% particulate content. The hybrid composites yielded highest flexural strength of 37.9 MPa at 20% rice husk and 20% coir content. It was deduced that hybridization of agro-waste bio-particulates leads to improved synergetic properties of the composites.

Mechanical properties of rice husk ash and bamboo fiber in epoxy matrix were evaluated by Narayana & Pai, 2016. Bamboo fiber volume fraction was maintained at 50% while rice husk ash filler loading was varied in steps of 5% from 5% (lowest) to 15% (highest). From the results, there was an increase in flexural strength, elastic modulus, and impact strength of the composites with increase in filler content. It was deduced that rice husk ash fills the air voids in the material, thus helping in the absorption of more energy and acting as a barrier to crack propagation throughout the composite.

Chandramohan & Kumar, 2017 developed bio-epoxy based hybrid composites reinforced with walnut shells, rice husks, and powdered coconut shell. Fiber composition ratio of 1:1 was used, while resin to hardener proportion was 10:1. Tensile, flexural, shear, and impact strengths of the fabricated specimens were evaluated. Test results showed that hybrid composites had far superior mechanical characteristics than fiber glass reinforced composites. Walnut and coconut shell hybrid shell hybrid composite yielded the highest flexural strength of 14.5 MPa and 14.9 MPa in dry and wet conditions respectively. Highest tensile strengths of 68.8 KN and 69.5 KN for the hybrid composite with and without moisture respectively, were also observed.

From the above review of past work, extensive research has been conducted on the utility of polymer-based rice husk composites in various applications by examining properties such as shear, flexural, impact, hardness, and tensile strengths. However, no definite focus has been directed towards investigating the effect of varying both fiber loading and fiber size on the mechanical characteristics of the composites. Flexural strength is the ability of a material to withstand bending forces applied normal to its longitudinal axis (Luna et al., 2015). When designing structures such as seats, coffee tables, mirror, door and window frames, flexural stress analysis is inevitable. Thus, this present work focused on fabrication of rice husk-polyester composites, and an investigation of the effect of fiber size and fiber content on the flexural behavior of the composite test specimens.

## **2. METHODS**

## 2.1. Raw Materials, Tools and Equipment

The main raw materials used in this work include rice husks (see Figure 2.1) as reinforcement, unsaturated polyester resin (UPR) as the matrix material, and methyl ethyl ketone peroxide (MEKP) as the catalyst. Sodium hydroxide (caustic soda) was used for fiber surface modification, MR-8 release agent for easy removal of composite, and acetone for cleaning. The freshly harvested rice husk fibers were procured from Mwea in Kirinyaga county, Kenya.



Figure 2.1. Fresh rice husks from Kirinyaga, Kenya

Main equipment used in this study include a universal testing machine (UTM), distiller, universal milling machine, standard laboratory sieves, fluid bed drier, surface grinding machine, vertical band saw machine, and a hot air oven. Miscellaneous items used were: galvanized iron metal sheet, stainless steel metal sheet, stirring rod, polyester mixing container, beaker, syringe, digital electronic balance, hand gloves, surgical gloves, goggles, and gas mask (respirator).

## 2.2. Experimental Design

Controllable parameters in this study were the fiber loading (% *wt*) and fiber size ( $\mu\text{m}$ ), whereas the measured response was the flexural strength of the fabricated specimens. Design of experiments involved varying rice husk fiber size i.e. small size (250 – 500  $\mu\text{m}$ ), medium size (500 – 1000  $\mu\text{m}$ ), and large size (1000 – 2000  $\mu\text{m}$ ) to examine their effect on flexural strength of the composites. Standard laboratory sieves were used to achieve the desired size classifications. For each fiber size category, fiber content was also varied in steps of 5% from 0% (lowest) to 20% (highest) (Islam et al., 2016).

## 2.3. Rice Husk Fiber Processing

Rice husks were first washed with water to remove dust particles, sand, and bran rice. The fibers were then dried in open sun for two days (See Figure 2.2 and 2.3).



Figure 2.2. Hand washing of RHF



Figure 2.3. Sun drying of RHF

After sun-drying, the fibers were chemically treated by soaking in 4% w/v NaOH, prepared by dissolving industrial grade sodium hydroxide in distilled water, in proportions of 4g of solute per 100 cm<sup>3</sup> of distilled water. The setup was left for three hours for effective chemical reaction during which lignin, hemicellulose and wax were removed from the fibers, thus improving their hydrophobic (water hating) property (Chandramohan & Kumar, 2017). The alkali was rinsed from the fibers using distilled water, and a universal indicator was used to check that all the alkali was removed. A fluid bed drier was then used to dry the treated rice husk fibers (See Figure 2.4), which were then taken to a hot air oven to reduce their moisture content. Oven drying temperature was set to 105 °C, and the fibers were removed after 6 hours (Odhong, Muumbo, & Mayaka, 2016).



Figure 2.4. RHF in a fluid bed drier



Figure 2.5. Removal of RHF from the oven

Hammer milling was done to the oven-dried rice husks to reduce their size. The fibers were then classified and separately packed in three different containers according to their respective sizes highlighted in section 2.2.

#### 2.4. Composite Manufacturing

A mold of internal dimensions 200 mm × 200 mm × 6 mm was made of polished mild steel. Ceramic tile was used as the mold base to provide a smooth finish. The mold was first cleaned using acetone, then MR-8 releasing agent was applied to allow easy removal of the cured composite from the mold. A clean plastic container was placed on the digital electronic balance for weighing and mixing the composite constituents. A measured amount of rice husk fibers was placed inside the container. Thereafter, unsaturated polyester resin (UPR) was added to the fibers until the pre-calculated mass of resin in corresponding proportion to the fibers was attained. Methyl ethyl ketone peroxide (MEKP) hardener, 2% by weight of UPR as per manufacturer's prescription, was measured using a syringe and a clean glass beaker, then poured into the plastic container containing RHF and UPR. The mixture was stirred gently for about 15 minutes to avoid bubble formation, and to minimize air entrapment (Islam et al., 2016). The composite was then carefully poured into the mold, the lid placed over the setup, and the mixture rammed mildly to allow for uniform settlement (Chandramohan & Kumar, 2017). The setup was left to cure for 24 hours at room temperature, and the composite was thereafter released from the mold. Figure 2.6 shows a sample of the cured composite. The composite thus formed was first marked with a scribe, then sized using a vertical band saw machine to the desired dimensions according to ASTM D790 standards for flexural testing. Figures 2.7 shows a CAD

model of the flexural test specimen, while Figure 2.8 shows samples of the actual specimens.

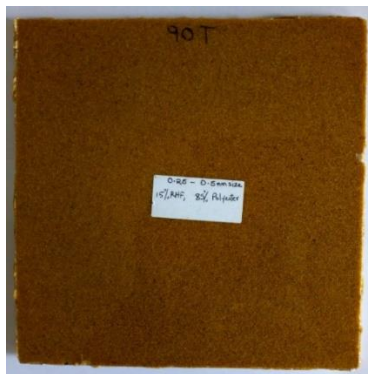


Figure 2.6. Cured RHF composite

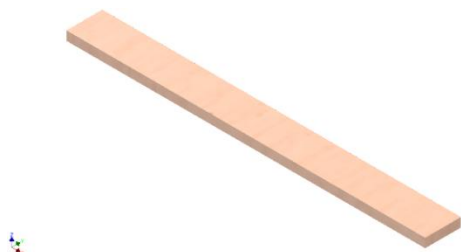


Figure 2.7. CAD model of flexural specimen



Figure 2.8. Flexural test specimens

### 2.5. Flexural Test

Flexural strength test was conducted as per ASTM D790-10 standards. A Universal Testing Machine (UTM) shown in Figure 2.9 was used. Test procedure involved the application of a three-point loading system to the simply supported test specimens at mid-span. Three-point loading (see Figure 2.10) was chosen because it requires less material for each test, and eliminates need for accurate determination of center point deflections with the test equipment (ASTM-International, 2010). The support span length was 48 mm, and the span to depth ratio was 16:1.

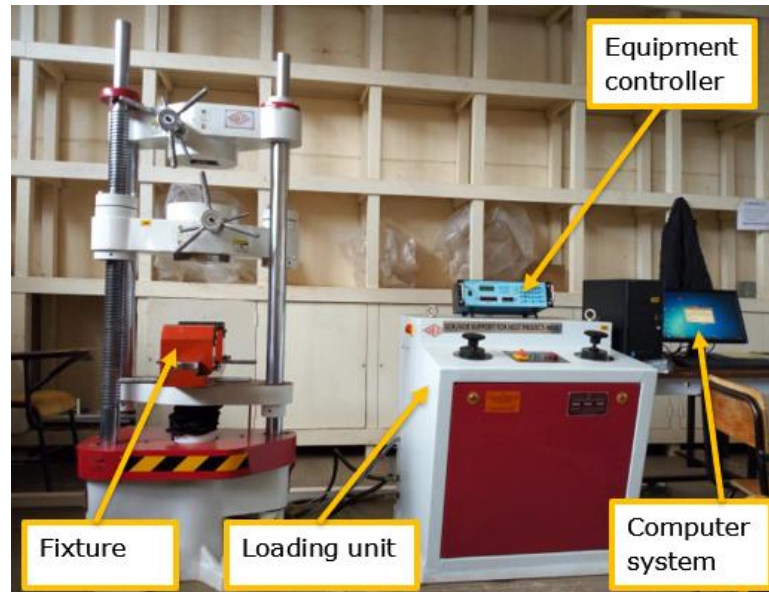


Figure 2.9. Universal testing machine



Figure 2.10. Test specimen under flexural loading

The universal testing machine computes flexural strength and flexural modulus of the composite test pieces based on equations 2.1 and 2.2.

$$\sigma_f = \frac{3PL}{2bd^2} \quad (2.1)$$

Where,  $\sigma_f$  is flexural strength (MPa),  $P$  is maximum load (N),  $L$  is support span (mm),  $b$  is width of test specimen (mm), and  $d$  is depth of test specimen (mm).

$$E_f = \frac{L^3 m}{4bd^3} \quad (2.2)$$

Where,  $E_f$  is flexural modulus (MPa),  $L$  is support span (mm),  $m$  is slope of initial straight line of the load displacement curve (dimensionless).

## 2.6. Hypothesis



The rationale for null hypothesis formulation was on the possible influence of fiber size and fiber weight fraction on the flexural strengths of the composites. This was articulated as follows:

2.6.1. Null hypothesis I ( $H_0$ ): Fiber content (% wt) has no significant effect on flexural strength of rice husk fiber reinforced polyester composite test specimens, and the observed differences are due to chance i.e.  $t_1=t_2=t_3=0$ , where  $t_i$  represents the influence of fiber content in each case.

Alternative hypothesis I ( $H_1$ ): Fiber content (% wt) has a significant effect on flexural strength of rice husk fiber reinforced polyester composites i.e.,  $t_1 \neq t_2 \neq t_3 \neq 0$ .

2.6.2. Null hypothesis II ( $H_0$ ): Fiber size ( $\mu m$ ) has no significant effect on flexural strength of rice husk fiber reinforced polyester composite test pieces, and the observed differences are due to chance i.e.  $b_1=b_2=b_3=0$ , where  $b_i$  represents the influence of fiber size in each case.

Alternative hypothesis II ( $H_1$ ): Fiber size ( $\mu m$ ) has a significant effect on flexural strength of rice husk fiber reinforced polyester composites i.e.,  $b_1 \neq b_2 \neq b_3 \neq 0$ .

The following model described by Montgomery, 2013 was used:

$$y_{ij} = \mu + \tau_i + \beta_j + \varepsilon_{ij} \quad (2.3)$$

Where,  $y_{ij}$  is the flexural strength,  $\mu$  is the mean flexural strength,  $\varepsilon_{ij}$  is the error term.

## 2.7. Statistical Analysis

Two factor analysis of variance (ANOVA) for completely randomized block design (CRBD) at 5% level of significance was conducted on the flexural test results. ANOVA tables were generated by the software, from which the  $F_{ratio}$  values were used as rationale for accepting or rejecting the null hypotheses.

## 3. RESULTS AND DISCUSSION

### 3.1. Results Summary

Table 3.1 shows the flexural strength and modulus test report for unsaturated polyester resin.

Table 3.21. Flexural properties of unreinforced UPR

Samples	Flexural Strength (MPa)	Flexural Modulus (MPa)
100% UPR	45.89	3720

Table 3.2 gives the flexural behavior of rice husk fiber reinforced composite test pieces at various fiber concentrations and size classifications.

Table 3.22. Flexural properties of RHF/UPR composites

Fiber Size ( $\mu\text{m}$ )	% wt (RHF/UPR)	Flexural Strength (MPa)	Flexural Modulus (MPa)
Small (250 – 500)	5/95	25.08	2816
	10/90	29.03	2632
	15/85	33.21	2860
	20/80	27.36	2283
Medium (500 – 1000)	5/95	22.38	2400
	10/90	27.39	2524
	15/85	30.18	2792
	20/80	24.73	1420
Large (1000 – 2000)	5/95	21.27	2488
	10/90	24.85	2672
	15/85	26.90	2197
	20/80	23.45	1918

### 3.2. Stress-strain Curves

Flexural stress-strain behaviors of the composite materials are illustrated in Figures 3.1, 3.2, and 3.3. From the graphs, it can be seen that unreinforced UPR registered higher elongation than RHF/UPR composites, giving maximum strain of 0.015 before failure.

Figure 3.1 shows the stress-strain relationship for various weight fractions of small size RHF composites. It can be observed that the 10 %wt RHF composite registered a maximum strain of 0.0133 before failure, while the 5 %wt gave minimum strain of 0.010 before failure.

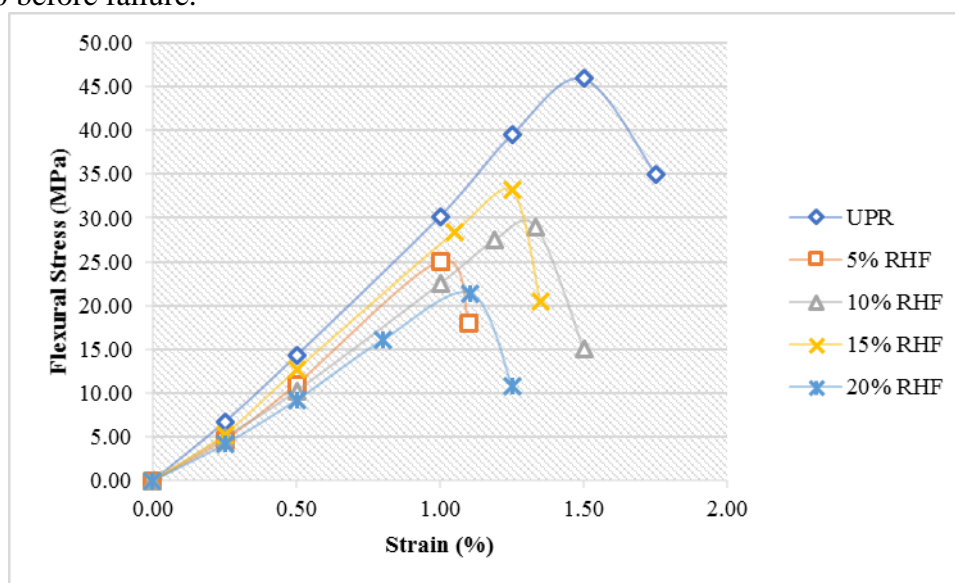


Figure 3.1. Flexural stress-strain curve for small size RHF composite

Stress-strain results for medium size RHF/UPR composites shown in Figure 3.2 showed great similarity with small size RHF composites. However, contrary to the small size RHF composites, maximum strain of 0.0135 occurred in the 20 %wt RHF composite, while minimum strain of 0.087 occurred in 5 %wt composite before failure.

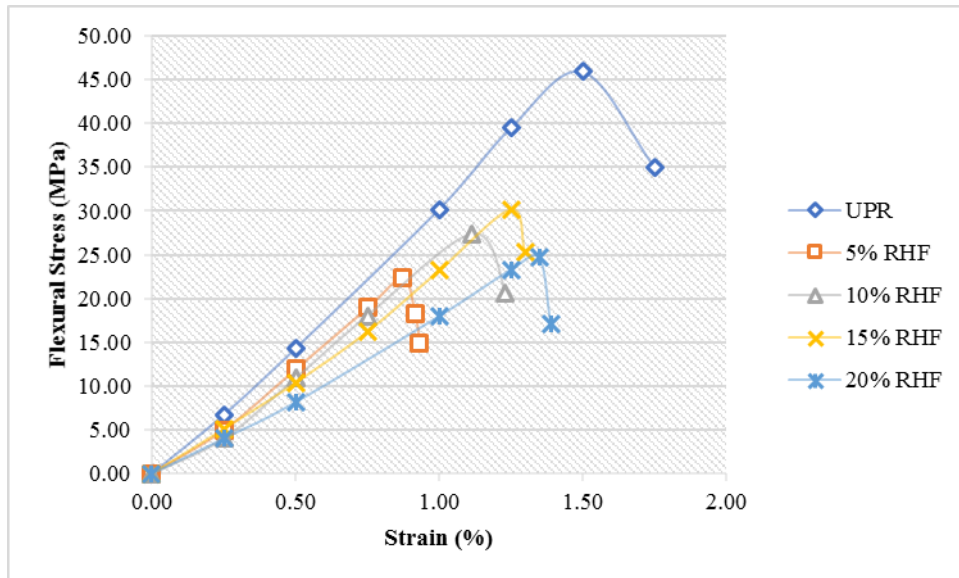


Figure 26.2. Flexural stress-strain curve for medium size RHF composite

The flexural stress-strain behavior of large size RHF composites at various fiber weight fractions has been represented in figure 3.3. From the graph, 20 %wt composite gave largest strain of 0.0139 before failure while 5 %wt recorded smallest strain of 0.084 before failure.

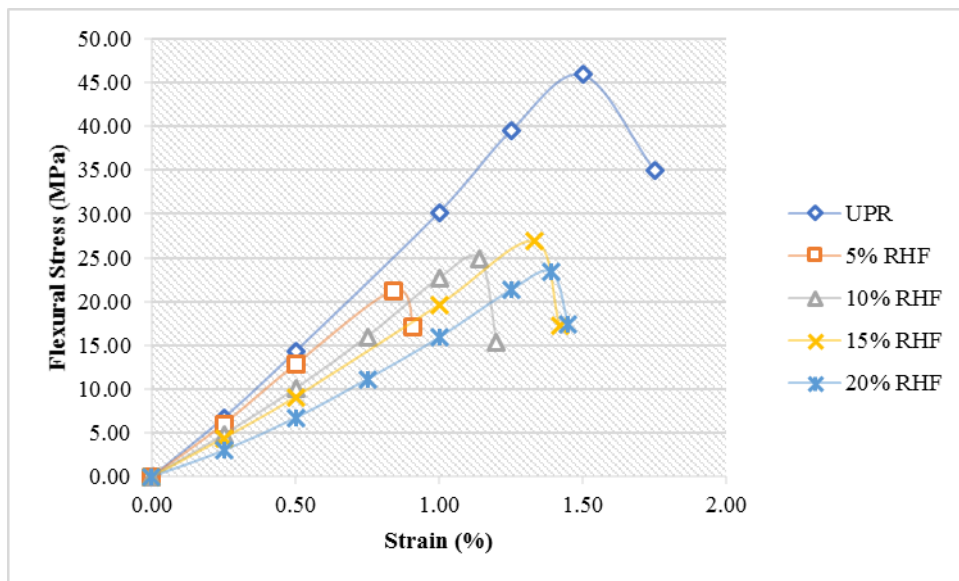


Figure 3.3. Flexural stress-strain curve for large size RHF composite

In all the three fiber size classifications, elongation at break appeared to increase with increase in fiber weight fraction from 5% to 20%.



### 3.3. Flexural Strength, Fiber Content and Fiber Size

The effect of fiber size and fiber weight fraction on flexural strengths of RHF/UPR composite test pieces has been illustrated in Figure 3.4. It can be seen that pure UPR yielded the highest flexural strength value of 45.89 MPa, while all the reinforced composites had relatively lower flexural properties. Thus, it can be stated that addition of rice husk fibers to the resin matrix reduces its flexural strength characteristics. A similar effect was observed by Mustapa, Hassan, & Rahmat, 2005 with polypropylene matrix.

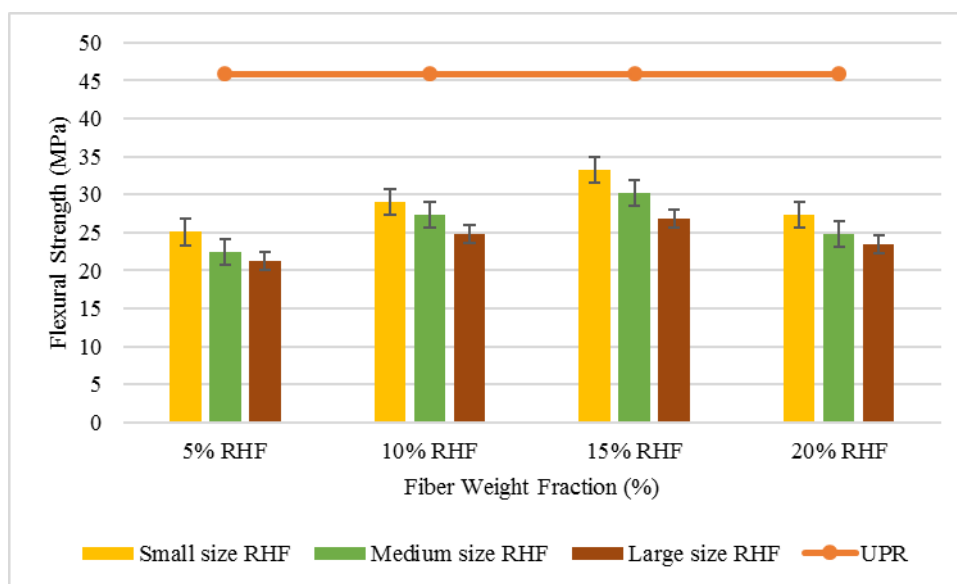


Figure 3.4. Effect of % wt fiber on flexural strength

In all the three fiber size categories, flexural strength increased with increase in fiber weight fraction up to 15 %wt. A drop was however noticed in the composite samples having 20 %wt. For the small size RHF/UPR composites, bending strength increased from 22.08 MPa to 33.21 MPa i.e. by 50.4% as rice husk fiber concentration was varied from 5 %wt to 15 %wt, whereas for medium and large size composites, the increase in strength was from 22.38 MPa to 30.18 MPa, i.e. by 34.98%, and 21.27 MPa to 26.90 MPa i.e. by 26.5% respectively. The low flexural strength of RHF composites at 5 %wt can be attributed to the poor distribution of particles within the polyester matrix (Ameh, Isa, & Sanusi, 2015).

The increase in flexural strength with increased fiber concentration is due to the fact that UPR transmits and distributes the applied flexural stress to the rice husk fibers, resulting in higher strength. Consequently, as fiber concentration increases the composites' ability to withstand higher loads before fracture is boosted (Ramanaiah, Prasad, & Reddy, 2012). This observation is also consistent with results obtained by Susilowati & Sumardiyanto, 2018, who pointed out that the bending stress exerted on the material is first received by the matrix then transferred to the fibers. Increasing fiber concentration within the matrix would therefore imply a corresponding reduction in load per unit fiber in the matrix, since the load will be shared by the fibers in the matrix. Consequently, the property of the material to withstand flexural load is thereby improved. A similar trend was also observed in a work published by Luna et al., 2015, who used rice husk and polypropylene matrix. The decrease in ultimate flexural strengths for all the three fiber size categories observed in the 20 %wt

composites is the result of agglomerate formation at higher fiber concentrations, as similarly observed in the materials' tensile behavior.

For any given value of fiber weight fraction, it can be observed that flexural strength decreases with increase in fiber size from small to large size category of the reinforced composites. As fiber content and particle size increases, the total surface area available for matrix fiber interaction reduces. Consequently, the mobility of matrix molecules increases. The reverse is true for lower fiber content and particle size due to increase in surface area.

### 3.4. Flexural Modulus, Fiber Content and Fiber Size

Figure 3.5 illustrates the effect of the controllable input parameters on flexural modulus of the composite test pieces. It can be observed that the small size RHF/UPR composite yielded the highest flexural modulus value of 2860 MPa at 15 %wt, while the lowest flexural strength of 1420 MPa was recorded by the medium size RHF at 20 %wt. The decrease in flexural modulus at 20 %wt could be the result of poor fiber-matrix interface as confirmed in a study done by Ameh et al., 2015. The small size RHF composites yielded higher flexural strengths than the other two size categories. The observed low modulus properties of large size RHF could be the result of internal defects of the specimens such as voids and fiber-matrix inhomogeneity.

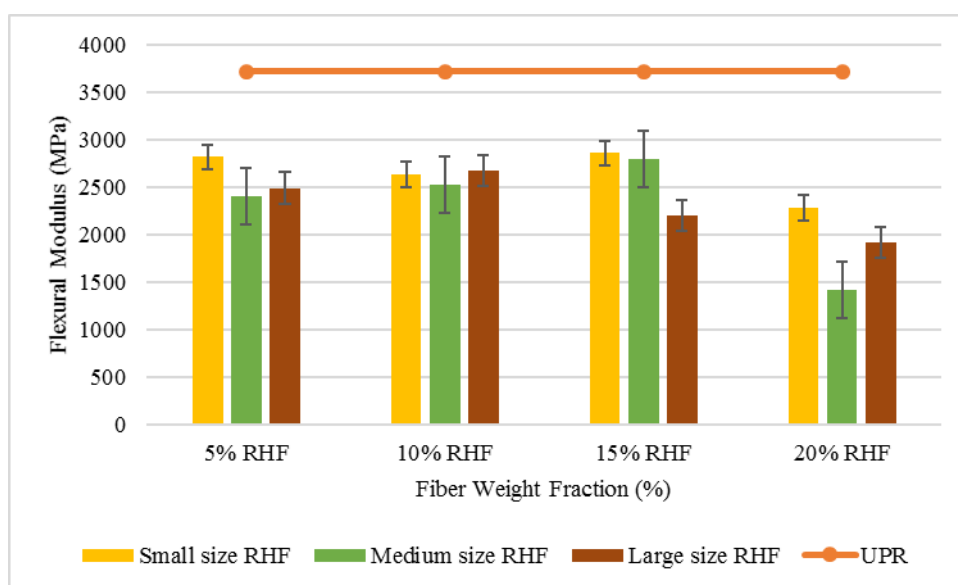


Figure 3.5. Effect of % wt fiber on flexural modulus

Unsaturated polyester resin gave higher flexural modulus value than all the reinforced composites i.e. 3720 MPa. This can be explained by the known fact that the addition of fibers to the matrix increases brittleness of the resulting material, which accelerates the materials liability to deform plastically.

### 3.5. ANOVA Report

Table 3.3 shows the selected experimental area for flexural test analysis. Analysis of variance for continuous randomized block design (CRBD) was conducted at 5% level of significance.

Table 23.3. Experimental area for flexural test

Fiber Size	Fiber Weight Fraction (%)		
	5%	10%	15%
Small	25.08 MPa	29.03 MPa	33.21 MPa
Medium	23.38 MPa	27.39 MPa	30.18 MPa
Large	21.27 MPa	24.85 MPa	26.90 MPa

The results obtained from data analysis software are shown in tables 3.4 and 3.5, where rows represent fiber weight fractions (%), while columns represent fiber sizes.

Table 3.4. Flexural test Anova: Two factor without replication

SUMMARY	Count	Sum	Average	Variance
Row 1	3	87.32	29.10667	16.52863
Row 2	3	80.95	26.98333	11.68403
Row 3	3	73.02	24.34	8.1193
Column 1	3	69.73	23.24333	3.643033
Column 2	3	81.27	27.09	4.4356
Column 3	3	90.29	30.09667	9.959233

Table 3.5. Flexural test ANOVA table for CRBD

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	34.21687	2	17.10843	36.81476	0.002655	6.944272
Columns	70.80507	2	35.40253	76.1809	0.000654	6.944272
Error	1.858867	4	0.464717			
Total	106.8808	8				

#### 3.5.1. Statistical Inferences

With regard to the formulated hypothesis in section 2.6, and examining the  $F$  and  $F_{crit}$  columns in table 3.5, it can be clearly seen that  $F > F_{crit}$  for rows which represent fiber weight fraction (%wt). The null hypothesis was therefore rejected, and it was concluded that flexural strengths of RHF/UPR composites were affected by the variation of fiber weight fraction. Considering the columns representing fiber size, we also see that  $F > F_{crit}$ , thus the null hypothesis was rejected and it was deduced that the variation of fiber size significantly influenced the tensile strengths of the fractured RHF composite test samples.

### 4. CONCLUSION

This research focused on the fabrication of composite materials made from unsaturated polyester resin matrix and rice husk fiber reinforcement, with specific

interest in examining the influence of fiber size and fiber concentration variations on the flexural behavior of the resulting composite. The aims have been successfully accomplished. The following conclusions have been made:

1. RHF/UPR composites manufactured by hand layup technique has a potential of replacing synthetic fibers, thus reducing environmental degradation and manufacturing costs.
2. Flexural strength of unsaturated polyester resin was higher than those of rice husk fiber reinforced polyester composites. There was a steady increase in flexural strength as fiber weight fraction increased up to 15 %*wt* and a decrease at 20 %*wt* in all the three fiber size classifications. The small size (250 – 500  $\mu\text{m}$ ) RHF composite generally had better flexural characteristics than medium and large size categories. At weight fraction ratio of 15/85, the composite yielded the highest flexural strength of 45.89 MPa and modulus value of 2860 MPa.
3. Statistical inference was made from ANOVA results, that both fiber concentration and fiber size have a significant influence on the flexural properties of rice husk fiber reinforced unsaturated polyester composites.
4. The process of fiber preparation and composite fabrication technique used in this work can be applied in examining mechanical properties of other lignocellulosic fibers. Further research should also be conducted in developing a mathematical model for predicting mechanical properties of rice husk composites at different fiber concentrations and size, thus further optimizing the performance of composite materials made from rice husks and polyester resin.

## **ACKNOWLEDGEMENT**

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## Simulating the influence of pm kit, spares replacement, and reuse strategies, on equipment reliability and maintenance cost

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### Abstract

Efficient and cost-effective maintenance of capital investment in the form of equipment, while attaining high productivity to remain economically feasible and competitive, through their effective life is important. In this regard, component deterioration and subsequent maintenance strategies employed, fulfill a significant role in affecting the reliability of the equipment. This aspect directly affects the availability due to unplanned downtime caused by failures. In this paper, spares replacement and reuse are identified as critical and complementing maintenance strategies. The stochastic component deterioration is modeled following the Semi-Markov Decision Process, where the remaining useful life of the components is changed by the impact of the maintenance strategy. A discrete event simulation model incorporating preventive (PM) and corrective maintenance actions performed on multiple components of a critical equipment is advanced. The proposed study is demonstrated through the use case of a thermal power plant, where components of the turbocharger which is one of the critical subsystems are modeled. From a moderate base turbocharger availability (with high reliance on replacement action), enhancement of reuse indicates a significant reduction in maintenance cost, while an increase in the PM interval depicts an increase in the maintenance cost. These findings have significant maintenance implications while understanding the dynamics of the various maintenance actions and offers maintenance decision support in various ways to enhance the equipment availability and reduce the maintenance cost which is also discussed.

**Keywords:** Spares, maintenance decision support, Semi Markov Decision Process

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## 5. INTRODUCTION

### 1.1 Background

Maintenance optimization seeks to balance the resources available at the disposal of the plant with the plant availability and cost reduction. Such a balance is not straightforward and requires oftentimes, in-depth study of the variables that affect the objectives of the plant including their interactions with each other which subsequently affect the performance. To address the challenge of optimizing plant availability and maintenance cost, several salient factors require to be considered to achieve this objective. Equipment usage, degradation, and failure characteristics are essential to enable accurate prescription of maintenance intervention. Similarly, significant are the maintenance interventions such as corrective, preventive and condition-based maintenance, which significantly affect the state of the equipment/component positively or negatively in case of perfect and imperfect maintenance respectively. Different variants of preventive maintenance (PM) can be followed during an optimization which includes use of PM kits that offer lower cost and reduce

maintenance time, use of newly manufactured spares for PM replacement (Chang 2012) and use product service system (PSS) where the plant purchases, the performance and not the equipment (Tukker 2015), and the conventional block-based replacement where components are replaced with new spares.

While considering the factors aforementioned in maintenance optimization, studies such as (Savsar 2015), have considered single factor optimization which follows the main effects of the single maintenance variable. Such studies, furthermore, ignore the interactive effects, where several objectives in an optimization often time conflicting to each other and hence maintenance decision support derived from optimizing one objective may be unreliable also corroborated by (Tian, Lin, and Wu 2012). Moreover, much of the research up until now, have not considered the effects and interaction quantification of the various variables, while selecting variables to incorporate in maintenance optimizations programs. This leads to challenges in the practical implementation of the optimization results in real life. This indicates the need to interpret the relationship of the various variables to the performance measures that will assist the maintenance manager wholesomely evaluates the optimization options from an informed position.

## *1.2 Related literature*

Several factors like reliability, maintainability, and availability (RAM) remain essential while addressing the maintenance optimization of critical components. Reliability of any component is determined oftentimes by the degradation or deterioration which infers the failure characteristics of the component. Maintenance strategies, on the other hand, consider policies that address the reliability aspects of the equipment. It is now well established from a variety of studies that these two aspects (maintenance strategies and reliability) are important in a maintenance program that considers optimization and further discussed in the following section (Atashgar and Abdollahzadeh 2017; Jiang, Chen, and Zhou 2015; Shafiee and Sørensen 2017). In this section, we review literature concerned with equipment failure and degradation characteristic, system or component analysis and finally we briefly review appropriate maintenance policies or strategies.

### *1.2.1 Failure and degradation*

Assets are utilized to generate performance that subsequently adds value in a business environment, for instance, engines in a power plant, are employed to generate electricity. The power is eventually utilized in facilities like hospitals and industries. The assets degrade or deteriorate while being exploited and may experience failure in the process, where this deterioration may be measured by an increase in the Operations and Maintenance (O&M) costs (Jardine and Tsang 2013).

Several approaches, that mimic as close as possible, the system's characteristic time to failure have been developed to model deterioration while undertaking maintenance optimization. A highly adopted approach employs statistical distributions like normal, exponential and Weibull to represent failure characteristic. However, this approach relies on the availability of failure data and other assumptions that offer less interpretability of the studied system. For instance, the Weibull approach retains several limitations; first, the implied assumption that the future is the same as the past and second, it applies to only one failure mode of an item, which means it cannot predict the life of a part that fails for several reasons or failure modes (Sondalini 2009). Approaches employing stochastic methods are used where the complexity of the model might be increased using statistical derived reliability. Such methods



include Markov models, Semi Markov and Hidden Markov which model the relationship between the observations and hidden states commonly represented using a conditional probability (Si et al. 2011). A distinct disadvantage of using these approaches is the state explosion that ultimately makes the optimization too complex to solve (Mahfoud et al. 2016).

### 1.2.2 System and Component level analysis:

While envisaging maintenance optimization, the analysis can be carried out based on system or component levels. A widely utilized analysis at the system level, considers interlinked equipment or components, such as a decomposed engine, into divergent equipment/systems such as a cylinder, governor, and oil pump. Several maintenance studies employing approach include (Alrabghi and Tiwari 2016; Wakiru et al. 2018b). In the contrast, distinct components such as bearings, gear, turbine blade, rotor blade are analyzed, while considering the component level approach. In situations where numerous components are considered, criticality analysis may be carried out to identify components that significantly impact the performance measure. In this analysis approach, each component is considered as an isolated unit (independent) and the possible dependency among components may be neglected (Shafiee and Sørensen 2017; Wakiru et al. 2018a). The indicated approaches can be considered depending on the expected optimization scope, data availability and clear information on all components constituting the system or subsystem. However, the combinatorial aspect while modeling the system/subsystem offers only a general high-level output which could further be used to analyze critical components. On the other hand, utilization of the component level analysis offers more intuition, insights and mimics the system being modeled to near reality in terms of operability.

### 1.2.3 Maintenance policies

Failure based maintenance also known as corrective maintenance (CM) is frequently employed upon failure of a component. Whereas it is not advisable to employ CM due to lack of planning and the consequences, it is advantageous where exploitation of the useful life of a component is fully achieved, hence reduced interventions and spare parts consumption (Poppe et al. 2017). This can be achieved by replacement of the failed components if, after inspection, the component is noted to retain significantly reduced the remaining useful life. Similarly, if a component is deemed to possess significant residual life left after an inspection, the reuse strategy can be advanced. The component, in this case, may be utilized in the same equipment or another similar equipment especially when new spares are unavailable. However, CM portends high downtime risk because when maintenance intervention is required, no prior planning has been done, hence lengthened downtime can be incurred while sourcing required materials and labor. To overcome this challenge, often enhanced required fill rate for spares or reuse strategy under the CM activities may be effective. To address the challenges posed by the CM strategies, preventive maintenance (PM) is advanced, where planned replacement of the components is scheduled either on a use-base or time-based approach, for instance after so many running hours of an equipment. Due to the inherent PM characteristics, the time taken for maintenance and the costs incurred are reduced compared to CM. However, the PM interval may be optimized to ensure, on one side the components are not replaced early so that their useful life is not fully utilized (over maintenance) or on the other side if PM interval is extended, fewer failures would occur and hence reduce significantly the CM interventions. Notable variants concerning PM replacement is the utilization of preventive maintenance kits, oftentimes referred to as repair kits, which are cost effective and

offer reduced replacement time due to their inherent intrinsic characteristics. Several studies on PM kits concept can be found here (ABB 2013; Hu et al. 2018).

### *1.3 Study aim and motivation*

The use of remanufacturing strategies such as reuse, and reconditioning has always been considered as part of maintenance strategies. The use of these often-interchangeable strategies (reuse and replace) in conjunction with other maintenance strategies such as repair and recondition would require a trade-off while seeking an optimal performance of an asset. The trade-off in this place represents the quantified value of equipment availability gain or loss and or reduced maintenance cost because of the adopted strategy. Reuse strategy is often employed in installations characterized by aging equipment that requires to perform optimally. In such a case, the maintenance functions seek to lengthen the life of a component beyond the expected end of life (EOL). This is further considered in cases prompted by obsolescence of some equipment and or components, which are no longer being produced or manufactured. Additionally, the replacement of such components with an advanced design would be costly in terms of modification and possible inherent failures due to the design change afterward. Furthermore, the maintenance cost represents a significant cost component on the total life-cycle cost of the equipment, hence the use of reuse and recondition strategies are employed (Wakiru et al. 2018a).

This study seeks to quantify the effect of reuse and replacement strategies, as well as the PM interval on the availability and maintenance cost, for a turbocharger whose deterioration is assumed to follow a Semi Markov process. The study seeks to expose the extent to which the maintenance strategies can be relied upon to improve the equipment performance. This will derive significant variables towards formulating an objective function that addresses the maintenance optimization of the equipment. Therefore, this study makes a significant contribution to maintenance optimization research, by developing a framework that will empower understanding the links between the variables which can be engraved in optimization models.

This is an extended work of (Wakiru et al. 2018a), nonetheless, several aspects differentiate the current study from the previous. This study incorporates the maintenance cost performance measure, while the previous study presented repair time. Moreover, the previous study modeled the turbine rotor as a single component while undergoing the repair strategy. This aspect in the current study is advanced after consultations with the maintenance function and the OEM, where the turbine rotor is disassembled and various components such as turbine blades, rotor shaft, turbine wheel, compressor wheel and complete turbine rotor system are incorporated separately in the model. Finally, in the current study, the bellows were expunged since, after consultation, it was established that for comprehensive analysis, the component did not directly affect specifically the turbocharger but affected the engine hence could be unaligned wholly to the turbocharger.

The remaining part of the paper proceeds as follows: Section 2 describes the methodology adopted, while Section 3 demonstrates the results and discussion from the case study. Finally, Section 4 concludes the paper and offers future directions.

## **6. METHODS**

The methodology adopted in this study consist of four steps. Step one involves the collection and pre-processing of the data, Step 2 allows for the extraction of the various variables to be employed in the simulation model. Step 3 involves developing

the simulation model and carrying out the simulation experiments, while Step 4 will include evaluating and interpreting the simulation experiment results.

### 2.1 Data collection and pre-processing

This study utilizes maintenance data on failures from a thermal power plant remotely located in Eastern Africa. The data for the components constituting the turbocharger i.e. base plate, bearings, gaskets, Lube oil pipe, others and turbine rotor system (disassembled to turbine blades, turbine wheel, and compressor wheel) considering a six-year period (2011- 2017) were used from the subject thermal power plant.

### 2.2 Parameter extraction

The turbocharger was decomposed into its components, failure analysis carried out for the various components and maintenance/recovery strategies parameters extracted. The various parameters include the time to next failure, spare costs for each of the components, repair time for respective (CM and PM) strategies, labor rate per hour for maintenance, failure frequencies and PM kits costs.

### 2.3 Simulation modeling

The simulation model mimics the failure generation and intervention for components of the turbocharger as illustrated in Figure 1.

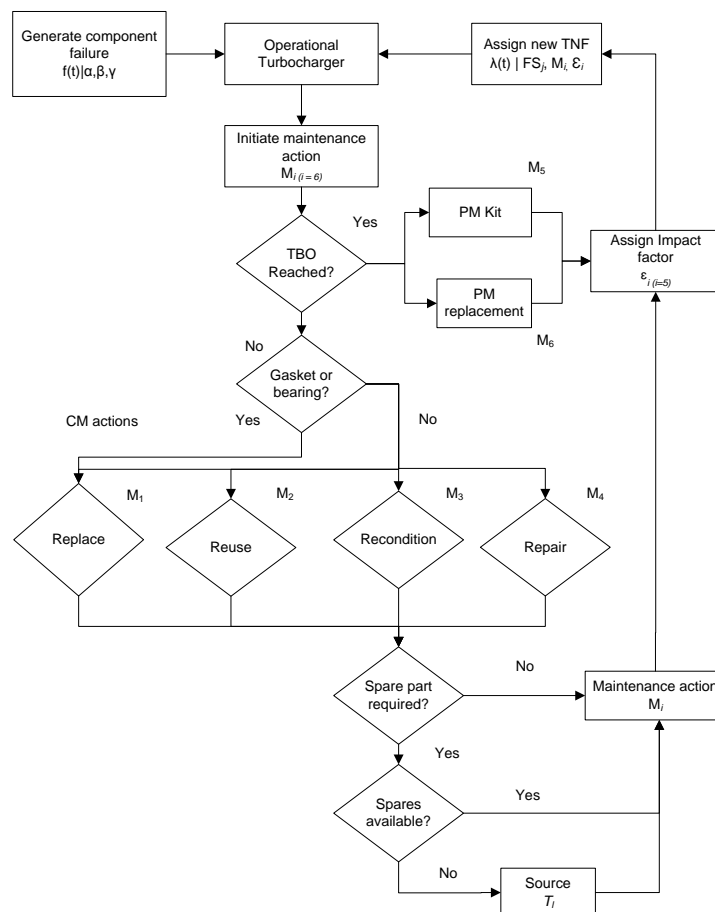


Figure 1: Conceptual representation of the simulation model

While the turbocharger is running, preventive maintenance, in this case, replacement of all components is done at scheduled running hours  $\tau$  (PM interval) of the engine. While running, random unplanned failures employ corrective maintenance that

includes several maintenance interventions. The first CM strategy is the replacement of failed components with a newly manufactured spare, which is mandatory for bearings and gaskets, while other components possess probabilistic utilization of the other strategies. This aspect is influenced by the fill rate, where if the spare is unavailable than it is sourced, hence incurring sourcing lead time. Reuse strategy is also employed for components that can be sourced from equipment either decommissioned or opportunistically waiting for other spares hence not operating. This is commonly termed as cannibalization, though in this study, more dominant, are spares stored from previously decommissioned or reworked turbochargers. Repair strategy is used where the components failure state is repairable, and the component can be brought back to its functional condition. Reconditioning strategy is also employed where the cores of the components are availed and the OEM or an agent can restore components and avail with some warranty. In this study, it is assumed that the reconditioning is done after failure occurrence.

Table 1. Notations utilized in the study

$i$	Number of maintenance actions	$I$	Turbocharger running hours
$M_i$	Maintenance strategies	$A_o$	Operational availability (%)
$\varepsilon_i$	Age renewal factor	$T_m$	Total maintenance time (hrs.)
$\tau$	Preventive maintenance interval	$PM_{poi}$	Preventive maintenance (PM) policy
$\eta_i$	Reliance factor/index	$C_{s_n}$	Spare cost for $n^{th}$ component
$FS_i$	Hazard rate/Failure severity	$T_{r_i}$	Recovery/repair time (hrs.)
$C_m$	Total maintenance cost (K€)	$T_l$	Sourcing lead time (hrs.)
$C_s$	Total spare cost (K€)		
$C_L$	Total labor cost (K€)		

Preventive maintenance (PM) is modeled following two options, where the first involve replacement of the components with newly manufactured spares, while the second, a preventive maintenance kit is utilized along replacement of components not included in the kit, following the lapse of the  $\tau$ . The maintenance actions/strategies  $M_i$  modeled include replacing ( $M_1$ ), reuse ( $M_2$ ), recondition ( $M_3$ ), repair ( $M_4$ ), PM using the kit ( $M_5$ ) and PM employing new spare replacement ( $M_6$ ). To model the maintenance strategy frequency of usage, reliance factor  $\eta_{i=1,2,3,4}$  is introduced, which indicates the percentage usage of the specific  $M_i$ .

The effective age renewal factor or the impact of the respective recovery/maintenance strategy on a component's remaining useful life is depicted using an impact factor  $\varepsilon_{i(i=1,2,3,4,5,6)}$  (note  $\varepsilon_5 = \varepsilon_6$ ), which range from 0 depicting "as bad as old" (ABAO) and  $\varepsilon=1$  "as good as new" (AGAN). A hazard rate  $FS_j$ , an index indicating the severity or seriousness of a component failure state is introduced, with stochastic transitioning severity state of a component prior and after maintenance action. Posterior  $\varepsilon_i$ , depends on the prior severity state and the maintenance strategy impact hence depicting a multi-state system (MSS). A Semi Markov Decision process is

employed to model deterioration of the components, which considers the partial observed degradation that influence the posterior state of the component after maintenance intervention. The maintained component is assigned the new  $\epsilon$  and  $\rho$  and subsequently continues to run till either next PM or CM.

## 2.4 Evaluation and interpretation

For this study, the key performance measurements include the turbocharger operational availability  $A_o$  and the total maintenance cost  $C_m$ . A sensitivity analysis is performed to ascertain the impact of reliance of replacement and reuse strategies separately. Additional analysis on the effect of the PM interval is also done. During the analysis, the indicated variables will be varied as follows:  $PM_{pol}$ (1-PM replacement, 2-PM kit),  $\tau$  (10,000 – 13,500 hrs.), replace reliance  $\eta_1$  (50% - 85%) and reuse reliance  $\eta_2$  (50% - 85%). The values of  $\eta_1$  and  $\eta_2$  are utilized alternately summing up to 85% (total of the probability utilization of the two strategies in real life operations).

## 7. RESULTS AND DISCUSSION

### 3.1 Modeling, verification and validation

#### 3.1.1 Model parameters

The model parameters adopted from the case established in the paper (Wakiru et al. 2018a)

$\tau$ , 8,000 hours;  $\epsilon_1$ , 90%;  $\epsilon_2$ , 40.5%;  $\epsilon_3$ , 43.94%;  $\epsilon_4$ , 55.59%;  $\epsilon_5$ , 95%;  $\eta_1$ , 62.71%;  $\eta_2$ , 22.03%;  $\eta_3$ , 9.33%;  $\eta_4$ , 5.93%. Other parameters extracted from data and maintenance schedules included, the respective component's new spares costs  $C_{s_n}$  and distributions depicting the time to next failure  $\lambda_n$ . Such distributions included WEIB ( $\alpha, \beta$ ), BETA ( $\alpha, \beta$ ), with shape parameter  $\beta$  and scalar parameter  $\alpha$  while exponential distribution has the mean and TRIA with the minimum, average and maximum. Additional parameters included, sourcing lead time  $T_i$ , repair/recovery time  $T_{r_i}$  for each maintenance strategy.

#### 3.1.2 Modeling

The performance measures turbocharger availability  $A_o$  and the total maintenance cost  $C_m$  are defined by equations (1) and (2) respectively as follows:

$$A_o = \frac{I}{I + T_m} \quad (1)$$

$$C_m = \sum_{k=1}^i C_{L_k} + \sum_{k=1}^i C_{S_k} \quad (2)$$

Since the model starts with no activity, attainment of a steady state is important. The use of a warm-up period of 10000 hours was employed, while the replication length was 105,120 hours equivalent to 12years operation. To address the issue of large half width, the number of replications was computed from the initial 10 replications generating half width of  $\pm 6.15\%$ , in our case approximately 100 replications leading to  $\pm 2\%$ .

$h_o$  = half width from “initial” number  $n_o$  of replications

$$h = n_o \frac{h_o^2}{h^2} = 10 * \frac{6.15^2}{2^2} = 94.55$$

### 3.2 Simulation results

Table 2 illustrates the model results which are categorized to two, where the first result considers PM with full spares replacement, while the second considers employment of the PM kits.

Table 2: Simulation base results

Model approach	$A_o$	$C_m$ (K€)
PM approach I	94.019%	1,005.2
PM approach II	93.176%	977.75

It can be seen from Table 2, that the use of the PM kit (PM approach II) offers a reduction of the total maintenance cost by 27.45 K€ compared to PM approach I. This could be attributed to the cost advantage the PM kit retains, when utilized, an aspect also corroborated by (Saccani et al. 2017). However, the use of approach II generates moderately reduced availability, which may probably be attributed to a moderate increase in repair time, occasioned by components which demonstrate their reliability negatively affected. This is because the approach I entrench significant probability to install higher values of  $FS_j$  compared to approach II. However, overall availability compared with the actual empirical of 92% show minimal deviation which is attributed lack of Condition-based Maintenance (CBM) strategy utilization.

### 3.3 Sensitivity analysis results

Sensitivity analysis was carried out following the objectives of the study as depicted in Section 1.3. The first experiment seeks to evaluate the reliance on replacing strategy, while the second evaluates a reuse strategy. The final experiment evaluates the influence of PM interval.

#### 3.3.1 Replacement strategy- $\eta_1$ reliance

From results depicted in Figure 2, it is demonstrated that reliance on replace strategy  $\eta_1$ , minimally reduces  $A_o$  and moderately increases the  $C_m$ . The reduction of  $A_o$ , may be attributed to the increased downtime time, occasioned by the increase in sourcing lead time for the unavailable spares as per the fill rate  $f$ . The employment of this strategy, as expected, retain a disadvantage of incurring higher spare costs, which negatively impact  $C_m$  as also seen in Figure 2. This is the case because, the spares utilized are newly manufactured and hence the spare cost increases. A trade off area of retaining  $\eta_1$  (55% - 65%) indicates optimum  $A_o$  and  $C_m$  for such a case study.

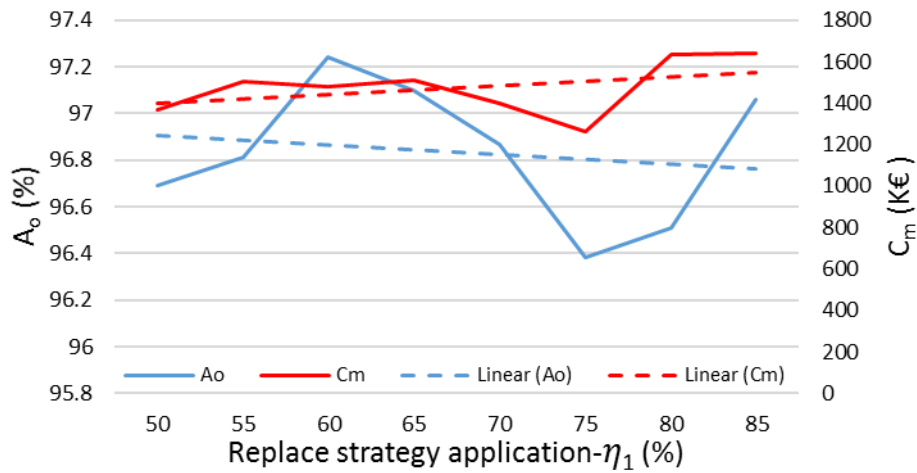


Figure 2: Variation of replace strategy  $\eta_1$  reliance

### 3.3.2 Reuse strategy- $\eta_2$ reliance

While investigating the effect of reliance on reuse strategy, Figure 3 shows that on an average basis, significant improvement of both  $A_o$  (increase) and  $C_m$  (decrease) is noted. The increase in  $\eta_2$ , firstly reduces the repair time due to significantly low sourcing lead times, while utilizing reusable spares. In the second place, the significantly low-cost characteristic of reusable spares positively affects the  $C_m$ . However, due to the utilization of this strategy, it is expected the system reliability is compromised hence the non-linear behavior of the curves as demonstrated in Figure 3. To employ such a strategy, caution should be observed, while addressing the reliability transition of the components or equipment being reused.

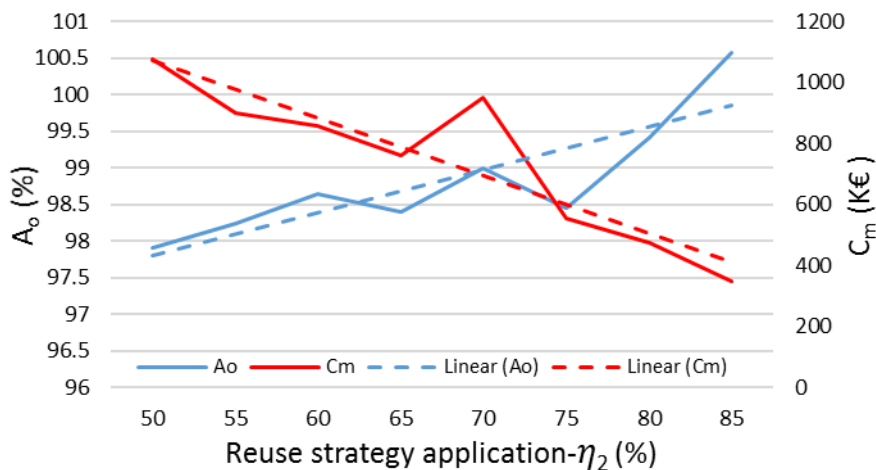


Figure 3: Variation of reuse  $\eta_2$  strategy reliance

### 3.3.3 PM Interval- $\tau$ variation

Figure 4 illustrates the changes in both  $A_o$  and  $C_m$ , while varying the PM Interval  $\tau$ . An increasing trend of  $\tau$  shows a remarkable increase in  $A_o$ . This can be attributed to the extended time of running for the turbocharger before the planned stoppage for PM.

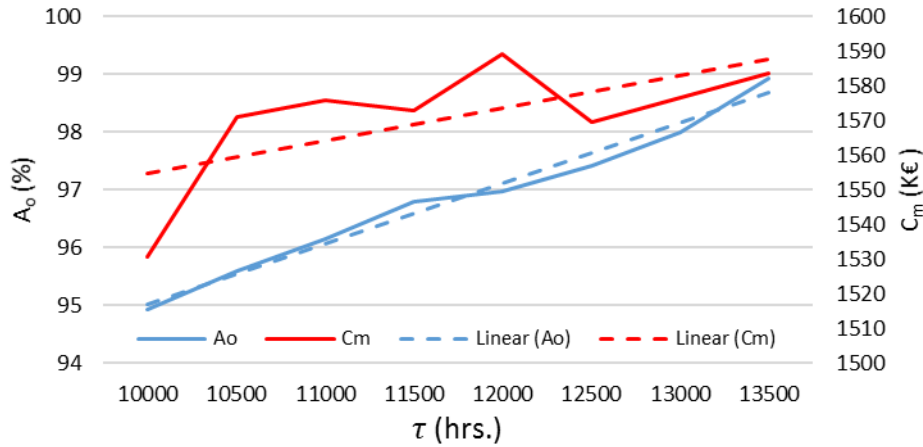


Figure 4: Variation of PM Interval  $\tau$  strategy

However, this extension produces a negative impact on the components failure rate since the reduced renewal process leads to a significant failure rate dealt using CM interventions which are costly, hence the increase in  $C_m$ . The non-linear characteristics of the  $C_m$  curve indicates potentially external factor (s) interacting with  $\tau$ . However, while considering optimal  $\tau$ , this aspect require consideration and further, the trade-off between the performance measure preferences of the maintenance team should cautiously be considered, in collaboration of the changing maintenance objectives of organizations, while determining the optimal value of  $\tau$ .

In summary, the enhanced replacement strategy will ensure the components in operation continuously retain high reliability, hence in the event, they are reused, the reliability retained within will ensure longevity and reduced failures. This subsequently will offer a reduction of the  $C_m$  if both reuse and replace strategy can be employed in a hybrid approach to complement each other. Another downside of the replace strategy, it infers the possibility of replacing component's whose whole lifetime is not fully exploited and hence, the reliance of newly manufactured spares during both the PM and CM activities, complemented with the high instantaneous availability of the inventory, undoubtedly will increase  $C_m$ . Both of this approach would indirectly relate to replacing components before full exploitation of their residual life, an exercise that may be referred to as "over maintenance".

### 3.4 Summary

Some of the issues emerging from these findings relate principally to the importance of accurately establishing the accurate time to make a specific maintenance intervention, to mitigate what was earlier highlighted as "over maintenance" as well as unplanned failures. It is clear, that an approach should be derived for such a plant, to either consider the severity or the mean residual life of the component while making decisions on when to intervene with a specific maintenance strategy/policy. Hence, further work is required to establish the viability of considering these two aspects i.e. the component severity (hazard rate) and remaining useful life (RUL) in maintenance intervention decision making. This combination of findings considering the influences of  $\eta_1$ ,  $\eta_2$  and  $\tau$  on both  $A_o$  and  $C_m$ , provides some support for the conceptual premise that reliance of single decision variable or main effects, leads to sub-optimal maintenance optimization. It is then prudent for maintenance managers to investigate beforehand, all the possible decision variables that demonstrate the potential to be included in the maintenance program. The evaluation should address



both effects or impacts to the performance measures, and interaction characteristics between them. This will inform the maintenance team on the essential decision variables to consider, hence, deriving a wholesome and accurate optimization outcome. From the sensitivity analysis, it has been demonstrated that enhanced utilization of the reuse strategy offers better optimization outcome compared to replace strategy. However, the utilization of both strategies under a hybrid approach forms a substantial issue for future work.

## 8. CONCLUSION

The aim of the present research was to examine the effects of firstly, reliance in reuse and replace maintenance strategy, secondly, the PM interval and thirdly the PM kit on both the Turbocharger availability and total maintenance cost. These findings provide significant implications to the understanding of how the investigated decision variables should be incorporated in the optimization processes. The results clearly show the reliance on a single variable for optimization would lead to the sub-optimal outcome. The insights gained from this study will be of assistance to the maintenance managers while prudently selecting the maintenance variables that will significantly affect their maintenance programs, especially as concerns optimization where various decision variables constitute the maintenance objective function.

To realistically attain near empirical performance measure, subsequent work incorporating the analysis of effect and interactions, condition-based maintenance and utilization of an RUL threshold for maintenance intervention decision making is proposed.

### Acknowledgment

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## **Design, Validation and Calibration of a Rapid protyped wind speed measuring instrument.**

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### **Abstract**

A Prandtl probe is one of the standard instruments used for flow measurements in wind tunnel facilities. It indirectly measures the mean air velocity at a particular point in a flow regime. Its conventional production cost is quite high hence making it expensive. The emergence of desktop platform in the additive manufacturing offers a relatively cheaper option; first by fabricating products at a fraction cost and footprint compared to Industrial 3D printers and secondly, ability to manufacture intricate shaped structures with less waste, development and production time than conventional manufacturing technologies. These advantages impelled the investigation of 3D printing of a Prandtl probe and also as evident by 3D printed instruments and equipment's built for scientific research in fluid dynamics. The aim of this research was to design, calibrate and validate a 3D printed Prandtl probe manufactured by additive desktop technology. A Prandtl probe was designed using NX software with dimensions according to standards derived from literature and a chosen reference standard metallic Prandtl probe. The diameter of the first prototype was 10 mm, with stepwise reduction of 2 mm for successional prototypes. Each design was printed using the selected desktop stereolithography technique and then tested in a wind tunnel for velocity ranges of 0 m/s to 51 m/s. Validation against a reference metallic Prandtl probe revealed that a 3D printed Prandtl probe gives accurate measurements. Comparisons against cup and hot-wire anemometers showed small deviations in the anemometers readings which were due to temperature changes and cup blockage effect respectively. This research attested the option of fabricating relatively cheap functional Prandtl probe with stereolithography techniques which can be used for accurate determination of flow quality in wind tunnel aerodynamics experiments. This promotes wind energy competitiveness in energy field as it cut costs of wind energy studies in instrumentation section.

Keywords: 3D-print, Prandtl probe, stereolithography

### **INTRODUCTION**

A wind tunnel is a rapid and an accurate experimental tool in the field of fluid dynamics, which is mostly used to conduct aerodynamics research, validate numerical flow simulation and support design decisions. Before it's put to use, it requires a number of flow characterization in order to explore the quality of the flow such as the mean flow, velocity profile, and turbulence /spectral intensity. All these are carried by specialized wind speed measuring instruments such as a Prandtl probe.

The Prandtl probe was often used as a standard metrological instrument for flow speed measurements (Vern E. Bean and J. Michael Hall, 1999, July) and currently it is still being used as a tertiary standard (Shinder, Crowley, James Filla, & Moldover, 2015). This is because of its capability to give fast, accurate and reasonable repeatable measurements in a simple and inexpensive set up in a wind tunnel. Its first description was given by Henri Pitot in 1732 (Brown, 2003). It is composed of two hollow tubes; one to measure the total pressure ( $P_t$ )[Pa], which has a port at the tip, directly facing the flow and the other one measures the static pressure ( $P_s$ )[Pa], which has a band of pressure ports downstream, parallel to the flow. From Bernoulli's principle, the difference of static pressure from the total pressure is the dynamic pressure,  $\Delta P_{dyn}$ , from which the mean fluid velocity (with local air density calculated from atmospheric pressure and temperature measurements) is calculated using equation 1 and 2 (OWER & PANKHURST, 1977), where  $\rho$  is the air density in [kg/m<sup>3</sup>].

$$\Delta P_{dyn} = P_t - P_s \quad (1)$$

$$U = \sqrt{\frac{2\Delta P}{\rho}} \quad (2)$$

The conventional fabrication method for the Prandtl probe requires skilled craftsmanship, precision drilling, lathing and soldering of its several parts. This reflects into high costs of production hence making it expensive which in turn reflects into high costs of wind energy studies. The motivation behind to investigate the fabrication of this instrument using additive manufacturing which fabricates products through layer by layer material deposition was due to the emergence of the desktop technology platform. The desktop technology platforms are relatively cheap as they offer the opportunity to fabricate products at a fraction cost and footprint compared to industrial 3D printers (formlabs, 2018b). In addition, this technology platform has the capability to manufacture intricate shaped structures with less waste, development and production time than conventional manufacturing technologies (Mpofu, T. P., Mawere, C., & Mukosera, M., 2014). These advantages have already led it to be used in fabrication of instruments and equipment's built for scientific research in fluid dynamics such as the liquid flow meters (Leigh, Purssell, Billson, & Hutchins, 2014) and models for wind tunnel testing (Olasek & Wiklak, 2014).

Therefore, the goal of this study is to investigate the capability of additive manufacturing desktop technologies to fabricate a functional Prandtl probe.

## METHODOLOGY

This section describes the steps involved in the fabrication of a 3D printed Prandtl probe (PP) and its validation with a standard metal Prandtl probe (SP). The comparison of PP against hot-wire and cup anemometers is also explained.

### Designing

NX 10 Siemens modelling software was employed to create the 3D CAD model for PP. Design measurements such as the nose section length, stem section length and position of static holes were all derived from SP.

Figure 1 and 2 below show a 3D CAD model and a 2D description of the proposed PP respectively.

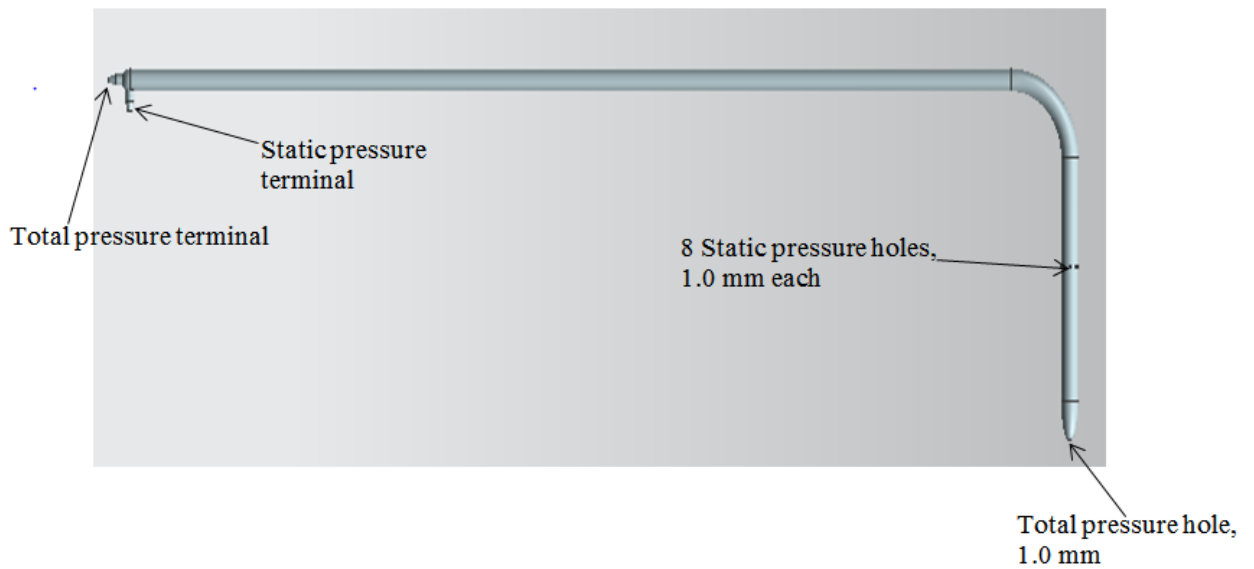


Figure 27: CAD model of PP probe.

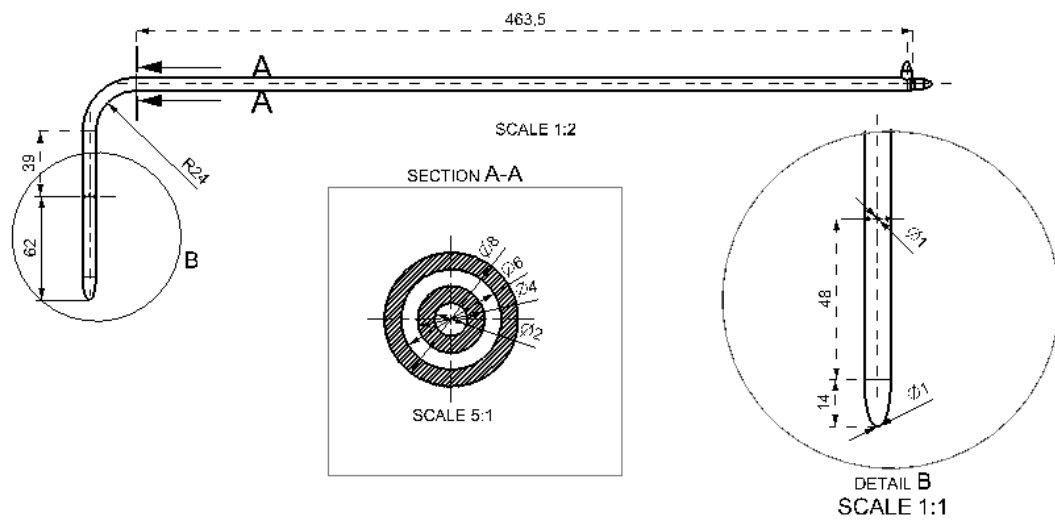


Figure 28: 2D drawing of proposed PP probe

PreForm software 2.17 was used to process the STL CAD files and generate the 3D printer building path.

### Fabrication Process

Three common desktop technologies for 3D printing plastics exist today with each having its pros and cons (figure 3 below).

	Fused Deposition Modeling (FDM)	Stereolithography (SLA)	Selective Laser Sintering (SLS)
<b>Pros</b>	Fast. Low cost systems and material.	High accuracy. Smooth surface finish.	Strong functional parts. Design freedom.

<b>Cons</b>	Low accuracy. Low details. Limited design compatibility.	Limited build volume Sensitive to long exposure UV light.	Expensive machinery. Limited material options. Rough surface finish.
<b>Price</b>	Mid-range desktop printers starts at \$2000 and Industrial systems acquirable at \$20,000.	Professional desktop printers' starts at \$3,500 and large-scale industrial machines are available from \$80,000.	Bench systems start at \$10,000 and Industrial printers are purchasable from \$200,000.

Figure 29: Desktop technology comparison (formlabs, 2018a)

From the desktop technology comparison (figure 3), desktop SLA technique was seen as better technique compared to the other two. More reasons for its choice also included:

#### High Resolution and Smooth Surface Finish

Parts created from SLA have a smooth surface finish. This is ideal for application requiring flawless finish and it helps to reduce the post processing time (finishing processes).

The resolution of a 3D printer is commonly defined using the Z-axis layer height. For SLA (Form 2 printer type from Formlabs company) this ranges between 25 and 100 microns with a trade-off between speed and quality. In comparison to FDM and (SLS), these have Z-axis layers at 100 to 300 microns. However, parts printed by SLA at 100 microns looks different than those from FDM or SLS. SLA prints are smoother because their outer perimeter walls are straight and newly printed layer interacts with the previous layer, smoothing out the staircase effect. FDM prints have clearly visible layers, whereas SLS prints have a grainy surface from the sintered powder.

SLA also give finer detail output, given 140 micron laser spot size on the Form 2 in comparison with 350 microns on industrial SLS printers, and 250–800 micron nozzles on FDM machines (formlabs, 2018b).

SLA prints are easy to clean and post-process. The resin is easy to wash out of internal channels, giving the possibility for design features like micro-channels or cavities, which would not be possible with any other 3D printing process (formlabs, 2018b).

Form 2 SLA printer was selected as the 3D printing machine. It has a print volume of 145 x 145 x 175 mm with ability to print parts with layer thickness of at least 0.25 mm.

#### Material choice.

There are varieties of engineering materials (resins) from Formlab company to use with their printers. Durable resin was chosen because it has the highest advertised impact strength as an engineering resin, (formlabs, 2018c). Its low modulus and high elongation make it highly resistant to deformation.

Due to the limit of the printing platform in terms of height of the printer space, printing was composed of four parts. Figure 4 below show the developed CAD model for the four parts.

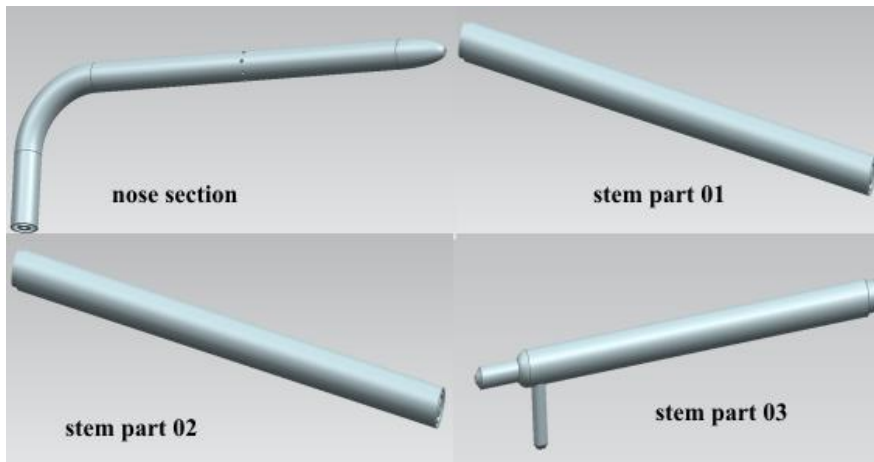


Figure 30: **Four CAD models for PP probe.**

The printing process involved the following steps.

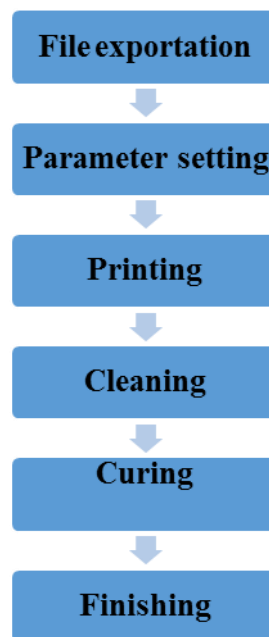


Figure 31: Fabrication flow chart diagram.

### **I. Uploading**

The design was exported in .stl file format that's readable by the software Preform which prepares the file for the 3D printer (Form 2).

### **II. Parameters setting**

The printer parameters were adjusted in order to slice the imported .stl file into layer thickness that determined high output resolution for the 'prints'. More adjustable settings such as orientation, support structures, and material choice best for printing were set.

### **III. Printing**

A quick confirmation of the correct setup was performed automatically and then printing process began. The machine ran unattended until the printing process was

complete. This included automatically refilling of the resin material from the cartridge tank.

#### **IV. Cleaning**

The printed parts were rinsed in isopropyl alcohol (IPA) to remove any uncured resin from their surface. In addition, air was also blown from the ends of the tube to remove any left resin or IPA.

#### **V. Curing**

It involved the finalization of the polymerization process and stabilizing the mechanical properties. The printed parts were placed inside a curing chamber for 1 hour at a 60 degree Celsius. This helped in finalizing polymerization process and stabilizing the 'print' mechanical properties.

#### **VI. Finishing**

The supports structures were removed using flush cutters and thereafter, the support marks left were removed through sanding by fine emery paper.

#### **Leakage tests**

The printed parts were joined together using glue and tested for any leakages through blowing air in each pressure line in search of any leakages in form of air bubbles in a water pool and a pressure drop reading in a Betz manometer. No leakages were found by these inspection criterions.

#### **Validation of the 3D printed Prandtl probe**

Two wind tunnels were used for the experimental validation; wind tunnel 1 and 2. Spatial distribution of these wind tunnels were measured in order to determine the velocity profiles and turbulence properties of the air jets. Hot-wire of type TSI 1210-T1.5 was used as a measuring instrument. The measurement time per measurement point was set to 1 second with a sampling rate of 1000 Hz. The measured area for both wind tunnels was defined by x, y and z coordinate system. The orientation of the Y-axis is parallel to the jet axis. A traverse (positioning) system was used to move the hot-wire probe along the two spatial directions (x and z). Wind tunnel 1 area was 100 mm by 100 mm (nozzle cross-section plus 20 mm edge on each side). Wind tunnel 2 area was 420 mm by 420 mm (nozzle cross-section plus 10 mm edge on each side).

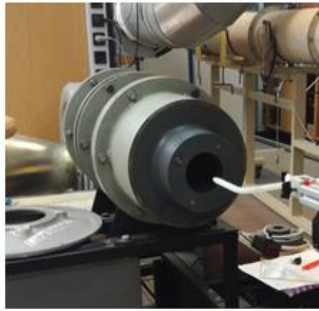
#### **Set up 1**

Wind tunnel 1 was used as a source of air flow for velocity between 0 m/s to 51 m/s. This set-up was used to calibrate PP 1 (10 mm diameter size) probe using SP probe as reference instrument. It was also used for calibrating the hot-wire anemometer.

The set-up was arranged as shown in figure 7 below and the data and command flow charts are as shown in figure 8.



**PP 1 configuration**



**Configuration of measuring devices at wind tunnel I**

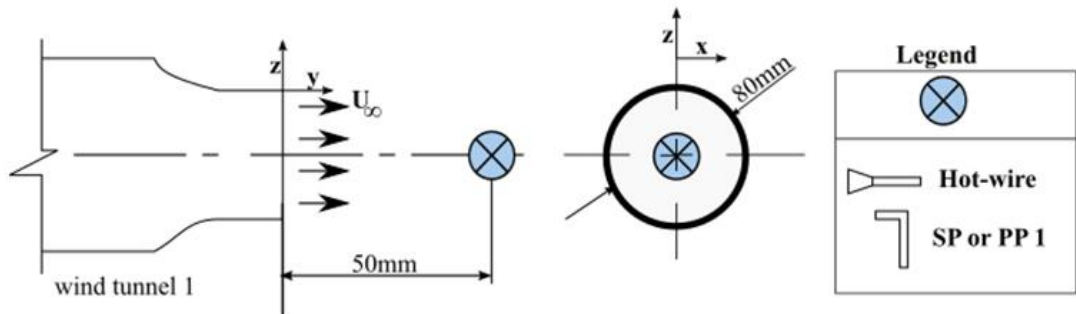


Figure 32: set-up 1 layout.

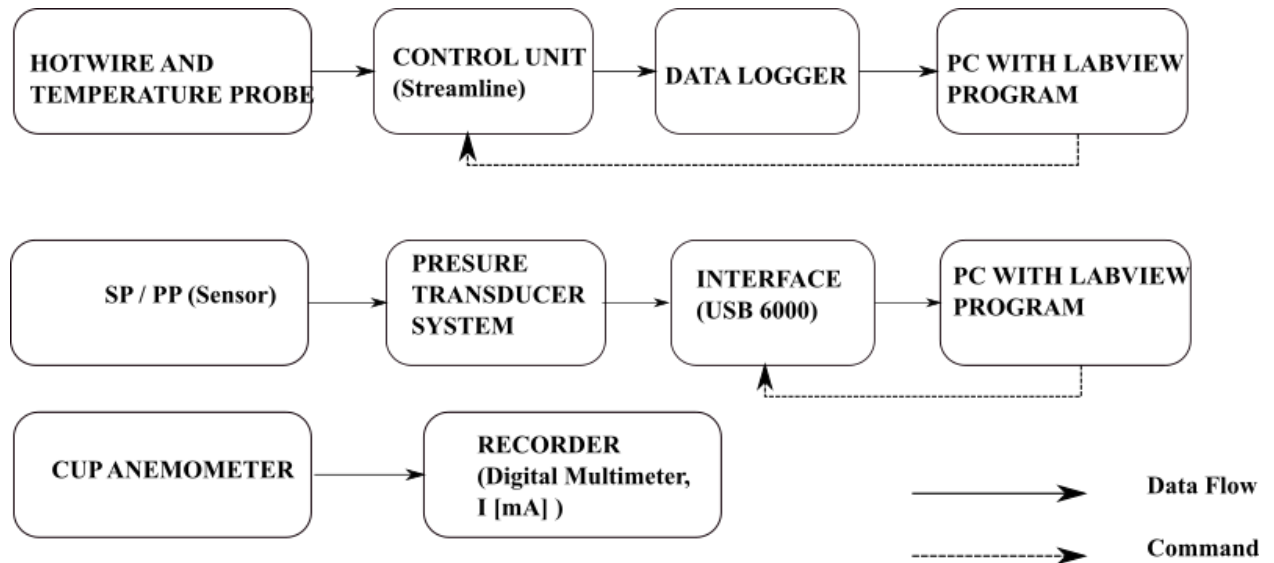


Figure 33: Data and command flow diagram of measuring instruments.

**Hot-wire calibration**

A Hot-wire is a thermal transducer which measures velocity and turbulence intensity of fluids by determining the heat convected away by the fluid. It has an exposed wire (filament) which is heated up by either a constant current or maintained at a constant temperature. The wire is made from a material possessing temperature coefficient of resistance; that is, the resistance of the wire varies with its temperature.

Calibration serves to assign a flow velocity to each measured bridge voltage. Based on King's law, the relationship between the flow velocity and the bridge voltage is not linear. Therefore in order to determine the calibration curve (equation 3), 31

measurements points were used for velocity between 0 to 50 m/s. Figure 5 gives the recorded voltage and equivalent velocities while figure 6 gives the calibration coefficients and the temperature values used.

$$U = C_0 + C_1 \cdot E_{corr} + C_2 \cdot E_{corr}^2 + C_3 \cdot E_{corr}^3 + C_4 \cdot E_{corr}^4 \quad (3)$$

Where

- U - the flow velocity
- C<sub>0</sub> to C<sub>4</sub> - the calibration coefficient.
- E<sub>corr</sub> - the corrected bridge voltage, which is given as in equation 4 below.

$$E_{corr} = \left( \frac{T_w - t_{ref}}{T_w - t_{amb}} \right)^{0.5} \cdot E_B \quad (4)$$

Where

- T<sub>w</sub> - Operating temperature of the hot wire.
- t<sub>ref</sub> - Reference temperature (ambient temperature for hardware configuration).
- t<sub>amb</sub> - Ambient temperature during calibration or measurement.
- E<sub>B</sub> - Measured bridge voltage.

Figure 8 below shows the calibration curve for the hot-wire anemometer.

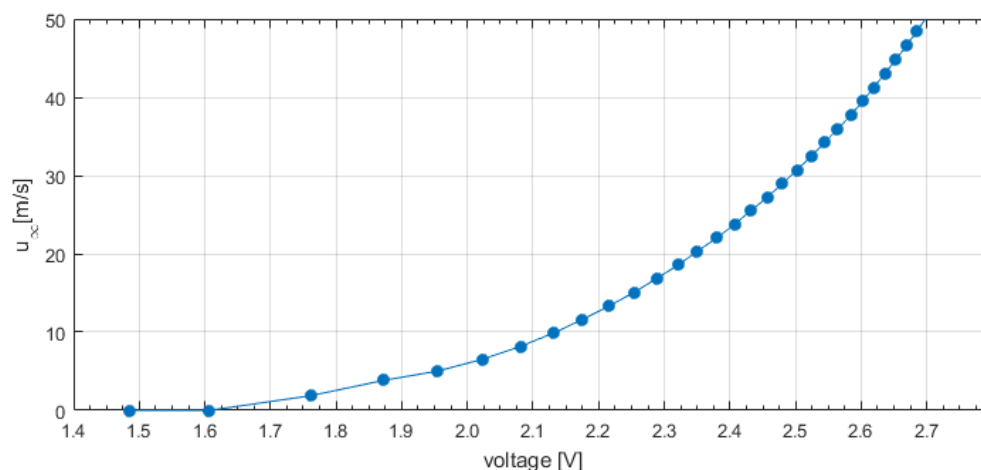


Figure 34: Hot-wire calibration graph.

### PP 1 calibration.

The PP1 probe was placed at the middle as shown in figure 7 above and velocity readings for air flow between 0 to 51 m/s wind tunnel 1 speed at approximately interval of 5 m/s were recorded. Calibration graph with SP probe as the standard reference instrument is as shown in figures 11 and 12 below.

## Set up 2

Wind tunnel 2 was used as source of air flow for velocity between 4 m/s to 13 m/s. This set-up was employed for taking velocity readings of both the cup and hot-wire anemometers and compare them to both PP1 and PP2 (8mm diameter size) probes. The set-up for data collection was arranged as shown in figure 9 below. Data and command flow charts are similar as those shown in figure 7 above.

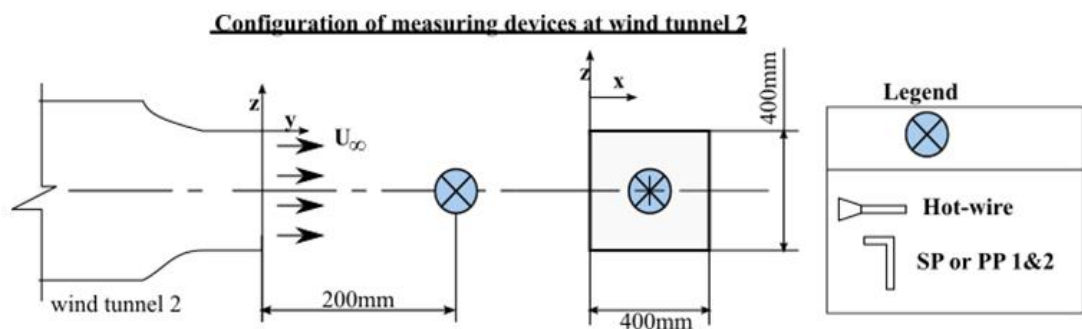


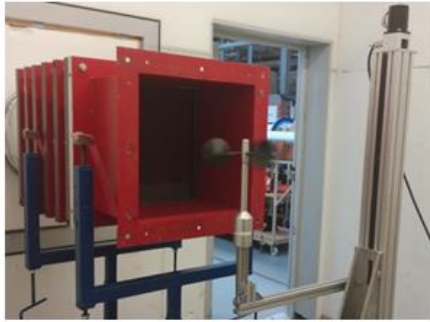
Figure 35: Set-up 2 layout.

### Cup anemometer calibration.

The cup anemometer was placed in a uniform flow field as shown in figure 11 below. Currents reading for air flow velocity of 4.8 m/s to 12.8 m/s were recorded. SP was used as reference instrument with velocity readings from the four positions (figure 11) averaged to give the flow velocity equivalent to the current readings. The calibration graph is as shown in figure 13 below.

Data and command flow charts are similar as those shown in figure 7 above for cup anemometer.

### Cup anemometer configuration



### Cup anemometer calibration set-up

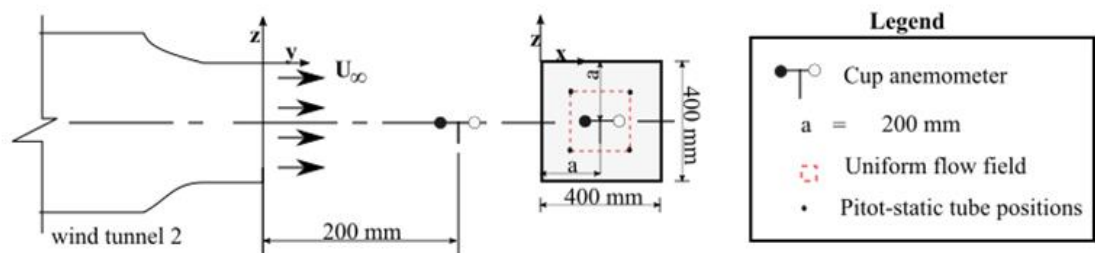


Figure 36: Cup anemometer calibration set-up layout.

## RESULTS AND DISCUSSION

Figure 11 below shows a fully joined 3-D printed Prandtl probe of 8 mm diameter.

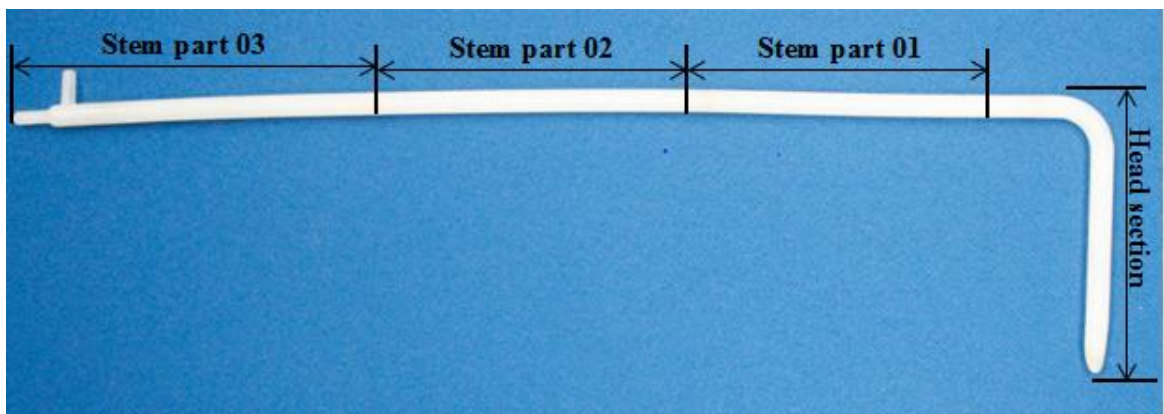


Figure 37: Fully joined 3D printed Prandtl probe.

Figure 12 and 13 below give the calibration graph of PP 1 at 1 m/s and 5 m/s intervals respectively.

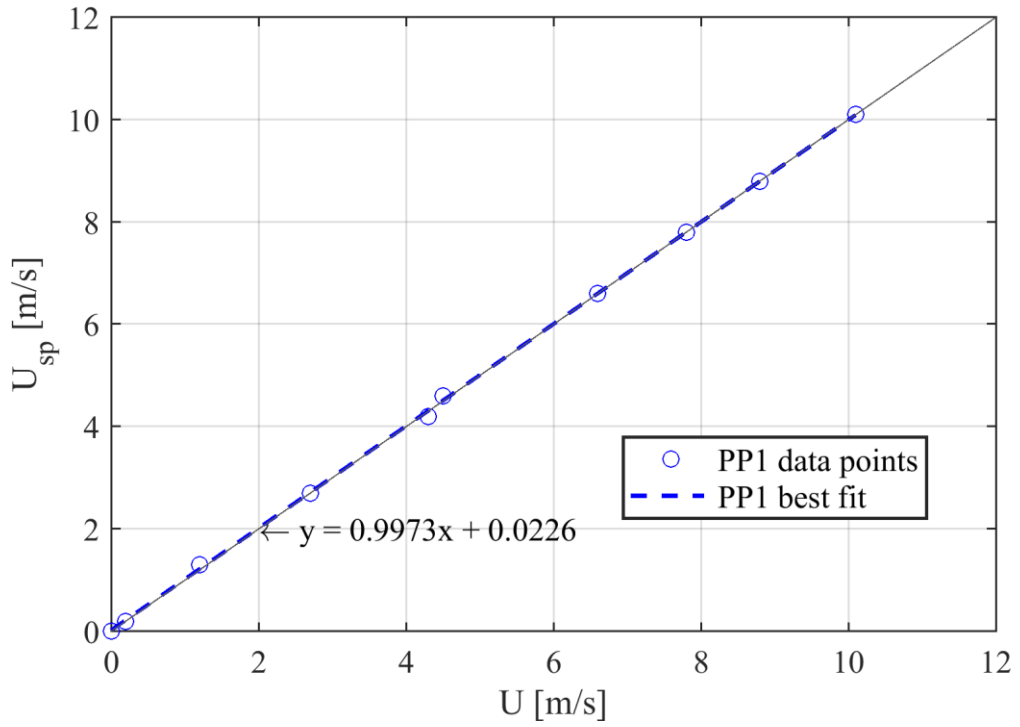


Figure 38: Calibration graph of PP 1 at low velocities.

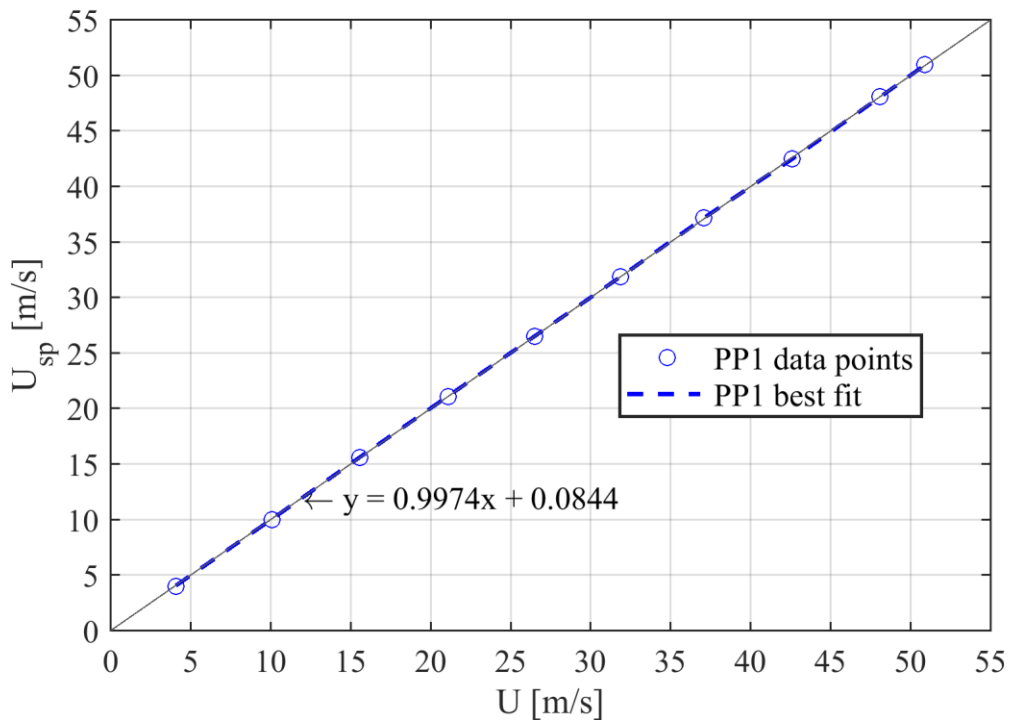


Figure 39: Calibration graph of PP 1 at high velocities.

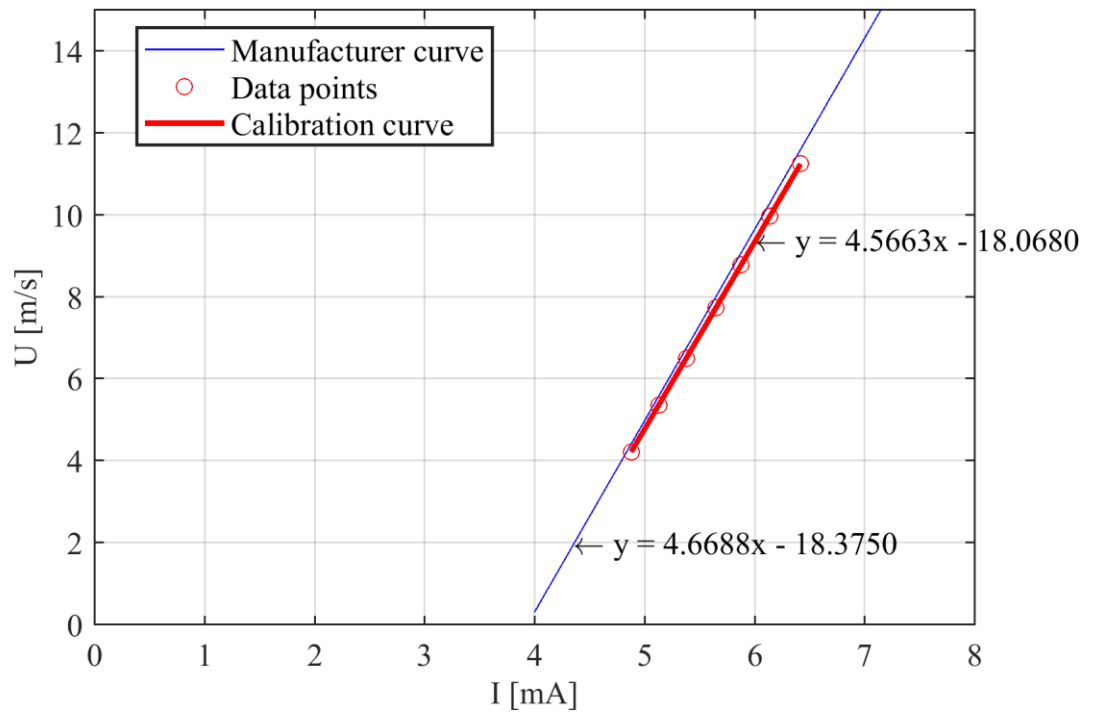


Figure 40: Calibration graphs of cup anemometer.

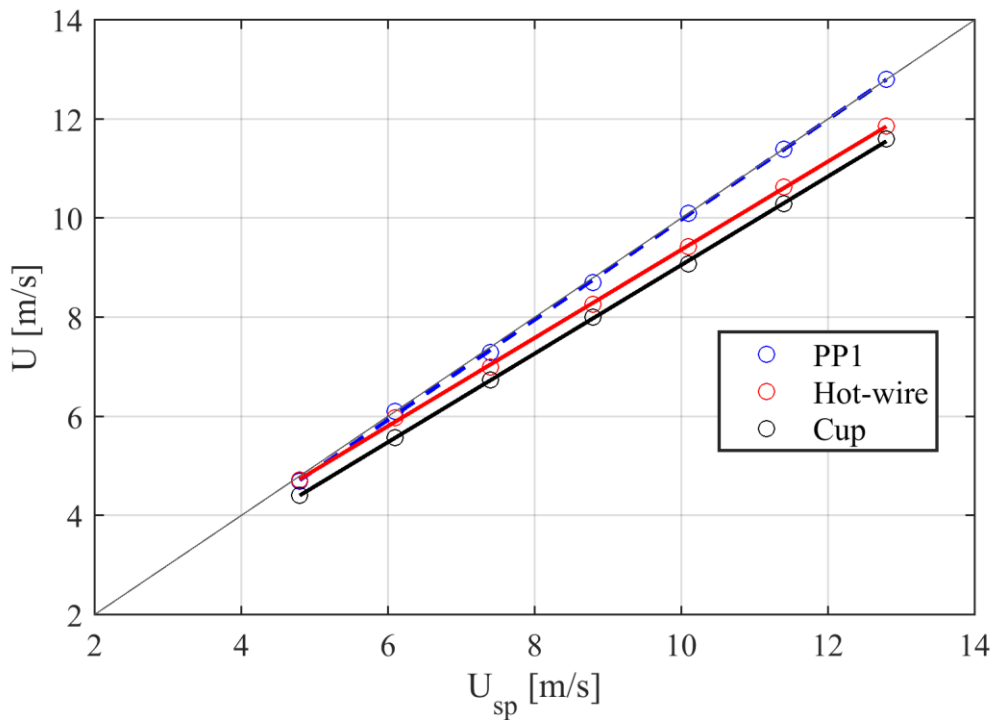


Figure 41: Comparison graph of PP 1 against cup and hot-wire anemometer.

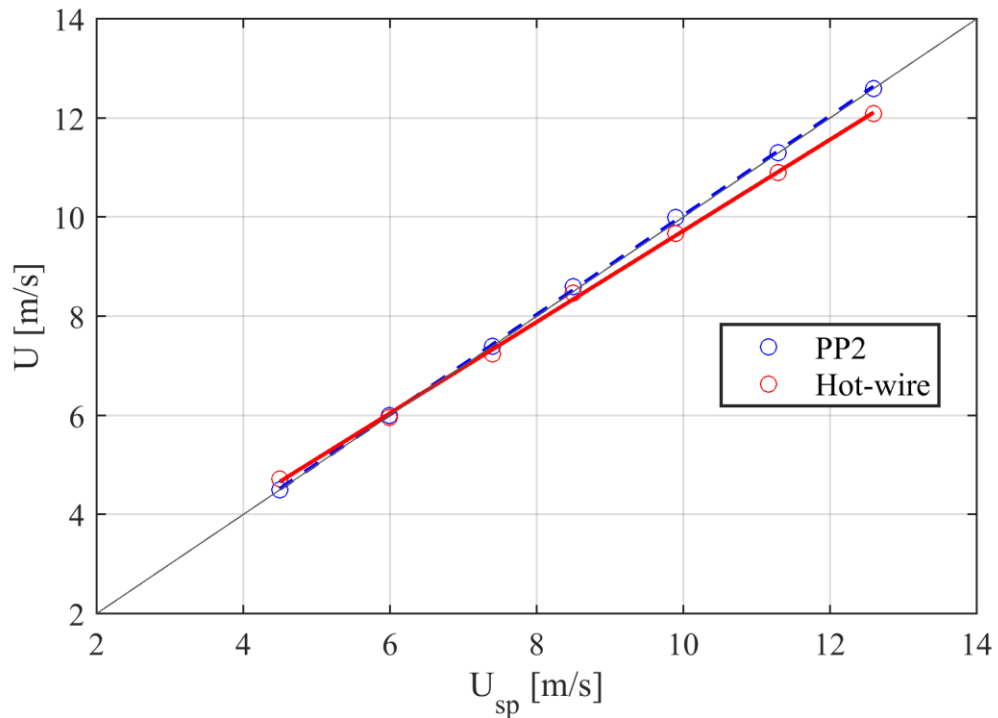


Figure 42: Comparison graph of PP 2 against hot-wire anemometer.

From figure 12 and 13 calibration graphs above, it can be observed that when PP1 probe is used for velocity measurements it gives accurate measurement results similar to SP probe.

The calibration curve of the cup anemometer (figure 14) is in agreement with the one given by the manufacture with slight measurement errors.

The cup and hot-wire anemometer velocity readings had small difference to the readings recorded by PP 1 and PP 2 as depicted in figure 15 and 16 above. These were accounted to temperature differences during calibration time and measurement sessions for hot-wire anemometer while for cup anemometer it was due to the cup blockage effect. Minus these effects, the recorded velocity readings are similar to PP velocity readings hence demonstrate the capability of PP to give measurement results similar to both anemometers. This expresses the confidence of velocity measurements readings from a printed PP.

## CONCLUSION

The design, fabrication and experimental validation of rapid prototyped Prandtl probe are clearly demonstrated. NX Siemens software was used for designing.

Stereolithography was the choice fabrication technique. A wind tunnel jet of range 0 to 51 m/s was used for experimental validation. A standard metallic Prandtl probe of 8 mm diameter in size was used as the reference instrument. The printed Prandtl probe, cup and hot-wire anemometers were calibrated; and then they were used to record velocity measurement. Velocity readings from the printed Prandtl probe were compared against cup and hot-wire anemometers.

The 3D printed Prandtl probe fabricated gave accurate velocity readings as evident from its velocity readings being similar as those of the standard reference instrument. Comparisons against cup and hot-wire anemometers showed small deviations in the anemometers readings which were due to temperature changes and cup blockage effect respectively.

This research show it is possible to rapid prototype a Prandtl probe with a diameter of at least 8 mm which can be used for accurate speed measurement in a wind tunnel jet. Furthermore, these findings indicate that with Stereolithography we can produce Prandtl probes that are easier and cheap compared to complex and costly traditional convectional fabrication processes.

The results from this work can be used in the field of rapid prototyping as evidence of its capability in producing functional products with affordable desktop rapid prototyping technology. In practise, through fabrication of cost effective 3D Prandtl probes, institutions interested in studies of wind energy can find good and cheap Prandtl probes as an alternative to costly metallic Prandtl probes.

More of 3D printed Prandtl probe validation can be done in testing the Prandtl probe in lower velocity below 4m/s in wind tunnel jets. For experiments carried out in high speed and hot environments, a better choice of resin such as High temperature resin type which has a good structural stiffness from Formlabs company is recommended. In addition, fabrication and validation of a 5-hole Prandtl probe can also be examined with additive desktop platform techniques.

### ACKNOWLEDGMENT

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Vern E. Bean and J. Michael Hall. (1999, July). NEW PRIMARY STANDARDS FOR AIR SPEED MEASUREMENT AT NIST.. *in Proceeding of the 1999 NCSL Workshop and Symposium, Charlottle, NC.*

## **Automatic leak detection and control system in water pipelines**

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Water distribution system is a key component of urban infrastructures, playing an important role in supplying municipal water, industrial water and fire water. This project addresses the existing problems caused by leaking pipes which include, the health risk hazard caused by contaminated water, wastage of precious natural resources i.e. the loss of soil fertility, damage of roads near the pipeline location among others. There is also the loss of public funds that are involved in the erection of new pipeline system, repair of the damaged pipes and flushing of the blocked pipes.

This project is aimed at designing a model system that automatically detects leak, determines leak location, control the global valve in the distribution pipeline and alert the relevant authority. The system is designed to be reliable, efficient, safe and diverse in that it can be used in other areas of application other than water pipeline systems, e.g., oil industry. It uses microcontroller for data manipulation, new developed leak sensor (Kapenjaji sensor) to detect leak in pipes, solenoid valve to control the affected line, and the GSM to alert the relevant authority through mobile phone. However, the system is intended to offer fast and calculated measures like alerting the relevant authority in case the pipeline leaks, controlling the affected pipeline by automatically closing the valve and keeps on updating in real time situation on pipeline condition without any effort of manual inspection.

Raw data from the newly built sensor was obtained upon conducting the various tests, which was then calibrated based on the distance estimation algorithm. The calibration indexing was then carefully matched with their respective distance along the pipeline. All individual components behaved positively as anticipated before by articulating their functions. The overall program was loaded and positive results obtained as all the objectives were achieved.

Key words: Detect, leak, automatically, design

## **Fuzzy logic based algorithm for optimization of handover decisions in a mobile cellular network for multimedia services**

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The increase in the number of multimedia services in the Telecommunication industry makes bandwidth a valuable resource to be scarce. A popular way to achieve higher capacity is by use of small cells that increases number of handovers as users move from one cell to another. Failure of handover process leads to a drop in Quality of Service (QoS) dissatisfying customers. These failures are brought about by frequent handovers as a result of increase in the number of multimedia network services. Several handover algorithms have been proposed for handover decisions taking into consideration only few input parameters. Also these algorithms does not take into consideration multimedia services basing on their QoS requirements and level of improvement on handover success rate. Service is a useful factor for the users and different services require respective QoS. This research aims at improving the process of handover through fuzzy logic system for cellular multimedia services by a combination of five input parameters to the Fuzzy Inference System (FIS) that include, the distance between the BTS and MS, Mobile station velocity, signal quality, signal level and the available bandwidth. In this research, the threshold for handover for the three forms of traffic (voice traffic, video traffic and web traffic) are calculated separately with more emphasis being given to the voice call as compared to the web traffic since web traffic can tolerate some delay but voice traffic cannot tolerate the same. The handover process is improved by increasing the number of input parameters to the Fuzzy Inference System, (FIS). The system calculates the handover thresholds for the three multimedia services. Basing on these threshold values, handover decision is executed. This algorithm ensures smooth and efficient handovers are executed.

**Key words: Fuzzy logic, handover, FIS, Multimedia, Thr.**

## **Maintenance driven performance improvement for cement plant roller press system.**

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### **Abstract**

The cement industry is currently undergoing consolidation and facing worldwide competition from plants within and outside the region. These aspects put today's plants under intense financial pressure where, maintenance and operations budgets are among the first to be targeted for reduction and compounded by minimal capital replacement. With shrinking maintenance budgets, the Cement plants therefore must increase the productivity of their existing equipment by optimising maintenance and operations strategies and teams, while continuing to look for ways to reduce costs further. Despite this challenges, the plant is expected to increase its availability in order to meet both the market demand and optimal production for optimal cost, for the end product to remain competitive. This paper aims at developing a simulation-based framework to identify the maintenance bottlenecks, their effect on the plant availability and maintenance cost and further offer maintenance decision support. The framework is applied on a real case study of a cement-manufacturing firm where maintenance and operational data captured are analysed, various model parameters extracted with expert guidance and finally building a model that depicts failure and maintenance of the system. The roller press is identified as critical subsystem using pareto analysis and is further modelled in this case study. The results of the study identifies the key aspect to consider while carrying out optimization of the subsystem to improve the availability and reduce maintenance cost offering maintenance decision support to the engineering manager.

Keywords: Maintenance, cement plant, roller press, simulation

## **Congestion Analysis in Deregulated Power System and Computation of Generator Sensitivity Factor**

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### **Abstract**

Power system, historically was vertically integrated. Some years ago, this power network has been unbundled. In the unbundled power system, the main issue that is facing the system operator is called congestion. The congestion in transmission system is the situation when technical constraints or economic restrictions are violated, the lineflow, thermal stability and voltage stability. In deregulated power system, the congestion management is taken as the main key of the system operator. Many methods have been used for congestion management and the most method used is the rescheduling of the generation based on their sensitivity factor. Congestion management has become the main area of many researches in deregulated electricity market, because it permits to the system to be secured and reliable. The aim of this paper is to show the utilization of Powerworld, an interactive power system simulation package, which is very efficient in computing of the power flow and it facilitates easily to identify the congested line in the power system. It permits also to determine the generator sensitivity factor. This paper presents one case study applying on IEEE 30 Bus System. Moreover, the paper presents Powerworld as one of the most important research tool, which permits the study of the power system problem.

**Keywords:** Congestion management, Generator Sensitivity Factor, Powerworld, Unbundled power system

## Voltage Stability Analysis on Shore-To-Ship Power Connected Systems

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### Abstract

The shore to ship power connection is a technology that has been recommended as one of the ways that will help reduce emissions from marine vessels which have increased in number as a result of rapid growth in international trade. This involves the shutting down of the onboard diesel generators in ships and supplying electricity from an existing shore grid to the ships. This interconnection to the existing network has raised concerns to system operators and regulators regarding the systems stability. The control of the power systems voltage stability is very significant in ensuring the stability of the overall system following a large disturbance. A model of shore to ship power connected network is going to be developed and the off-shore load connected to it. Dynamic voltage analysis of the system shall be studied under normal and contingency conditions to determine the stability of the system.

**Keywords:** Off-shore, Shore to ship power connection, Voltage stability

## Optimal Resource Allocation in Femtocell Using Combinational Approach

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### Abstract

Demand for increased throughput and inclusion of more users to transmit more data at higher rates will always be a trigger for improved methods of cell phone services. This has made it necessary to keep on seeking for ways to connect users and accommodate their requests.

In this paper, users are allocated resources using the combinational approach with their individual requests and SINR values taken into account. Furthermore, a further comparison is done on the effect of considering fairness while allocating users so as to accommodate all users with analysis of their SINR total values with and without fairness optimization.

An example of users positioned in a given femtocell recorded at 5 different times (A to E) is hereby carried out. The intervals of recording are: at interval A, the femtocell has users 1, 3, 7 and 8. During interval B, it has users: 7, 8, 4 and 2. During interval C, it has users: 8, 4, 7 and 1. At interval D, it has users: 4, 8, 2 and 5 and finally at interval E, it has users: 7, 2, 8 and 1. Their resources requests and SINR values are tabulated and plotted using MATLAB as described in this paper. From the simulations done in MATLAB, it is found that the SINR total is slightly lowered but not severely with fairness application, but all users who have requested resources are able to communicate through the femtocells.

**Keywords:** Fairness, Femtocell, Signal to Interference plus Noise Ratio.

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## 9. INTRODUCTION

Mobile user numbers will always keep on increasing hence demand more services from cell phone operators. This makes it inevitable for providers to increase capacity and look for optimal usage of vital resources such as bandwidth and resources provision to users. This has driven the rapid evolution of network technologies from first to fourth generation (Sousa, Vasco , & Tiago, 2004) . In addition, technologies have reached a level that prioritizes users in terms of power utility, resources requests (Anritsu, 2009), rather than allocating bursts of time slots or frequency slots, as was being practiced in technologies prior to fourth generation of cell phones.

## 10. LITERATURE REVIEW

Cell phone technologies have improved since their inception in early 90s and have rapidly grown in terms of accommodation of many users and transfer of data across their platforms (Sousa, Vasco , & Tiago, 2004).

### A. REVIEW OF RELATED TECHNIQUES

#### I. GLOBAL MOBILITY PREDICTION SCHEME

In this scheme, the movements of a user are recorded in this scheme and a pattern is drawn based on this movement. A sequence of cells that the user has traversed are then stored (Oyie , Langat, & Musyoki, 2014).

This sequence is then used to predict the position of a user at any given time in future so as to determine the user to allocate a resource (Oyie , Langat, & Musyoki, 2014).

The scheme can be outlined as shown below.

$$P_e = \frac{M(F_f, F_{f+1})}{N(F_{f-1}, F_f)} \quad (1)$$

Where:

$P_e$  gives the Transition probability between previous and future traversed femtocells by a user.

$N(F_{f-1}, F_f)$ : gives the number of the transitions of the previously visited to the current femtocell.

$M(F_f, F_{f+1})$  give the number of the transitions from the current femtocell and the future femtocell that a user moves.

The combinational technique uses the present request at a given position of a user to consider the resource requests (Macharia, Langat , & Musyoki , 2016) without necessarily giving priority to historical movements.

#### II. LOCAL PREDICTION SCHEME

In this scheme, a continuous-time Markov chain is utilized. According to (N. O. Oyie, 7th-9th, 2014), it is meant to assist the global mobility prediction scheme in case of unsuccessful trial.

This technique calculates the probability of a user transiting to every adjacent cell. Each user is allocated a unique ID that is used to determine and allocate the number of resources to be allocated. All adjacent femtocells are listed and given an equal probability of transition (N. O. Oyie, 7th-9th, 2014).

This scheme is elaborated by the following expression:

$$P_m = \frac{N(F_f, F_{f+1})}{Z(F_f)} \quad (2)$$

Whereby:

$N(F_f, F_{f+1})$  gives the number of the transitions between current femtocell and all the adjacent femtocells to be visited.

$Z(F_f)$  gives the number of times the femtocell  $F_f$  appears in the mobility trace (N. O. Oyie, 7th-9th, 2014).

$P_m$  is the transition probability of a user between the current femtocell and all adjacent femtocells.

The combinational technique seeks to improve on this technique in a manner similar to the global prediction. This is by determining the requests per user at a given interval and finding the best SINR group to allocate resources as described regardless of possible movements in (Macharia, Langat, & Musyoki, A femtocell users' resource allocation scheme with fairness control, 2017).

## 11. METHODOLOGY

### I. COMBINATIONAL SCHEME

This technique bases its scheme on the combinations formula as given in (Pintea, 2014). The combinations formula is given below.

$${}^n C_x = \frac{n!}{x!(n-x)!} \quad (3)$$

Where:

${}^n C_x$  is the different combinations of 'n' items that can be done in a space of 'x' items

$n!$  gives the factorial of n

$x!$  gives the factorial of x

$(n-x)!$  gives the factorial of (n-x).

In previous presentations, this scheme has been used to arrange users in terms of their requests. The users were first of all considered to have individual requests of resources (Macharia, Langat , & Musyoki , 2016).

This works as follows:

An example of 6 users in a femtocell with 3 resources available is considered. The users have single resources requests. The users are arranged as shown in the table given.

Table 1: Users' SINR values (with single resource requests)

<b>USER</b>	<b>SINR (dB)</b>
1	20
2	15
3	18
4	30
5	8
6	12

As presented earlier in (Macharia, Langat , & Musyoki , 2016), the users are subjected to a combinations algorithm as described above and all possible single arrangements are done.

When the possible arrangement of the users above is outlined, the highest combination is found to be: [1 3 4].

The SINR total for this group is 68 dB. In this technique, each user only requests a single resource hence the combinations are done directly on the SINR values (Macharia, Langat , & Musyoki , 2016).

A further analysis was done on the resource requests per user. Owing to OFDMA technology used in Femtocells, simultaneous data can be transmitted to several users with the user of multiple subcarriers assigned to users. This supports the several IP (Internet Protocol) based applications' traffic requirements such as voice and data requirements (AlQahtani, 2015). It also allows the network to introduce user privileges in traffic requirements that can allow classification of user equipment applications in terms of resource requests. This classification can be further subjected to category based call admission control (CAC) for resource requests per application for a given user in the femtocell (AlQahtani, 2015). In addition, users' applications can simultaneously request for resources from the femtocell with regard to their traffic demands. Therefore, a user can place request for several resources for communication in the femtocell as described in (AlQahtani, 2015). This also is determinant on the adaptive modulation and coding that gives the maximum number of resource blocks that can be allocated per given bandwidth (Anritsu, 2009). This

paper seeks to utilize the sum of all application resources requests per user so that they can be mapped in a serialized manner, using the combinational approach on their total SINR values.

## II. ANALYSIS OF THE FAIRNESS SCHEME

This paper seeks to evaluate the fairness scheme as presented in (Macharia , Langat, & Musyoki, A femtocell users’ resource allocation scheme with fairness control, 2017). After the allocation sequence has been executed, it is found out that not all users have been allocated resources. The low SINR valued users are left out particularly in situations where the available resources are very few. In (Macharia , Langat, & Musyoki, A femtocell users’ resource allocation scheme with fairness control, 2017), a fairness scheme was suggested to be carried out by the femtocell that would identify the next low SINR value user. The femtocell would scan applications run by this user(s). Applications can have guaranteed bit rate which needs a given value of resources for them to operate or can be non-guaranteed bit rate that do not require an exact amount of resources to operate (AlQahtani, 2015). Using category based CAC approach, the femtocell would determine the applications that do not require a given guaranteed bit rate for operation then reallocate these resources to the user who has been left out to enable that user communicate in the femtocell. This reallocation is minimized to just a resource or two so as not to adversely affect the bit rates of the major users. This paper seeks to analyze the effect of this reallocation to users in terms of optimizing resources and the overall SINR total effect per user. This determines the throughput effect of considering fairness of reallocating resources to low SINR users.

## 12. RESULTS AND DISCUSSION

A second example of users who are positioned in a femtocell recorded at 5 different intervals of time (A to E) is considered as shown in the tables: 2 to 6 outlined.

Table 2: Femtocell users’ resource requests with SINR values recorded at interval A

TIME INTERVAL A		
USER	REQUESTS	SINR (dB)
1	3	8
3	4	6
7	4	3
8	3	4
Available resources = 9, requested = 14		

Table 3: Femtocell users’ resource requests with SINR values recorded at interval B

TIME INTERVAL B		
USER	REQUESTS	SINR (dB)
7	4	3
8	3	4

4	5	2
2	2	10
Available resources = 6, requested = 14		

Table 4: Femtocell users' resource requests with SINR values recorded at interval C

TIME INTERVAL C		
USER	REQUESTS	SINR (dB)
8	3	4
4	5	2
7	4	3
1	3	8
Available resources = 10, requested = 15		

Table 5: Femtocell users' resource requests with SINR values recorded at interval D

TIME INTERVAL D		
USER	REQUESTS	SINR (dB)
4	5	2
8	3	4
2	2	10
5	3	9
Available resources = 7, requested = 13		

Table 6: Femtocell users' resource requests with SINR values recorded at interval E

TIME INTERVAL E		
USER	REQUESTS	SINR (dB)
7	4	3
2	2	10
8	3	4
1	3	8
Available resources = 5, requested = 12		

At interval A, when combination is done on the users, it is found out that resources are allocated as follows:

[1 1 1 3 3 3 3 8 8]. The SINR total for this group is 56 dB. It is found out that user 7 is left out. Fairness can be considered here. In the allocated group, user 8 is the next lowest SINR valued user hence; a resource can be reallocated to user 7 so that now the allocation of resources would be as follows:

[1 1 1 3 3 3 3 8 7]. The SINR total for this group is 55 dB, after all users have been allocated resources.

At interval B, the combinational sequence produces a string of users' requests in the following format. [7 8 8 8 2 2]. The SINR total for these users is 35 dB. But from the above sequence, it is found out that user 4 was left out in the sequence. Hence, one of the low SINR users: User 8, has more than one resource allocation compared to user 7, whose has only one resource allocation. Therefore, the femtocell can reallocate one resource from user 8 to user 4 so that user 4 can be connected to the femtocell. The new allocation sequence then becomes: [7 8 8 4 2 2]. The new SINR total is 33 dB. The SINR total is lowered a bit but all users are now connected compared to when the earlier arrangement where one user is left out.

At interval C, 15 requests from the users' requests are tabled. When these requests are subjected to combinations against the available 10 resources, the arrangement of the users in terms of their individual request is as follows:

[8 8 8 7 7 7 7 1 1 1]. This arrangement leaves out user 4, however the total SINR is 48 dB. When the fairness is taken into account, it is found out that one resource can be reallocated from user 7 to user 4 since he is the lowest SINR valued user. Hence the new arrangement of allocation of resources is as follows:

[8 8 8 7 7 7 4 1 1 1]. The new SINR total with all the users' allocated resources is 47 dB.

At interval D, the total requests are 13 resources. When this is simulated against available 7 resources, the best possible arrangement of users is as follows:

[8 8 2 2 5 5 5]. This sequence gives an SINR total of 55 dB. However, not all the users have been allocated resources using this sequence. User 4 has been left out. When fairness is considered, the femtocell can reallocate one resource from user 8 to user 4. This enables user 4 to communicate in the femtocell. Hence, the new arrangement is as follows: [8 4 2 2 5 5 5]. The new SINR total now becomes 53 dB.

Finally during interval E, the total requests are 12 resources. However the available ones are only 5. Upon simulation of the combinational scheme, the following arrangement of users' requests is generated: [2 2 1 1 1]. The SINR total is 44 dB. However, users 7 and 8 have been left out of the sequence. In order to include them, the femtocell can reassign resources from each of the users: 1 and 2 and re-allocate to user 7 and 8. So the new sequence now becomes:

[2 7 1 1 8]. The new SINR total now is 33 dB. This has significantly lowered it in order to accommodate all the users.

Therefore the above data can now tabulated and graphically represented as shown in table 6 and figure 1 respectively.

Table 6: A summary of Femtocell trials during time intervals: A to E, SINR total values recorded.

TIME INTERVAL	SINR total (dB)	
	Without fairness	With Fairness
A	56	55
B	35	33
C	48	47
D	55	53
E	44	33

The above data can be compared to users' allocation as shown in table 7 below, which compares number of users allowed to communicate in the femtocell during the different time intervals.

Table 7: A summary of Femtocell trials during time intervals (A to E) with the number of users who request resources and the ones allocated

TIME INTERVAL	Users allowed to communicate in the femtocell	
	Without fairness	With Fairness
A	3	4
B	3	4
C	3	4
D	3	4
E	2	4

The data in table 7 above can be plotted on a graph using MATLAB so as to show the difference when fairness optimization is done to include all users and without including all users. The graph in figure 1 is the SINR comparison to show how the fairness scheme affects it.

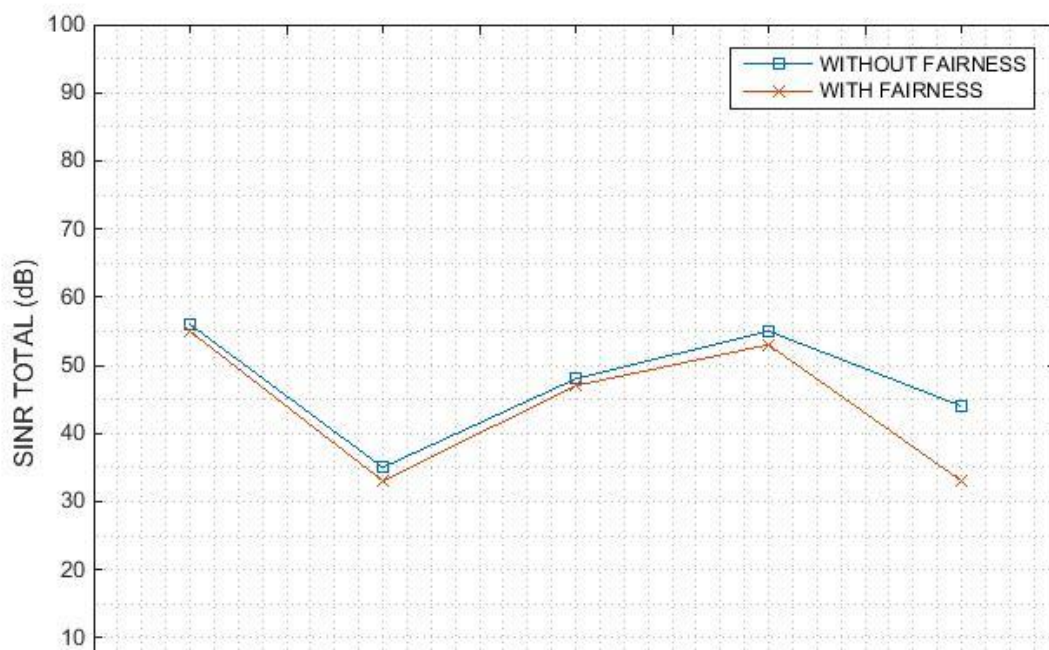


FIGURE 1: A GRAPH OF SINR TOTAL VS TRIALS (WITH FAIRNESS COMPARISON)

Furthermore, a further graphical comparison analysis can be done using MATLAB for users who request for resources against the ones that are allowed to communicate in the femtocells with and without fairness consideration as tabulated earlier.

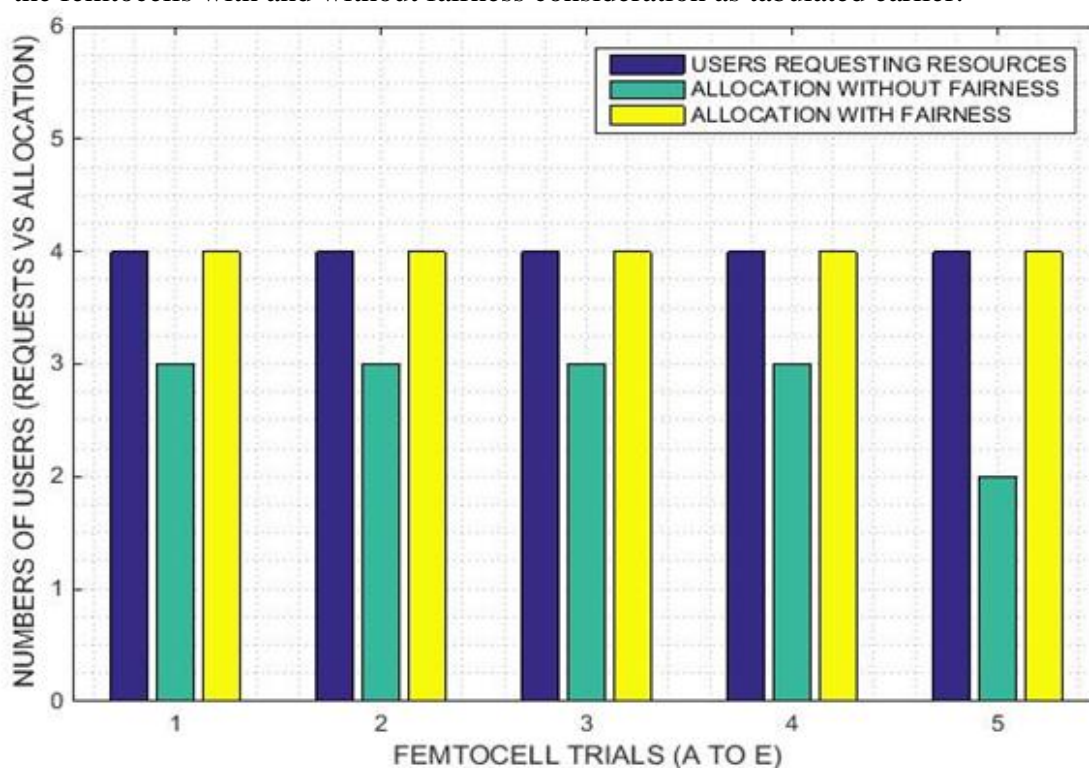


FIGURE 2: A GRAPH OF NUMBER OF USERS REQUESTS VS ALLOCATION (WITH FAIRNESS COMPARISON)

From the MATLAB graphs plotted, it is seen that fairness lowers the SINR total: between 1 to 3 dB. For the last interval: E, the SINR total is significantly lowered, by 11 dB, due to having to accommodate all users in very limited resources. But on the other hand, fairness guarantees that all users are able to be allocated resources to communicate in the femtocell.

### 13. CONCLUSIONS AND RECOMMENDATIONS



This paper applies the combinational allocation of resources to users. It also further analyses the effect of the fairness scheme to re-allocate resources to the lowest SINR users in a femtocell.

The trials done in the femtocell during the different time intervals try to optimize on resources with fairness distribution to all users to ensure that all users are able to communicate. This process does not adversely affect the SINR total, but ensures that all users are able to communicate through the femtocell.

Hence, fairness is therefore recommended as an optimal approach as an applicable technique in allocation of resources to users in femtocells.

As noticed in the last interval, the fairness scheme lowers the SINR total significantly since the available resources were too few: 5 resources. This caused 2 users to be left out and thus fairness had to accommodate them. This means that fairness scheme here has a drawback on the SINR total where there are very few resources available compared to requests because it attempts to accommodate all users.

Therefore, further research on ways of accommodating all users with better SINR levels in such scenarios is hereby recommended.

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## **Multiphysics meshless modelling of ambient vibrations transmission in MEMS accelerometer elements**

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MEMS accelerometers have become common sensors in many inertial measurement units. The application environments in which they are employed are characterised by varying non-targeted ambient vibrations. These introduces vibration errors which are not easily calibrated as the effect of dynamic coupling between ambient vibrations and MEMS elements dynamics have not been sufficiently modelled. While traditional analysis techniques employing finite element method is robust and proven, they become insufficient for the analysis of MEMS due to the multi domain and multiphysics nature of MEMS. In this paper we present a multiphysics meshless model of ambient vibration transmission in MEMS accelerometer elements which is sufficiently accurate and efficient.

*Keywords:* MEMS accelerometer, Ambient vibrations, Vibration errors, vibration transmission and Meshless method..

# Transit Vehicle-Capacity Optimisation for Uncoordinated Systems Operating in Mixed Traffic

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## Abstract

*Road-based public transport in the cities of many developing countries comprises a large component of unconventional public transport. Vehicle size and type is one of the principal factors influencing the efficiency of transit service. This study proposes an approach to the optimization and selection of transit vehicle sizes for uncoordinated systems operating in mixed traffic. Empirical data were collected along a seven-kilometre portion of the Nairobi-Thika Highway in Kenya. The relationships between occupancy rates and vehicle size; and between Passenger Car Equivalence values and vehicle size were then established. A model was developed that optimizes transit vehicle size based on occupancy rates achieved by different transit vehicle sizes and the road occupancy of a vehicle. Optimum vehicle sizes were determined for two segments as 45 and 56 seats respectively.*

**Keywords:** *Transit demand, vehicle-size optimization, transit service efficiency, paratransit*

## Introduction

Road-based public transport dominates the cities of developing countries and comes in a variety of physical and organizational forms. One common characteristic of transit in these cities is the presence of a large component of unconventional or intermediate public transport, commonly referred to as paratransit (Vijayakumar 1986). While these informal transit industries share generic characteristics, each paratransit industry has its own specific characteristics that reflect the environment of the city in which it operates (Graeff, 2009). Size of vehicle is of particular importance in the developing world because vehicles of different size are in common use and are frequently in competition with one another (Vijayakumar 1986). Transit vehicle size is one of the principal factors influencing the efficiency of a transit system. Other factors include; the regulatory framework, pricing, route planning, fleet size, revenue integrity, competition, and bus utilization, among others (Iles and Nielson, 2006).

There are few transit performance studies that consider systems operating in mixed traffic. Vehicle capacity and route frequency are the most important elements of most bus service plans. However, most existing bus network design procedures consider vehicle capacity as a fixed value and compute frequency either to minimize a certain total generalized cost, or to provide the capacity needed during peak hour operation (Shih & Mahmassani, 1994). While this approach is computationally efficient, it renders impossible, the consideration of various existing bus sizes. This approach is, thus, not easily applicable in the uncoordinated transit systems that abound in cities of most developing countries such as Kenya, where multiple vehicle capacities serve in the same transit system. Further, road transit systems in these cities operate in mixed traffic, competing for road space with private motorists and other types of traffic.

### 1.1 Transit Vehicle Size Optimization Approaches

Optimal bus capacity entails trade-offs between vehicle size and operational variables for a given frequency of service (Ceder (2007)). The use of smaller buses offers passengers a better service frequency for a given service capacity, but costs more to operate per seat provided. Most existing vehicle size selection models accentuate a trade-off between vehicle capacity cost and passenger waiting-time cost (Ceder, 2007). Within this trade-off there is an optimal

bus size which maximizes social benefit (Oldfield and Bly, 1988). These models require extensive data collection efforts, and might be impractical in uncoordinated transit systems.

Jansson (1980) explored the consequences of monetizing certain social costs such as passenger waiting, riding times, etc. These costs were considered alongside producer costs as part of the supply price for bus transport. A simple bus line model was used to assess the cost of operating similar services at peak and off-peak during daylight. The results showed that for a given demand, more buses should run and they should be much smaller. Further, the model showed that in some circumstances, it would be optimal to maintain the same frequency during off-peak times as during peak hours. Oldfield and Bly (1988) agreed that the use of smaller buses results in a better service frequency, noting, however, that it would cost more to operate per seat provided. A mathematical model was proposed that describes an explicit relationship between optimal bus size and factors such as operating cost, level of demand, and demand elasticities. The model determines optimal bus size by assuming elastic demand; that is, demand that varies with passenger-trip cost. The model also considers the influence of changes in demand on road congestion. Further, it takes trip time to increase with average bus load because of boarding times. It makes use of complex expressions to explain the dependence of headway on bus size.

Jansson (1993) proposed a model that simultaneously optimizes vehicle size, frequency, and journey price. Two interesting effects of frequency on passenger behaviour were observed. The first effect has two components: for low frequencies and given the availability of a reliable timetable, passengers will plan their trips according to the timetable. For high frequencies, they prefer to show up at the transit stop simultaneously, rather than consult the timetable. The second effect is based on the fact that the disutility of waiting at a stop is higher than that of waiting at home or at work, and that the cost of waiting may vary differently with the duration of the wait; typically increasing with the duration for high frequencies and decreasing for low frequencies.

Shih and Mahmassani (1994) proposed a vehicle-size optimization model that requires the total demand matrix of the whole route system to be given, not the line demand used by Jansson (1980). The results of a transit trip assignment model are used to assign a set of the initial frequencies to different routes on the network. The vehicle size for each route is then optimized analytically by minimizing the total cost- comprising operator cost and user cost- of each individual route. The resultant frequencies are revised by applying the maximum allowed load factor for the calculated bus sizes. The results are further iterated until the frequencies of two iterations converge. This approach enables the use of different bus sizes on different routes.

Lee *et al.* (1995) furthered Shih and Mahmassani's work, describing a model that attempts to optimize bus size not just for each route but also for each period of day, so that more than one bus size can be used on one route. The findings show that a mixed-fleet operation is preferable if the ratio of peak demand to off-peak demand is more than 1.92. The model considers only the fixed portion of the operating cost function to influence the vehicle size. Gronau (2000) investigated the viability of running two types of vehicles along the same route; one type consisting of smaller vehicles to cater for high time-value passengers, while the larger type caters for lower time-value customers. The study found out that the usefulness of a second type of vehicle would depend on two factors: its effect on waiting time and its effect on in-vehicle travel time, and hence depends on the value of waiting versus in-vehicle travel time.

Ceder (2007) derives a simple formula that involves a trade-off between vehicle capacity cost and passenger waiting time cost. The assumptions are that operating cost per vehicle hour is the same (independent of vehicle size and load carried), average waiting time is half the headway, riding time is independent of vehicle size, and travel time and stopping time are independent. According to the square root formula, the optimal vehicle size is proportional to the square root of the number of passengers carried. This being a cost minimization model, the assumption that operating cost is independent of vehicle size might result in a larger than optimum vehicle size being selected.

Dell' Olio et al (2012) proposed bi-level optimization model with constraints on bus capacity. The model assigns buses of different sizes to public transport routes by using the observed levels of demand on each route to optimizing the headways. At the upper level the model considers the optimization of the system's social and operating costs, these are understood to be the sum of the user's and operator's costs. At the lower level there is an assignment model for public transport with constraints on vehicle capacity which balances the flows for bus sizes and headways at each iteration.

Most of the above transit vehicle size optimization approaches use costs only - mostly generalized costs - to optimize transit vehicle sizes. The possibility that different vehicle sizes would achieve different occupancy rates, thus affecting the overall system capacity, is ignored. Most previous approaches focus on the design of conventional bus systems which provide fixed-route, fixed-schedule, and coordinated operation. This study proposes an approach to the optimization of bus sizes for uncoordinated transit systems operating in mixed traffic. The study focuses on the fact that different vehicle sizes will achieve different occupancy rates at different times of day.

## **1.2 Transit Vehicle Size and Roadway Utilization**

Travel time increases with vehicle capacity and occupancy because, firstly, bulkier vehicles are often slower-particularly in congested conditions, and secondly, an increase in occupancy means more frequent and longer stops for boarding and alighting (Gronau, 2000). Small buses can be advantageous in severely congested conditions as they are more manoeuvrable than larger buses. However, a very high service frequency may mean that there are often several vehicles running in convoy. This can create significant congestion compared with a single large vehicle carrying the same number of passengers (Iles & Nielson, 2006). In order to quantify the relative road-space occupancy of different vehicles, traffic flow data from classified counts is converted into Passenger Car Units (PCU) by multiplying vehicular flow by the corresponding Passenger Car Equivalent (PCE). Highway Capacity Manual (HCM) 2000 defines PCE as "the number of passenger cars that are displaced by a single heavy vehicle of a particular type under prevailing roadway, traffic and control conditions".

The 1965 HCM used relative reduction to determine PCEs for two lane highways using the Walker method. For multilane highways, PCEs were based on relative delay due to trucks. Werner and Morral (1976) proposed the headway method to determine PCUs on level terrain at low levels of service. This considers that one of the primary effects of heavy vehicles in the traffic stream is that they take up more space. Chandra and Sikdar (2000) proposed a methodology for estimating PCE values for mixed traffic conditions, by expressing PCE as a function of vehicle area and speed. Shalini and Kumar (2014) reported that Demarchi and Setti (2003) proposed the PCE's formula to eliminate the possible error for mixed heavy vehicles in the traffic stream, including interaction between multiple trucks types, by

expressing the equivalent passenger car only flow rate for a given v/c ratio as a fraction of the mixed flow rate.

Most existing methods for estimating PCE values are based on measured delay caused by a vehicle relative to the delay caused by a passenger car. As a result, many of them are suited for data collected during periods of low Level-of-Service. Most applications of PCE values make use of the standard conversion factors provided in manuals such as the values given in the Kenya Road Design Manual (1987). These values are not easily adaptable to certain applications such as where marginal increases in vehicle sizes are considered. The method proposed by Chandra and Sikdar (2000) is adaptable to different vehicle sizes, different operating conditions and different terrains, and was thus adopted for use in this study.

### Model Development

The proposed transit vehicle size optimization model accentuates a trade-off between maximizing the occupancy of public transport vehicles while minimizing their contribution to congestion for a given level of demand. The procedure may be described as follows:

Step 1: Define Model inputs. These include: vehicle occupancy rate, vehicle sizes, passenger car equivalence factors, and the hourly passenger flows along a link.

Step 2: Input-data: Occupancy data is collected directly from the field; occupancy rates are then computed by expressing the level of occupancy as a fraction of the vehicle capacity; vehicle size is a decision variable; passenger car equivalence is obtained by applying the method proposed by Chandra and Sikdar (2000); passenger demand is measured as ridership from cross-sectional counts and occupancy surveys.

Step 3: A mathematical relationship is established between occupancy rate and vehicle size, and between Passenger Car Equivalence and vehicle size.

Step 4: The resultant traffic in Passenger Car Units is established from the variables for different sizes of vehicles. A plot is then made of vehicle size against the resultant flow.

Step 5: A vehicle size is selected that minimizes the resultant flow

### 2.1 Model Formulation

Based on the peak-load factor concept (Ceder, 2007), the number of vehicles required to cater for the passenger demand in a particular hour is given by:

$$F_j = \frac{\bar{P}_{mj}}{\gamma_j \cdot c} \dots \dots \dots (1)$$

Where  $\bar{P}_{mj}$  is the average maximum number of passengers observed on-board in period j, c represents the capacity of a vehicle, and  $\gamma_j$  is the load factor during period j. In an uncoordinated transit system where the service is demand responsive and with no central agency, the frequency is not set. The capacity of transit vehicles varies, and the load factor is difficult to enforce. In order to overcome these challenges, the equation was adapted as follows:

- Maximum number of passengers observed on-board in period j,  $\bar{P}_{mj}$  remains unchanged

- The load factor,  $\gamma_j$  is replaced with occupancy rate on vehicle size  $Z$  during hour  $j$ , and the notation becomes  $\gamma_{zj}$ .
- Vehicle capacity remains unchanged but the notation changes to  $Z$
- Frequency,  $F_{zj}$  becomes the flow of  $Z$ -sized vehicles in hour  $j$

Thus equation 3.1 above becomes:

$$F_{zj} = \frac{\bar{P}_{mj}}{\gamma_{zj} \cdot Z} \dots \dots \dots (2)$$

Where,  $F_{zj}$  is the count of vehicles of size  $Z$  that would be observed during the design hour if vehicle size  $Z$  is used.

In order to measure the contribution of vehicle size  $j$  to congestion along a roadway, the flow of vehicles is converted into the equivalent passenger car units by multiplying the equation by the PCU value of vehicle size  $Z$ . Further, lower and upper bounds for occupancy level are introduced in order to avoid crush loads or very low occupancy levels. Equation 3.2 thus becomes:

$$F_j = \frac{\bar{P}_{mj} * E_z}{\gamma_{zj} \cdot Z} \dots \dots \dots (3)$$

$$\gamma_{min} \leq \gamma_{zj} \leq \gamma_{max}$$

Where  $F_j$  is the resultant flow of vehicles in hour  $j$ , in passenger car units, and  $E_z$  is the Passenger car Equivalence of vehicle size  $Z$ .  $\gamma_{min}$  and  $\gamma_{max}$  are the lower and upper bounds for the occupancy rate. The other notations are as previously defined. The proposed method is thus a minimization model of Equation 3.3 above. It seeks the  $Z$  value that minimizes the resulting  $F_j$ .

- Peak passenger loads were computed from cross-sectional vehicle counts and occupancy surveys. The approach is premised on the method proposed by Kadiyali (2002). Thus the peak passenger load is computed as:

$$P_{mj} = \max_{i \in I} \sum_{n=1}^N P_{nij}, \dots \dots \dots (4)$$

Where  $P_{nij}$  is the passenger load carried by mode  $n$  along route segment  $i$  in the  $j^{\text{th}}$  hour;  $N$  is the number of vehicle modes considered,  $I$  is the set of all route segments  $i$  along the study route, and  $j$  is the hour under consideration.

- Vehicle size,  $Z$  is a decision variable.  $Z$  is a random number picked from the set of positive integers.
- Occupancy rate,  $\gamma_{zj}$  is obtained from its relationship with vehicle size,  $Z$ . A mathematical relationship is established by plotting  $\gamma_{zj}$  against  $Z$ . From this the value of  $\gamma_{zj}$  can be obtained for any chosen value of  $Z$ , either by reading from the graph or by computing from the trend line equation.



- The PCE values can be obtained by any suitable method that gives a PCE value for any vehicle size. In this research, the Passenger Car Equivalence values are obtained by applying the method proposed by Chandra and Sikdar (2000). This methods proposes that the PCE value can be obtained as follows:

$$PCE_i = \frac{V_c/V_i}{A_c/A_i} \dots\dots\dots 5$$

Where  $V_c$  and  $V_i$  are mean speeds of car and vehicle of type  $i$  respectively and  $A_c$  and  $A_i$  are their respective projected rectangular area (length \* width) on the road.

### Methodology for Data Collection

The primary data for this study was collected along seven-kilometre long section of the Nairobi-Thika Highway (A2), which links Kenya’s capital city, Nairobi, to the satellite town of Thika. The study section of the road was divided into two route segments, 3.2 and 3.7 kilometres long respectively. Data collection was carried out for 12 hours (0630-1830hrs) on three weekdays. Data collected included: Distance measurement along road segments, classified traffic counts, speed studies, vehicle occupancy surveys, and measurement of vehicle plinth areas.

### 3.1 Classified Traffic Counts

Classified traffic counts were carried out along the two route segments. Counts for private/commercial and public transport were recorded separately. The traffic counts were further categorized in terms of their seat capacities as shown in **Table 24** below.

**Table 24:** Classification of traffic counts

Category	Description	Seat capacity
<b>Public Transport Vehicles</b>	10-seater matatu <sup>1</sup>	10
	14-seater matatu	14
	29-33-seater bus	31
	50-52-seater bus	51
<b>Private/commercial vehicles</b>	passenger cars	5
	Commercial vehicles	3
	10-14 seater private van	11
	29-33-seater bus	30
	50-62-seater bus	55

### 3.2 Vehicle Occupancy Survey

The windshield method was used for collecting vehicle occupancy data. Random sampling was used to make at least five observations for each vehicle type for each 15-minute interval between 6.30am and 6.30pm. For the case of large vehicles such as buses where it is not possible to count the occupants quickly, the observers would record the extent of occupancy as full, three quarters-full, two thirds full, half full, and so on. These fractions were later to occupancy by multiplying them by the seat capacity of the respective vehicles.

<sup>1</sup> A ‘matatu’ is a public service vehicle in Kenya having a seating accommodation for not more than twenty-five passengers exclusive of the driver, but does not include a motor car

### **3.3 Mode-specific Space Mean Speed**

This is a measure of the speed of travel over a measured distance, rather than at a single point. It is computed by dividing the length of the segment under consideration by the average travel time of the vehicles traversing it. A 50 metre long basic freeway segment was marked out along the second segment. Stratified random sampling was used to collect data in order to include the different types of vehicles in the sample. The time taken to traverse the 50m segment was recorded. Data was collected for passenger cars, 10-seater matatus, 14-seater matatus, 26-seater minibuses, 33-seater minibuses, and 52-seater buses. The data was collected during off-peak hours (1400hrs to 1700hrs).

### **3.4 Vehicle Plinth Area**

This refers to the road area occupied by a vehicle. First, a vehicle model survey was carried out at same station as the speed survey described previously. This was achieved by carrying out a 15-minute classified vehicle count for passenger cars only. Passenger cars were classified into five categories according on their shape and plan area. These were: subcompact cars, saloon cars, hatchbacks, SUVs, and double cab pickups. External dimensions of each of the categories were retrieved from the internet from <http://www.automobiledimension.com/>.

For public transport buses, data on bus dimensions for various buses from 26-seaters to 62-seaters was provided by Banbros Limited, a bus body manufacturing company located in Kenya.

## **Results and Discussion**

Motor cars comprised 71% of traffic along the road with public transport vehicles taking 20% of traffic. The remaining 6% comprised goods vehicles, private vans and buses. Among public transport vehicles, 10-seater vans took 2%, 14-seater vans took 53.4%, 33-seater minibuses took 23.5%, while 51-seater buses took 21%. This represents in the proportion of larger buses as compared to previous years (KenHA, 2007).

An average occupancy of 1.65 persons was established for private cars, 8.6 persons for 10-seater vans, 12.7 persons for 14-seater vans, 32.5 persons for 33-seater minibuses and 50 persons for 51-seater buses. Expressed as a percentage of the seat capacity, the average occupancy rates were 33%, 86%, 91%, 105%, and 98% for cars, 10-seater vans, 14-seater vans, 33-seater minibuses and 51-seater buses respectively. Occupancy rates for all public transport vehicles were found to be higher in the morning hours than in the evening hours while those of private cars remained more or less the same. This shows a higher demand for CBD-bound travel in the morning hours than the rest of the day.

### **4.1 Passenger Loads**

51-seater public transport buses had the highest passenger loads on both route segments. Among transit vehicles, large buses dominate the passenger loads followed by 33-seater vans, 14-seaters and 10-seaters in that order. Large buses were found to take 49% of the passenger load against 27% by 33-seaters, 24% by 14-seaters and less than 1% by 10-seater vans.

### **4.2 Space-mean Speeds**

This is a statistical term denoting the average speed based on the average travel times of vehicles to traverse a section of a roadway. Passenger cars had the highest speed with an average of 82.9km/h, 14-seater vans followed with 77.4km/h, 10-seater matatus with

73.5km/h, 51-seater buses with 73.4km/hr, 26-seater minibuses with 72.8km/h, 62-seater buses with 69km/hr, and 33-seater buses with 68.2km/h. The general trend indicated a little reduction in speed with increase in vehicle size.

### 4.3 Vehicle Plinth Area

The 15-minute traffic count of different sizes of passenger cars was tabulated and used to determine the proportions of different car sizes on the road. The proportions of different car sizes were used to compute the weighted average plan area of a passenger car as follows:

$$A_p = \frac{1}{n} \sum_{i=1}^n A_r \dots \dots \dots (6)$$

Where  $A_p$  is the average projected area of a passenger car,  $n$  is the number of passenger car categories considered (six categories), and  $A_r$  is the area of the representative model in each size category. The overall average area for passenger cars was obtained as 7.74 square metres. This was taken as the average area of a passenger car in all subsequent computations. The areas of 10 and 14-seater vans were obtained as 7.52m<sup>2</sup> and 7.96m<sup>2</sup> respectively. Plinth areas for common buses in Kenya were obtained as 14.06m<sup>2</sup> for 26-seater, 15.82m<sup>2</sup> for 29-seater, 17.08m<sup>2</sup> for 33-seater, 23m<sup>2</sup> for 51-seater, and 29.29m<sup>2</sup> for 62-seater.

### 4.4 Relationship between Vehicle Size and Occupancy Rates

The relationship between vehicle size and occupancy rate was determined for the max load hour along each route segment, by drawing a scatter plot of vehicle size against occupancy rate. A line or curve of best fit was fitted to the data for each graph and a model governing the relationship between the two variables generated for each case. Figure 43 and Figure 44 below show the relationship between occupancy rate and vehicle size along the two route segments. A line of best fit is shown on each graph. For segments 1 and 2, polynomial curves were fitted with squared Pearson correlation coefficients of 0.612 and 0.674 respectively (see **Error! Reference source not found.** and **Error! Reference source not found.**). This implies a moderate correlation between the two variables. The arithmetic equation for the modelled values is shown on each graph.

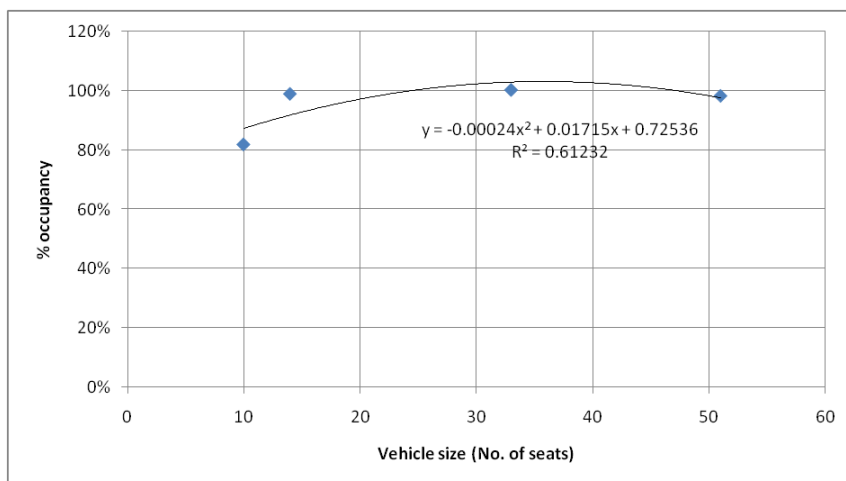


Figure 43: Percentage occupancy vs vehicle size along segment 1

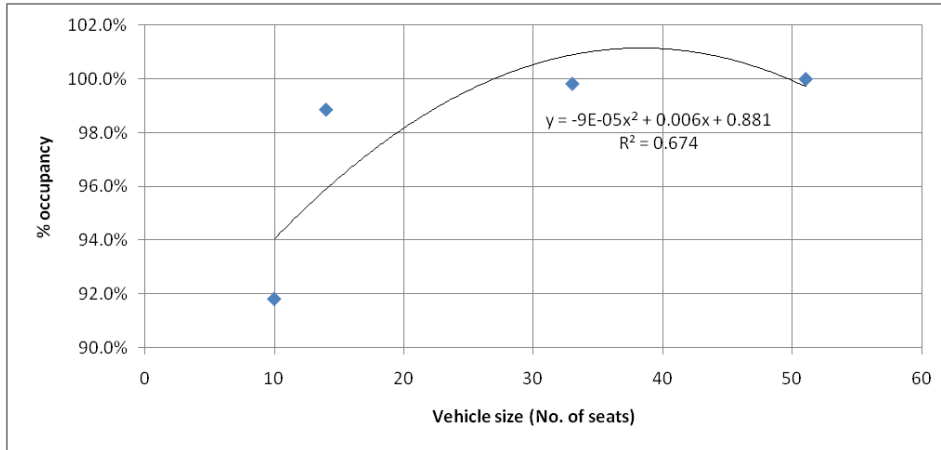


Figure 44: Percentage occupancy vs vehicle size along segment 2

#### 4.5 Relationship between Vehicle Size and PCE Values

Passenger Car Equivalence values for different vehicle types were computed using Chandra and Sikdar's (2000) method as described in Section 2. The relationship between the PCE values and vehicle size was then established by plotting vehicle size against PCE values. A line of best fit was fitted to the data and a model governing the relationship between the two variables was generated. **Error! Reference source not found.** below shows a plot of PCE values against vehicle size. A line of best fit was added and an equation for the modelled values is shown on the graph. An  $R^2$  value was obtained for the trend line indicating a strong correlation between the two variables. From the equation generated, a PCE value could be computed for any vehicle size.

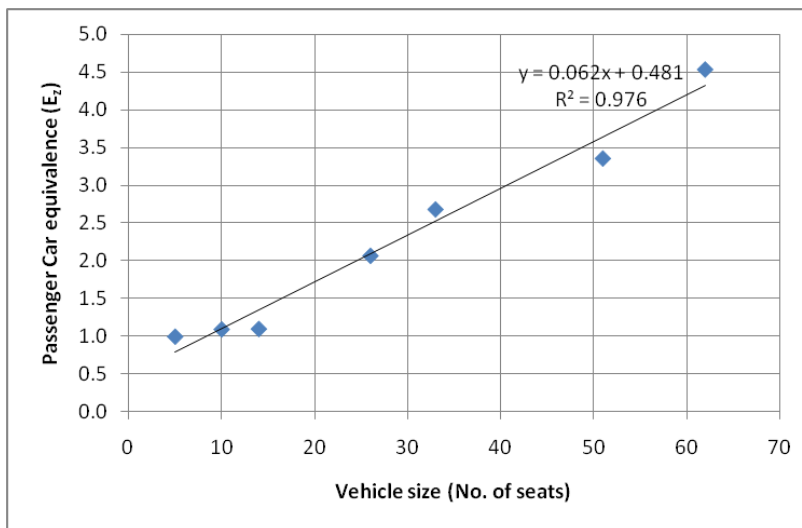


Figure 45: Passenger Car Equivalence vs vehicle size

#### 4.6 Vehicle Flows Simulation for Peak Demand

The equation below (See Section 3) was used to generate resultant flows for a range of vehicle sizes with capacity ranging from 5 seats to 100 seats, for peak demand along each route segment.

$$F_j = \frac{\bar{P}_{mj} \cdot E_z}{\gamma_{zj} \cdot Z} \quad \dots\dots\dots(7)$$

$$\gamma_{min} \leq \gamma_{zj} \leq \gamma_{max}$$

The proposed method is thus a minimization model of the above equation subject to the limits of occupancy rates. From this data, flow was plotted against vehicle size for a range of vehicle sizes. A line of best fit was fitted to the data and a model governing the relationship between the two variables was generated.

Table 25 below shows the peak demand values for each route segment. It also gives the equations used to compute occupancy,  $\gamma_z$ , and PCE values,  $E_z$  along each route segment. These equations were generated in the previous section. Vehicle size values were generated as integers between 10 and 150. Thus, occupancy rate and PCE value could be computed for each vehicle size between 10 and 150 seats.

Table 25: Peak demand values and equations used to model occupancy and PCE values

Segment	Peak Demand	$y$ vs $Z$	$E$ vs $Z$
1	10819	$y' = -0.00024x^2 + 0.01715x + 0.72536$	$y = 0.062x + 0.481$
2	20329	$y = -0.00009x^2 + 0.00679x + 0.88138$	$y = 0.062x + 0.481$

For each section, the resultant flows in PCU/h were computed for each vehicle size in terms of number of seats, by applying equation 7. Figure 46 and Figure 47 below are plots showing the relationship between vehicle size and the resultant traffic flow, in PCU/h for segments 1 and 2. The type of trend line was selected to ensure the  $R^2$  value of the resulting trend line was above 0.5. A line of best fit is shown on each graph. Second order polynomial curves were fitted with squared Pearson correlation coefficients of 0.944 and 0.924 respectively. The arithmetic equation for the modelled values is shown on each graph.

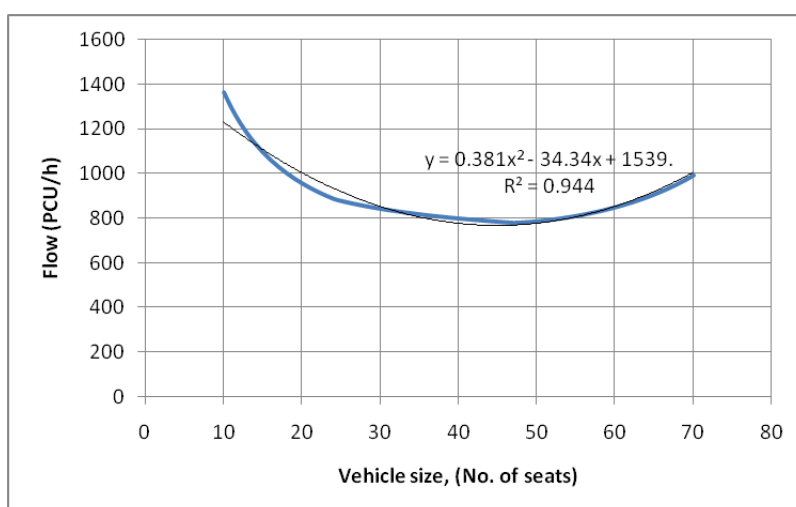


Figure 46: Segment 1 flow vs vehicle size

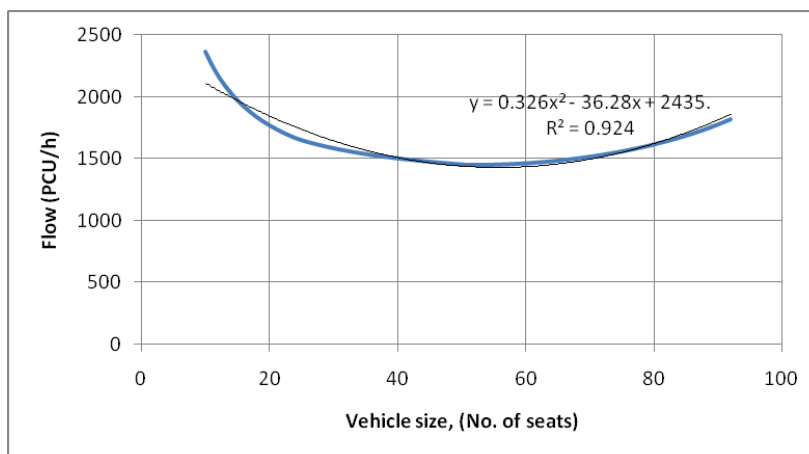


Figure 47: Segment 2 flow vs vehicle size

For segments 1 and 2, optimum values for transit vehicle size were obtained by equating the first derivative of the vehicle size-flow equation to zero, then solving for x. **Table 24** below shows the peak demand, first derivative of the vehicle size-flow equations, the optimum vehicle sizes and the resultant vehicle flows for segments 1 and 2. An optimum vehicle size of 45 seats was obtained for the segment 1, resulting in a vehicle flow of 1478PCU; while an optimum vehicle size of 56 seats was obtained for Segment 2, resulting in a vehicle flow of 1455PCU.

Table 26: Optimum transit vehicle sizes for segments 1 and 2

Segment	Peak Demand	dy/dx	Optimum vehicle size (Number of seats)	Flow (PCU/h)
1	10819	$y' = 0.762x - 34.34$	45	1478
2	20329	$y' = 0.652x - 36.28$	56	1455

## SUMMARY AND CONCLUSIONS

The main objective of this study was to develop and apply a model for selecting suitable transit vehicle sizes along the Nairobi-Thika Highway. Optimal bus size entails trade-offs between vehicle size and operational variables for a given frequency of service (Ceder (2007). Most of the earlier models concluded that it was more efficient to use smaller buses at higher frequencies (dell' Olio et al, 2012). The use of smaller buses offers passengers a better service frequency for a given service capacity, but costs more to operate per seat provided. Further, most of the earlier models for vehicle size optimization deal with operator and user cost minimization. In contrast, the proposed model gives the resultant flows in PCU of public transport vehicles that would theoretically result from the selection of a particular vehicle size. The input variables for this model are occupancy rates and vehicle PCU value. The model was applied along the two segments of the study route. The optimum vehicle sizes were established as 45 and 56 seats for route segments 1 and 2 respectively.

The proposed model thus offers a simplified approach to vehicle size selection. It can be used to guide policy on transit vehicle size restrictions. For instance, it can be used to determine how close to the city centre certain vehicle sizes should be allowed. Hence, suitable locations for transfer stations and terminals for upcountry vehicles can be identified. However; further investigation is required to identify more variables that have an influence on vehicle size in uncoordinated bus systems.

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## **Simulation of MT movement through microfabricated guiding track designs towards system integration into nanodevices**

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Interfacing of biological system with the synthetic environment is a new upcoming field which will lead to the expansion of nanoscale devices and systems. Biological systems can move, self-assemble and maintain its dynamic state far from the thermodynamic equilibrium. Investigation of different motor proteins like Microtubule powered by the kinesin motors will aid in extracting the overall principles that govern them. The principles will aid in designing the artificial dynamic system like the microfabricated guiding track and surface sensing probes. The systems can be studied in details and will ultimately lead to the innovative implementation in biomimetic smart assemblies and materials like lab on chip devices. Our aim is to simulate the movement of the molecular shuttle (microtubule powered by kinesin motors) in a microfabricated track design in order to extract the governing principle for integration into the nanoscale devices. The simulation will be validated through the experimental data obtained from the lab. Monte Carlo simulation will be developed; which model the guiding track shapes then obtain the properties of the microtubule movement along the microfabricated track designs. The appropriate gliding speed will be obtained, the appropriate external force for uniform movement of microtubule will be obtained and the appropriate guiding track design will be recommended. Overall, this research will aid in utilizing the potential of molecular machines in developing the nanodevices and synthetic nanoscale systems. However, its application will be restricted only by our inventiveness and imagination.

Key words: Microfabricated, microtubule, nanoscale, systems, devices

## BME

### The Status of the Furniture Value Chain in Kenya

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Kenya has limited forest resources, covering about 7.2 % of land area. Kenya is the largest regional producer of furniture in East Africa. The furniture value chain in Kenya is crucial both to employment and economic growth in the country. This paper provides a value-chain analysis of the furniture industry and assesses the available policy options and recommends critical interventions to stimulate the industry's development. A total of 244 respondents from 16 counties were interviewed and discussions held with key actors in the value chain. The results indicate that the furniture market is worth approximately US\$496 million in sales, with a Compound Annual Growth Rate (CAGR) of 10% over the past five years. Furniture imports are worth US\$66 million, (13 % of the total market) and growing at a CAGR of 24% (2009-2014). Labour productivity for the informal furniture subsector, estimated at US\$ 114 to 609 annually is much lower than US\$ 2300 estimated for the formal furniture firms despite the former accounting for over 80% of the employees. The main challenges include: constrained input supply, limited labour skills and poor production facilities, lack of furniture specific data and statistics, limited access to appropriate infrastructure, technology and markets and limited engagement and collaboration between different stakeholders. The strategic interventions include: enhancing collaboration, linkages and synergies among stakeholders; increased supply of inputs; improving innovation and quality; enhancing access to domestic and regional markets and inducing greater demand for Kenyan furniture products. It is concluded that the huge interval in the estimated size of the furniture industry makes it hard to postulate policies and strategies with precision and certainty. Furthermore, if the identified constraints are tackled, Kenya has the opportunity and potential to expand its furniture industry to meet growing local and regional demands. Strategies that address the identified challenges are recommended.

**Key words: Kenya, furniture, value chain**

## **Effects of Staff Training On Performance of Public Organizational In Kenya. A Study on Kenya School of Government, Embu Staff Perception on Current Training Status**

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### **Abstract**

The study aimed to establish the effects of staff training on performance of public organizational in Kenya. Researches show existence of a direct correlation between staff training and the general performance an organization. Staff training plays a pivotal role in enhancing organizational performance. In the wake of; Kenya Vision 2030, enhanced public service reforms and Kenya constitutional 2010, the importance of training staff cannot be overemphasized. Government organizations and private institutions have embraced the culture of training staff and adopted various modes and methods of training. The objectives of this study were; to find out how mentorship, how internal training and how trainee selection affects KSG Embu performance. This study employed descriptive research design to collect and analyze data. All 103 KSG Embu employees were targeted under following categorizes; administrative, teaching and non-teaching staff. Stratified random sampling method was used to select a sample of 20 respondents. Structured questionnaires were used to gathering data which was processed quantitatively. Microsoft excel package was used to ease analysis. Data was presented using tables, graphs and pie-charts. Study findings revealed that internal training greatly enhanced organizational performance while mentoring and trainee selection process had both positive effects on the general performance of a public organizational. The study concluded that staff mentorship, internal staff training and trainee selection process had direct correlational effects on the general performance of Kenya School of Government Embu. The study recommends that; the school employer need to ensure that all staff were capacity build to acquire necessary skills, knowledge and competencies that leads to continuous general improvement in performance of the School. KSG director and Human resources officers to initiate mentorship programs for all staff and trainees selection be streamlined or be structured to cater for training needs all staffs in KSG Embu.

### **Key words**

**Performance, trainees, mentorships, selection, Kenya vision 2030, Kenya constitution 2010,**

## **Agricultural policies and market access by smallholder cereal farmers in Buuri Sub-county**

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### **Abstract**

Agriculture continue to be the dominating and the leading sector of the economy in Kenya, agriculture contribute about 25 percent of the Gross Domestic Product and is a source of employment to 40 percent of Kenyans. This sector offers employment to more than 70 percent of the population in the rural areas. How this sector performs directly affects the general performance of the economy. In Kenya there are many laws and legislations as well as plans for the different phases of growth in agriculture. But in regards to marketing of agricultural produce, policies taken up haven't been entirely doing well, mostly since the laws are disjointed in addition to not placing marketing systems that are orderly and guarantees the farmers a market that is reliable for their produce countrywide. This study examined the influence of agricultural policies on market access by 380 smallholder cereal farmers in Buuri Sub-county. Descriptive research was adopted for the study, data was collected using well structured and validated questionnaires. Statistical Package for Social Science (SPSS) was used to analyse the dataset while a logistic regression analysis was conducted. The research established despite there being many agricultural policies most of the farmers were not aware of them. They however felt that if the policies were well implemented they could easily access markets for their produce. The study concludes that agricultural policies affect market access by cereal farmers and recommends that various policies be streamlined for easier implementation.

Key words: smallholder, agricultural policies, farmers, market access,

### **INTRODUCTION**

Market access is an subject that several governments from underdeveloped nations, supporters as well as NGOs keep on struggling with. Markets for farm produce are frequently viewed at as important constituents for growth of the economy as well as for tackling poverty. Accessing markets by smallholders is nevertheless laden with difficulties. The issues of accessing markets that give way to linkages both locally and internationally that attest to prospects as well as difficulties for farmers with small holdings in the rural area (IFAD, 2010)

This study was carried out in Buuri Sub-county is in Meru County, Kenya, in its first county Integrated Development Plan 2013-2017, Meru county government noted that and the county relies heavily on agriculture, and these agricultural produce are sold without any form of value addition thereby fetching low prices in the market. Buuri

Sub-county is in the Northern Grazing Area (NGA) where small scale farmers have settled though the area is predominately semi-arid and farmers rely on rain fed agriculture. Buuri has a population of 109,803 persons, an area of 987 square kilometers containing 36,880 small scale and 21 large scale farmers (Kenya National Bureau of Statistics [KNBS], 2013).

According to Patrick and Rosemary (2006), regulations for farming include the government regulations that affect how stable the prices of input and output are and their level of any investment that affect farm production, expenses as well as incomes and sharing of wealth. In Kenya regulations on agriculture gyrate approximately towards the key objectives of rising production as well as increasing proceeds, particularly for small farmers, improving security of food and fairness, prominence on irrigation to bring in steadiness in commercialization, as well as yields of agricultural produce, and intensify farming more-so amongst smallholder farmers through suitable and involvement of all stakeholder in formulating policies as well as sustaining the environment. These policies affect farming and market access for farm produce either directly or indirectly.

Alila et al (2006), agricultural guiding principles or policies are made up of resolutions by the government that impact the intensity and steadiness of inputs and yield costs, communal use of funds on projects that affect production in farms, expenses as well as incomes and the distribution of wealth. These policies influence farming directly as well as indirectly. Enhanced farming produce has been noted to be a major general goal for decrease in paucity in any nation. Alila et al (2006) noted that the goals of the stratagem of the agricultural include escalating growth in agricultural sector, viewed as significant for rising incomes for the rural poor as well as making certain there is unbiased distribution of resources. In Kenya the policy on agriculture gyrate more or less around the key objectives of growing output as well as increase in returns, particularly for smallholder farmers, improved food security as well as impartiality, importance on irrigation to initiate constancy in farming production, commercialisation and strengthening of farming more so amongst the smallholders, suitable as well as all inclusive strategy formulation and ecological sustainability.

Alila et al (2006) stated that the SRA 2004 in Kenya was established to work hand in hand with the Economic Recovery Strategy in crop growing and animal husbandry so as to emphasize cooperation between the public and the private sectors so has to enhance markets, make it possible for competition to thrive, ensure effective resources use as well as make better hush-hush prosperity. Farming in Kenya mostly relies on weather conditions therefore it is necessary to lay down vigorous adjustment structures which will concentrate on susceptibilities of climate change and threats previously felt and the future ones. Planning to adopt climate changes ought not to be looked at as a fresh division of community laws instead it should be viewed like an important component in a collection of plans whose aim is lessening of poverty as well as bringing forth of long lasting development of the people. But in regards to marketing of agricultural produce, policies taken up haven't been entirely doing well, mostly since the laws are disjointed in addition to not placing marketing systems that are orderly and guarantees the farmers a market that is reliable for their produce countrywide taking into consideration the perishability of the produce and risks which may be related to these measures. Additionally, the capability of the stakeholders in agribusiness moreso in the buying and selling of farm produce as well as inputs is

inhibited by lack of finance or capital, infrastructure that is poor, undeveloped entrepreneurial skills, legal and institutional structures that are not conducive as well as an inadequate competition. Therefore farmers who are the producers do not receive returns that are fair.

Markets for farm produce are most of the time considered an important component for the development of Kenya's economy as well as reducing poverty. Good markets will ensure the attainment of Sustainable Development Goals on ending poverty, ending hunger and also ensuring good jobs and economic growth. Market access is a restrictive issue which must be considered by governments of developing nations, their supporters and NGOs. Accessing markets by smallholders is laden with difficulties. In Kenya there are many laws and legislations as well as plans for the different phases of growth in agriculture. Kenya's Vision 2030 lays emphasis on the necessity to boost worth in farming, rearing of animals as well as fishing. Vision 2030 gives an overview of seven major schemes in crop and animal areas. The major goal in the any policy is meant to rouse the agricultural sector in the direction of the preferred development so as to realize the dream of a country that is food secure. Despite being a great as well as a worthwhile goal, its achievement is marred by challenges. In regards to marketing of agricultural produce, policies taken up haven't been entirely doing well since the laws are disjointed they do not introduce marketing systems that are orderly and guarantees the farmers a reliable market for their produce countrywide and are not well implemented.

According to FAO (1997), the meaning of smallholders vary amongst nations and also amongst agro-ecological regions. In regions that have favourable farming conditions that have high populations, they farm fewer than an hectare of land, but they may also possibly farm 10 hectares or higher in areas that are semi-arid. For the purpose of this study this will be someone who farms or cultivates 5ha of land and these farmers rely on rain to grow their produce and they depend on harvest seasons which are two per year to harvest and sell their produce.

### **Research objectives**

The study sought to accomplish the following objectives:

1. To examine the agricultural policies in Kenya
2. To assess the farmers level of knowledge of agricultural policies
3. To determine the effect of agricultural policies on market access

## **METHODS**

### **Research Design**

The researcher used descriptive design in this study, the design was flexible and allowed the researcher to collect the appropriate data, both qualitative and quantitative.

## **Target Population**

The study targeted all smallholder farmers in Buuri Sub-County. According to Meru County Directorate of Agriculture (2015) Buuri has 36,880 smallholder farmers.

## **Sample and Sampling Procedure**

The sample size was drawn by use of a sampling matrix by Krejcie and Morgan (1970). As the population size is 36,880 from the matrix the corresponding sample size is 380. The questionnaires were administered by the researcher. Secondary data was found in government records and documents that is the policies in agriculture and the data on the number of smallholder farmers in Meru county.

## **Validity and Reliability**

To test the validity of the questionnaire it was presented to an expert, this was to assist get an idea for the practical accuracy and accurateness of the questionnaire, how big the questionnaire will be and how much time will be required to answer the questions. While Alpha Test of Reliability was used to test and ensure inner consistency of the model used. Tavakol (2011) stated that the score that is deduced from the test should be in the range of 0 - 1 and is used to interpret and establish the inner consistency of the calculated variables. Obtaining score of 0.7 and greater indicates a higher internal reliability of the scale items. The overall score for this study was found to be 0.843, thus indicating a good reliability.

## **Data analysis**

SPSS was used in the analysis of the dataset and descriptive statistics, which include tabular, graphical and numerical representation of data were used to present the results. Logistic regression was used to analyse the dataset, it is defined as an arithmetical technique use to analyse data where the independent variables are one or more and decide on the end result.

## **RESULTS AND DISCUSSION**

### **Response Rate**

The researcher administered 380 questionnaires which was the sample size of the study, the number of those who that correctly answered were 375 (98.7 %) and 5 (1.3%) had errors thus not suitable for the analysis. 98.7% responses were found to be very significant to carry out the study by the researcher.

### **Farm Size and Ownership**

The study sought to analyse the farm and family size of the respondents. This was deemed useful to understand the sizes of the family and farm tilled and to ascertain

they fall within the smallholding category set out for this research, which was less than 5 hectares of land. On the size of farm tilled majority of the respondents (57.9%) indicated that they tilled a land of less than one hectare, 33.6% tilled a land of 2 to 3 hectares while 8.4% were tilling 4 to 5 hectares of land. Botlhoko and Oladele (2013), noted that size of a farm does not have any impact on better proceeds since smaller farms can yield higher per acre more than huge farms. On land ownership 88.3% of the respondents stated that they owned this land while the 11.7% had leased.

### **Level of Education**

*Table 1: Respondents Education Level*

Education Level	Frequency	Percent
Primary	170	45.3
Secondary	157	41.9
Tertiary	19	5.1
None	29	7.7
Total	375	100.0

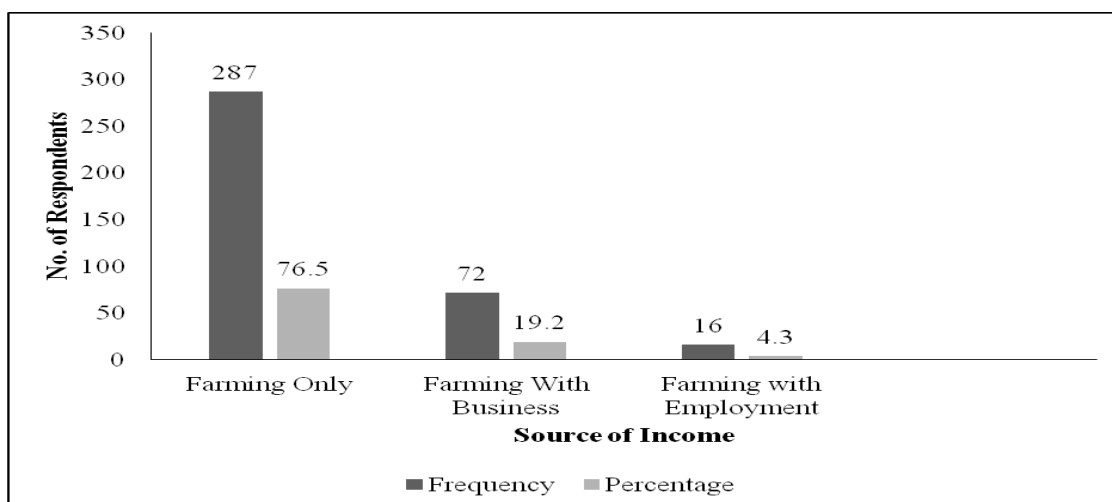
As shown in Table 1, 45.3% attained a primary level education, 41.9% attained a secondary level education, 5.1% attained tertiary level while 7.7% did not have any basic education. Majority of individuals in the sub-county were found to have attained formal education. On education, Botlhoko and Oladele (2013) established that educated farmers are more probable to accept modernization than uneducated farmers, therefore, their production is enhanced resulting to larger farming proceeds. While Gilbert et al (2001), noted that education played a very vital role in the sale of produce for the farms by having less transaction costs.

### **Source of Income**

The researcher sought to determine the source of income for the farmers in Buuri Sub-County. This was important in understanding the economic activities of the respondents, Alene et al (2008) noted that income from non-farming activities may contribute to what is sold if it is invested in the farm. To achieve this the respondents were given three options to choose from that farming only, farming with business and farming with employment. As indicated in Figure 1, the study established that, 76.5% of the respondents had farming as their sources of income, 19.2% farming with business and 4.3% of the respondents' income came from being in employment alongside farming.



Fig 1: Source of income



### Level of Knowledge

The level of knowledge of agricultural policies amongst the smallholder in Buuri was low as 72.6% were not aware of any policies while 27.4% indicated they had some awareness on policies on weights and measures governing marketing of produce. This could be attributed to the level of education among the respondents as 5.1% had tertiary and higher level of education, 41.9% had secondary education level, 45.3% had primary level education while 7.7% did not have any basic education.

### Taxes

#### *Type of Fee Charged for Selling Produce*

Fee	Frequency	Percent
Tax	1	0.3
County License	11	2.9
None	363	96.8
Total	375	100.0

Table 2 shows that only 0.3% and 2.9% of the respondents indicated that they pay tax and county license respectively but they only pay when they sell their cereals produce at the main market while 96.8% did not pay any form of tax. On taxation Gitau et al (2009) stated that Strategy for Revitalizing Agriculture (SRA) identifies key areas among them improving access to markets for example through rural roads development and internal taxes.

## Set Prices

Buyers were found to set the prices for the produce with 98.4% of the respondents stating so, while 1.3% of the respondents stated that the farmers did set the prices for their produce and 0.3% of the respondents indicated that government was responsible for setting the prices.

## Agricultural policies in Kenya

The Kenyan Government has formulated various policies over periods of time to deal with reduction in poverty and food security. These policies include:

Policy	Year	Purpose
National Food Policy	Sessional Paper no. 4 of 1981	Sustain food self-sufficiency and to guarantee food of nutritional value is equitably distributed to all Kenyans.
National food policy	sessional paper No.2 of 1994	Promote a market focused look to food security
Kenya Rural Development Strategy (KRDS)	2002-2017	Emphasized food security as the first step to alleviating or reducing poverty and rural development
Economic Recovery Strategy (ERS)	2003 -2007	Achievement of wealth and employment creation
Strategy for Revitalizing Agriculture	(SRA 2004-2014).	Provide a framework to increase agricultural productivity, to promote investment and encourage private sector involvement in agriculture.
Kenya vision 2030	launched in 2007	The vision identifies agriculture as the key mover of raising Kenya's GDP to 100%.
Agriculture Sector Development Strategy	(ASDS), 2009	To align sector initiatives to vision 2030.
The National Food Security and Nutrition Policy	(NFSNP), 2009	Deals with the necessity for better food and sustenance security, coordination of information management systems and the roles of various ministries and agencies to achieve food security.
Agriculture Act	(Cap 318)	Aims to promote and maintain a

		stable agriculture, provide conservation of soil, stimulate development of agricultural land
price stabilization and producers support prices for maize policy		Aims to: (i) imports by the National Cereals and Produce Board (NCPB) for strategic grain reserve (ii) supply of maize to millers at prices fixed (iii) fixing the purchasing price of maize (iv) input subsidies on a continuous basis

Table 3

### Effects of agricultural Policies on Market Access

Effect	Frequency	Percentage
Very High	285	76.0
High	83	22.1
Moderate	7	1.9

Table 4 shows the effect of agricultural policies on market access, indicates the effect was very high with the majority of respondents at 76% stating so.

### CONCLUSION

The farmers in Buuri were not aware of any agricultural policy, since they sold their produce to middlemen they did not pay any tax or cess to the government and the few who paid did so when they sold their produce to the urban market. The buyer set the prices of the produce, this could lead to exploitation by the middlemen by giving the farmers lower prices than the prevailing market price.

Though policies on agriculture have been developed over time little has been done in regards to marketing of cereals save for tariffs that have been imposed and lifted but not felt by the farmers. The level of knowledge on any agricultural policies was very low, thus in cases of exploitation farmers were not aware as it was the buyers who mostly set the prices. The effect of agricultural policies on market access as very high, an indication that if the policies are well actionalized they would greatly benefit the farmers.

## RECOMMENDATIONS

Farmers need to be sensitized on use of formal agricultural information from agricultural officers. This would assist farmers in getting the correct information about the market and the government should formulate policies to make market information available to all farmers. This would make market information a public good therefore available to everyone who needs it. The government should synchronize the different agricultural policies and have the extension officers disseminate the knowledge on the various policies to the farmers. The policies formulated and implemented should guarantee farmers a market for their produce.

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## **An assessment of Key ICT skills for special needs people and entrepreneurship**

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### **Abstract**

Entrepreneurship is not meant to be enjoyed by normal people only but also to special needs group this includes the deaf people and the blind people .This paper examined the technology and skills needed by special needs people that is the deaf and the blind category. The study used desk research where online journals and information were reviewed .The findings revealed that for the deaf to succeed in entrepreneurship, they needed A high-speed internet , Video relay services (VRS) assist us to communicate in sign language with an interpreter who then speaks to a hearing person via the phone, Video remote interpreting (VRI) allows hard of hearing business owners to communicate with people in the same location, which is great for business meetings and Smart phones and apps like Ava, created by deaf people for deaf people, provide real-time captions .For the blind the study found out that they needed Tape Recorder, Speech Compressor, Talking Computer Terminal, Kurzweil Reading Machine, Optacon, Talking Calculators, Paperless Braille Machines, Computer Driven Braille Printer. The study further noted that most modern equipment for the blind are expensive thou of help to the entrepreneurs .The study therefore proposed subsidy in technology equipment to facilitate special needs entrepreneurship

**Key words :** ICT Skills, Special needs people Entrepreneurs, Entrepreneurship ventures

# Use of Public Private Partnerships as an Innovative Tool for Achieving Sustainable Development Goals in Nairobi County, Kenya

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## Abstract

Developing countries have laid a continuous emphasis on Public-Private Partnerships (PPPs) as a superlative tool to achieving Sustainable Development Goals (SDGs). PPPs have become a dominant model and proved to be an effective mechanism through which Kenya, in line with global trends, is striving to provide the much-needed infrastructure and services. The main purpose of this paper is to provide expert knowledge on how to manage and implement successfully the innovative agendas of SDGs through PPPs. The specific objectives will be to assess the adequacy of capital planning; to establish the level of capacity building; and to assess the intensity of data management towards achievement of SDGs in Nairobi County. SDG's influence and guide the society and global development cooperation in a variety of aspects: People-ending poverty and hunger; planet- initiate positive and reliable measures to climate change; prosperity- fortify fulfilling lives; peace- amicable, just and inclusive coexistence for all. Kenya through the PPP Act 2013 created structures that ensure a smooth operation of PPPs. The main source of data for this research is a study of various PPP initiatives in Nairobi County geared towards achieving SDGs. The study is centred on a mixed research methodology and descriptive research design. The target population is 15 PPP projects across Nairobi County selected using purposive sampling. Interview guides and semi-structured questionnaires are the main tools of data collection. This research shall adopt descriptive statistics analysis. Data will be presented as frequencies, figures, and tables. This research noted that capital planning; availability of budgets and other financial resources, new assets and replacement of old and worn out machinery, capacity building; acquisition of skills, knowledge and other competencies and data management: collection, storage, processing, analysis and interpretation and dissemination of results are key influencing determinants to the use of PPPs for sustainable development.

**Keywords:** *Sustainable development, public-private partnerships, capital planning, capacity building, and data management*

## 1.0 INTRODUCTION

Public private partnerships have become a super model trough which developing countries can achieve sustainable development. Sustainable development is tailored on a vision, ambition, a target and a measure for countries with regards to a sustainable future and sustainable development. PPPs are sometime contrasted to public delivery method. Under public deliver, key to note is that a government agency designs, build and finances the related service or infrastructure. Therefore the public

agency remains responsible for the infrastructure and related services and is fully responsible for all the project risks (Delmon, 2014).

Under the PPPs model, significant risks such as designing, delivering, operating, monitoring and maintaining and partly financing the related projects are transferred to the private partner. The roles, responsibilities and risks of the partnership are formally outlined in the PPP contract. PPPs can directly address the provision of social services and healthcare by improving the coverage, quality and accessibility. PPPs are a bright avenue to ensure inclusive and affordable quality education for all for long life learning through vocational educational facilities and services. PPP initiatives can also involve delivery and management of water and sanitation infrastructure and services (Hoppe & Schmitz, 2013). PPP initiatives in Kenya have targeted the energy sector through generation, distribution and transmission including renewable energy initiatives.

According to Iossa and Martimort (2012) there has been multiple occasions where PPPs have been perfectly involved in building resilient infrastructure, making cities safe through sustainable security, ending all forms of poverty through job creation, actively involved in ensuring gender equality and empowering all women and girls, promoting sustainable consumption patterns, combating climate change through by regulating emission and designing projects to withstand the future impacts of climate change related events.

Capital planning is key in budgeting for resources of a PPP project long-term plan. Proper capital planning brings about sound financial stability for a PPP project thus ensuring that budgeting for new and replacement of machinery, research and development and other major capital expenditures. Without proper capital planning mechanisms it's difficult for PPP project to achieve its strategic goals and objectives. Financial dyslexia is the major reason as to why many PPP projects fail. Without proper financing projects will delay leading to an escalation of costs thus failure in the long run (Maheshwari & Varshney, 2010).

Capacity building in PPPs ensures that the partnership and the project in general is able to obtain, improve and retain the skills knowledge, tools, equipment and other resources needed to ensure that the project is managed and completed competently to a great capacity (Teferra, 2010). Capacity building brings about capacity development that greatly empowers the PPP initiative. Focusing on capacity building brings clarity in understanding obstacles that inhibit PPPs from realizing their development goals and enhancing their abilities thus allowing them to achieve measurable and sustainable results (Heslop & Vivienne, 2010). With the increasing concern on climate change and in order to ensure local communities are empowered to be self-sustaining, capacity building has become a crucial part towards achieving sustainable development.

Data management has slowly evolved to information management and integrated information data management easily helps in resource management thus improving performance. Data is the most valuable resource in a PPP project. Data management very much depends on what you do with it. Well-managed data should be easy to access, clean and well integrated with the PPP project. Data should go through a proper data analysis system as it flows through the project. Ease of data access is key and proper technologies should be in place to make access to data easy and efficient. Data quality should be credible and usable for the intended purpose. Data integration mechanisms are important to facilitate combination of different data from multiple sources. According to Kjorstad (2015) data management aids in the development and



execution of practices and policies that properly manage the full lifecycle of a PPP project.

## **1.1 Background study**

### **1.1.2 Global perspective**

Developing countries in Asia and the Pacific worked towards sustainable development by strengthening the delivery of infrastructure and socio-health services through PPPs (Mathieu, 2016). Most countries in this region, inline with global trends, have established long term contractual relationships between public and private parties. Collaboration with private parties involves a competitive tendering process in which the financing required is provided by the private partner and sufficient risks are transferred to private partner and remunerations linked to their performance.

In Philippine, PPPs initiatives such as the Jakarta Coastal Defence project, the Manila Bay Integrated Food Control and the Coastal Defence and Express Way Project. In Australia PPP solutions were considered for developing social housing (Housing Choices Australia, 2012). To enhance security and reduce losses due to exposure and deterioration the Indian government developed grain storage facilities in Punjab through a PPP initiative (IFC Advisory Services, 2011).

In Samoa, the outsourcing of road construction projects to the local Samoa private companies greatly improved the quality of roads according to an African Development Bank study (Asian Development Bank, 2018). The mining sector in Indonesia introduced specific requirements for community development in mining through public private partnerships (PwC Indonesia, 2018). PPPs were used in the development were considered in the development aquaculture and the fisheries sector in a socially and environmentally responsible manner.

### **1.1.2 Regional perspective**

PPPs in Nigeria were widely accepted and used in achieving sustainable infrastructure project (Aliyu, 2013). The Lagos-Ibadan Expressway, Maervis Management of Airports, Lekki-Epe and Kuto-Bagana Bridge are perfect examples of PPP projects in Nigeria. However there's need to formulate enough laws and policies to guide PPP procurement and contracting.

According to a report by the Government of Ghana (2015) the government has shifted to PPPs for development (Africa Infrastructure Country Diagnostic , 2015). The report indicates that the government of Ghana through the Ministry of Finance has embarked on a massive sensitisation drive to create awareness, improve knowledge and understanding of PPPs. This has attracted advocacy for PPP on a national level and use it as a formidable tool to close Ghana's infrastructure gap in order to accelerate socio-economic development. The re-development of the of Salaga market in the greater Accra region and the Accra-Tema Motor Way are perfect examples of PPP project in Ghana (InfraPPP Partners, 2018).

In South Africa energy project dubbed Offshore Supply Base in Western Cape town and the Durban port cruise terminal are among the many such partnership projects driving the South African economy to sustainable development (InfraPPP Partners, 2018). The South African PPP environment is very strong with a solid tract record of delivering major infrastructure and socio-economic projects. This has mainly been

brought about by the presence of firm legal framework that guides and governs PPP initiatives (National Treasury, 2004).

### **1.1.3 Local perspective**

The Konza Technology City project in Makueni County is an ICT sensation project that has grabbed the headlines for a couple of years now. This project is part of an economic blue print PPP project geared towards transforming Kenya into middle class economy by 2030 (Advantech Consulting, 2017).

The construction of a Coal Fired Power Generation Plant in Lamu is consortium between East African Centum investment and Oman's Gulf Energy. This PPP that was commissioned in 2015 will add more than 1000 Mega Watts of energy to the national grid. (Oxford Business Group, 2015).

The commencement of this project also culminated to another PPP project dubbed 35MW Ormat Orpower Geothermal power project in Olkaria, Naivasha. The project is a PPP green field geothermal electricity generation project whose aim is to increase more Mega Watts of power to the national grid in an eco friendly way.

The Mombasa- Nairobi Dual Carriage Toll Project is a mega PPP initiative between Kenya and the American government through the Kenya National Highways Authority (Government of Kenya, 2018). The over 400 Kilometre road forms part of the longer Trans-African Highway and will be the main transport route serving East and Central African countries from the Indian Ocean Seaport of Mombasa.

Likoni Cable and Expressway project is an initiative between the Kenya government and the African Development Bank (Infrappworld, 2017). This PPP project is currently under construction and is expected to complete by 2020. The project will offer Kenyans safe and secure transport across the Likoni harbour. This will be more cost efficient to operate compared to the conventional ferry system.

### **1.2 Statement of the problem**

A World Bank Benchmarking Report in 2016 revealed that Kenya is among the top most countries in Africa as regards preparing an ambient legal and regulatory framework through which PPPs can thrive (World Bank, 2016). While Kenya is still at the top cream as regards the regulatory framework, there is much room for improvement. There are many areas that require greater clarity and reviewing.

PPPs contribute in several ways in the delivery of services and infrastructure in a country. They can easily improve the volume and pace of infrastructure delivery in by effectively mobilizing the technical, operational, managerial and financing capability. PPPs improve the value for money improving the efficiency of capital consumption. An opportunity exists for developing countries like Kenya to establish the much-needed PPPs and ensure they contribute optimally to attaining sustainable development.

Kenya needs to move with haste and ensure PPPs are well initiated in the sustainable development agenda. Developing PPP projects that lead to sustainable development have to be directly linked to social and economic development infrastructure and plan for the country. There is a dire need for an immediate country guidance mechanism who's intend is to provide the much needed inspirational and practical action thus maximizing the contribution by PPPs. This guidance will act as a reference by leaders, experts, manager and practitioners from the public and private sectors as well as the civil society who act as a watchdog for PPP initiatives.

Kenya the necessary capacity building geared towards PPPs. Lack of proper legislation, policies and institutional arrangements to guide PPPs is major reason as to why they fail to take off or thrive to achieve their potential. Capital planning is also a major concern for PPPs. Lack of financial resources and other capital related facilities for PPP project origination and transaction support has gravely affected PPPs take off and operations in general. By failing to incorporate proper data management right from the beginning, public authorities are bound to miss a unique opportunity to significantly reduce the whole life cycle cost of a PPP infrastructure project.

### **1.3 Research objectives**

#### **1.3.1 General objective**

The general objective of this study is to analyse the use of public private partnerships as an innovative tool for achieving sustainable development goals in Nairobi County, Kenya

#### **1.3.2 Specific objectives**

This study was guided by the following specific objectives:

- 1 To assess how the adequacy of capital planning influences achievement of sustainable development in Nairobi County Kenya.
- 2 To establish how capacity building influences achievement of sustainable development in Nairobi County Kenya
- 3 To assess how the intensity of data management influences achievement of sustainable development in Nairobi County Kenya

### **1.4 Research questions**

- 1 How does the adequacy of capital planning influence achievement of sustainable development in Nairobi County Kenya?
- 2 How does capacity building influence achievement of sustainable development in Nairobi County Kenya?
- 3 How does the intensity of data management influence achievement of sustainable development in Nairobi County Kenya?

### **1.5 Literature review**

#### **1.5.1 Theoretical framework**

##### *1.5.1.1 Capital Structure Theory*

Decisions related to capital planning have irritated theoreticians for many years to date. This theory assumes that the benefit that a project derives from the infusion of proper financing structures determines the viability and efficiency of a project. Without proper financing and an increase in debt leads to an increase of other risks associated with the project, mainly bankruptcy risk and such risks interfere with the expectations of a project. Risk of corruption and financial mismanagement are a big blow to feasible project management. Clear financial structures and frameworks ensure that PPP projects are well financed and remain stable to achieve their long-term goals and objectives.

### ***1.5.1.2 Theory of Change***

The theory of change is a comprehensive theory addressing capacity building as an initiative made to bring about continuous improvement in performance of a project. This theory does this by first of all mapping out the current position and coming up with the best structures that ensure continuous improvement in performance by initiating changes that ensure achievement of desired goals. The theory advocates for initiatives like continuous skill upgrade and training, continuous facility improvement in performance and above all creating an ambient environment for the best of skills and techniques to thrive.

### ***1.5.1.3 Information Theory for Data management***

This theory is fundamentally about harnessing data to extract information and discover new patterns by analysing well managed data into a glean structure. Data management presents multiple cost beneficial trade-offs. If more data is store it is easy to get proper answers to queries. The ability to properly quantify data makes it possible to improve the ability of designing the best representations, storage mechanisms and analysis tools for data. Information theory provides the best tools for quantifying information. The theory clearly explains that data management involves the creation, obtaining, transformation, sharing, protecting data by documenting and preserving it in the best way possible that ensures ease of access for analysis and review. Well-structured data comes in handy when entering into contractual agreements or when seeking funding for a project.

## **1.5.2 Empirical literature**

According to the UK government, PPPS give local authorities access to capital investment and management skills thus availing the much needed financing and operational skills (Fitzgerald & Melvin , 2002). They help the state to afford and engage in more capital investment that it would through the conventional procurement methods. This research noted that poor capital planning was a major reason for failure of many PPP projects.

A research study conducted by Suresh and Debdatta in 2006 on capacity development as a research domain in a food production industry project concluded that capacity building strengthens the production of a project. With improved knowledge, skills and capabilities projects are better enabled to meet the urgent policy and production challenges. This researcher therefore agrees that capacity building is a major influencer to the success of a PPP initiative thus creating an ambient environment through which PPPS can become fully sustainable development (Suresh & Debdatta, 2006).

A study by Divesh Srivastava in 2010 on information theory for data management in Utah noted that taking a long term view in data management leads to a better understanding and utilization of between cost and benefit when designing effective projects. Data management brings about the best cost effective trade-offs leading to efficiency in operating projects (Divesh, 2010). The researcher further noted that the quality of data management goes further to determining the quality of output of a project and the same applies to PPPs.

## **2.0 RESEARCH METHODS**

### **2.1 Research methodology**

This research adopted a mixed research methodology, which entailed collection, analysing and integration of quantitative and qualitative research to give a better understanding of the research problem.

## 2.2 Research design

The research study adopted a descriptive research design emphasizing in quality regarding collection of data and analysis. Nairobi County was selected based on its high-ranking number of PPPs based on a Kenya PPP Pipeline Status Report of June 2018 regarding current status of PPP projects in Kenya thus attracting a lot of interest.

## 2.3 Sampling design

According to Kothari (2008) a well-chosen sample of at least 10% of a population can often give a reliability that is good. This study however used approximately 30% of the total number of PPPs in Nairobi County. The sample size comprised of managers, directors and chief officers working in various PPP projects in Nairobi County.

## 2.4 Data collection instruments

Questionnaires were the main tools used to collect data used in this study. Semi structured questionnaires were used to collect primary data. Descriptive statistics and content analysis was used to analyse data.

## 2.5 Data analysis

Quantitative and qualitative methods were used to analyse data. Frequencies, percentages and tables were used in presenting data. Prose form was used to present qualitative data. The researchers employed content analysis in order to discover and describe the focus of individual and group attention.

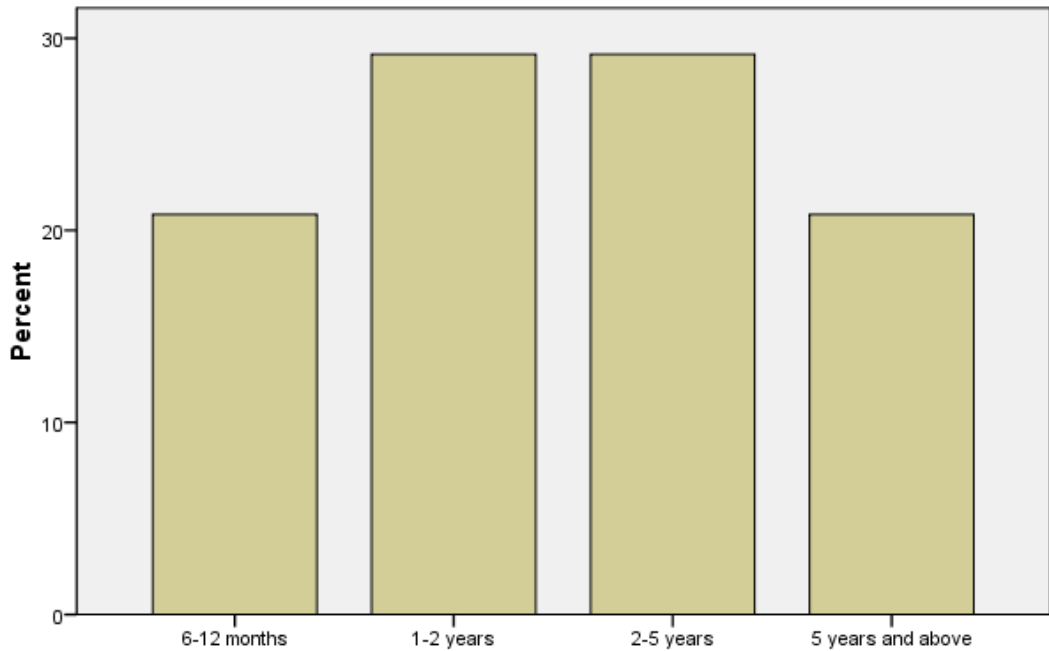
## 3.0 RESULTS AND DISCUSSION

### 3.1 Response rate

**Table 27: Response rate**

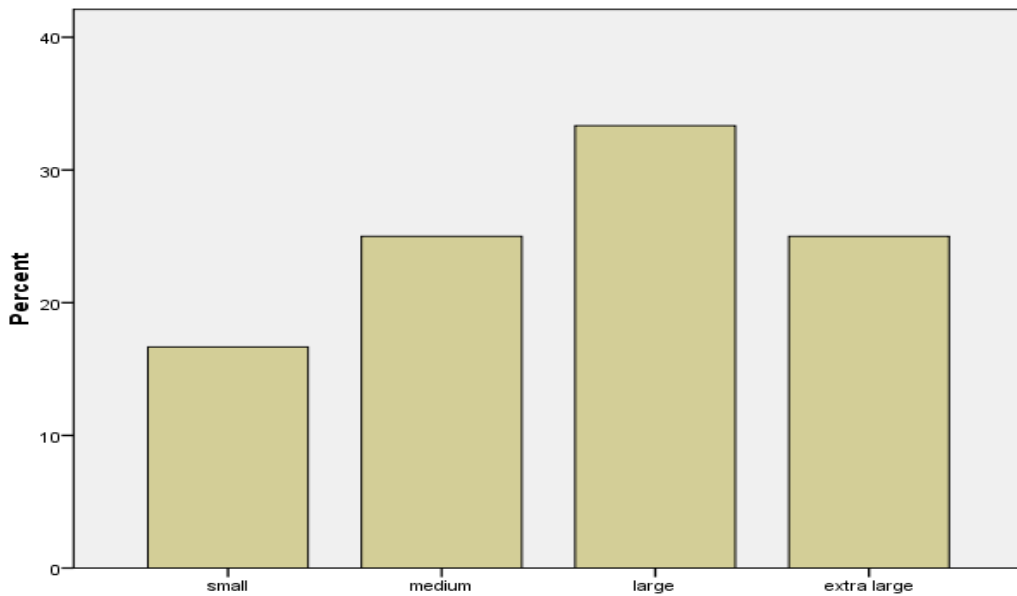
Items	Respondents	Response rate
Filled questionnaires	24	88.9%
Non-filled questionnaires	3	11.1%
Total	27	100%

A total of 27 questionnaires were administered and only 24 were filled and returned yielding an 88.9% response rate as indicated in **Table 1**. The data was considered sufficient just as (Babbie, 1995) who considered over 70% to be sufficient.



**Figure 48: Duration of the PPP Project**

From the findings in **Figure 1** a majority of 78% of the PPP Projects in Nairobi County were one year old and above.



**Figure 49: Size of the PPP Project**

From the findings **Figure 2** above a majority 58% of the PPP Projects in Nairobi County are large and extra large.

**Table 28: Extent of agreement of statements regarding influence of Capital planning on the use of PPPs for sustainable development**

	Very large extent	Large extent	Moderate extent	Small extent	Not at all
Capital planning is important for the PPP project	41.7	41.6	16.7	0	0
The PPP project is well funded	0	29.2	41.7	29.2	0
The PPP project operates on a strict budget	0	20.8	41.7	37.5	0
The PPP project observes budget and other capital guidelines	0	25.0	37.5	37.5	0
The PPP project is free of financial crisis	0	4.2	20.0	41.7	33.3

From the findings in **Table 2** 100% of the respondents agreed that capital planning has large influence on the use of PPPs for sustainable development. 100% of the respondents agreed that the PPP is funded to a fair extent. A majority 100% also agreed that the PPP operates on a fairly strict budget. 100% of the respondents agreed that the PPP fairly observes budget and other capital guidelines. A majority 67.7% agreed that the PPP is fairly free of financial crisis thus presence of poor capital planning.

**Table 29: Extent of agreement of statements regarding influence of Capacity building on the use of PPPs for sustainable development**

	Very large extent	Large extent	Moderate extent	Small extent	Not at all
Capacity building is key to the success of the PPP project	25	37.5	25	12.5	0
The PPP invests in improving employee skills	12.5	16.7	29.2	25.0	16.7
The PPP appreciates trained and skilled staff	0	12.5	25.0	37.5	25.0
The PPP provides the necessary resources and tools	4.2	16.7	29.2	29.2	20.8
The PPP secretariat assesses the capacity	20.8	29.2	29.2	20.8	0

From the findings in **Table 3** A majority 100% of the respondents agreed that capacity building is key to the success of a PPP project. 83.3% of the respondents agreed that the PPPs fairly invest in improving employee skills. A majority 75% of the respondents agreed that the PPP appreciates and rewards employee skills to a fair extent. 100% of the respondents agreed that the PPP secretariat assesses the capacity needs of the PPP to a fair extent.

**Table 30: Extent of agreement of statements regarding influence of Data management on the use of PPPs for sustainable development**

	Very large extent	Large extent	Moderate extent	Small extent	Not at all
The PPP acquires and validates all data relevant to the project	0	25	45.8	29.2	0
The PPP protects and stores safely all data relevant to the project	20.8	37.5	33.3	8.3	0
The PPP has invested in the best data processing tools relevant to the project	0	12.5	20.8	37.5	29.2
Data is conveniently accessible	8.3	20.8	33.3	37.5	0
Data is reliable and trustworthy	0	16.7	29.2	37.5	16.7

From the findings in **Table 4** 100% of the respondents indicated that the PPP acquires and validates all data relevant to the project to a fair extent. 100% of the respondents indicated that the PPP protects and stores safely all data relevant to the project to a fair extent. A majority 70.8% of the respondents indicated that the PPP has invested in the best data processing tools relevant to the project. 83.3% of the respondents indicated that the PPP data is only reliable and trustworthy to a fair extent.



**Table 31: Mean and Standard Deviation**

	Descriptive Statistics			
	N	Mean	Std. Deviation	Variance
Capital planning	24	14.9583	2.21613	4.911
Capacity building	24	14.8750	1.84891	3.418
Data management	24	14.2917	2.11576	4.476

From the findings in **Table 5** it is evident that Capital planning has a high contribution to the use of PPPs for sustainable development with a mean of 14.9583. Data management has the lowest influence to the use of PPPs for sustainable development with a mean of 14.2917. Capacity building has a moderate influence with a mean of 14.8750 to the use of PPPs for sustainable development.

**Table 32: Karl Pearson Correlation****Karl Pearson Correlation (r)**

		Use of PPPs for sustainable development	Capital planning	Capacity building	Data management
Use of PPPs for sustainable development	Pearson Correlation	1	.769**	.551**	.594**
	N	24	24	24	24
Capital planning	Pearson Correlation	.769**	1	.243**	.188*
	N	24	24	24	24
Capacity building	Pearson Correlation	.551**	.243	1	-.090
	N	24	24	24	24
Data management	Pearson Correlation	.594**	.188	-.090	1
	N	24	24	24	24
<b>P-Value</b>					

### Karl Pearson Correlation (r)

Use of PPPs for sustainable development	Sig. (2-tailed)	.000	.005	.002
	N	24	24	24
Capital planning	Sig. (2-tailed)	.000	.253	.379
	N	24	24	24
Capacity building	Sig. (2-tailed)	.005	.253	.675
	N	24	24	24
Data management	Sig. (2-tailed)	.002	.379	.675
	N	24	24	24

\*\*. Correlation is significant at the 0.01 level (2-tailed).

\*. Correlation is significant at the 0.05 level (2-tailed).

The results of Karl Pearson Correlation of the Use of PPPs for sustainable development **Table 6**, the correlation between Capital planning and Use of PPPs for sustainable development, the coefficient of correlation was  $r(24)=0.769$ ,  $p\text{-value}=0.000<0.05$ . Therefore the variables have a strong positive relationship that is significant at 5% level of significant. The correlation between Capacity building and Use of PPPs for sustainable development, the coefficient of correlation was  $r(24)=0.551$ ,  $p\text{-value}=0.005<0.05$ . Therefore the variables have a moderately strong positive relationship that is significant at 5% level of significant. The correlation between data management and the Use of PPPs for sustainable development, the coefficient of correlation was  $r(24)=0.594$ ,  $p\text{-value}=0.002<0.05$ . Therefore the variables have a strong positive relationship that is significant at 5% level of significant.

## 4.0 RECOMMENDATIONS

### 4.1 Recommendations for practice

The national and county government in Kenya should foster for the use PPPs in attaining sustainable development. PPPs can easily help the government achieve big projects within a short time as they avail all the necessary finances, knowledge, expertise and other resources necessary for the PPP project. We recommend that they capitalise on this sort of partnership in undertaking the Big Four Agenda.

### 4.2 Recommendations for future research

We recommend that future research be conducted in order to review the strategies proposed in this research and improve where necessary. Researchers should also perform similar studies in other counties and explore more objectives as well.

## 5.0 CONCLUSION

This research noted that capital planning; availability of budgets and other financial resources, was the strongest determinant of the achievement of PPP goals, while capacity building acquisition of skills, knowledge, and other competences and data management: collection, storage, processing, analysis, interpretation and dissemination of data rated closely as key influencing determinants to the use of PPPs for sustainable development.

## 6.0 ACKNOWLEDGEMENT

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## **Eliciting Attitude of Farmers towards Agricultural Insurance and Willingness to Pay In Çarşamba District of Samsun, Turkey**

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This study examined the attitude of farmers towards agricultural insurance and willingness to pay for agricultural insurance in Çarşamba district of Samsun province, Turkey. Research data were collected from randomly selected 42 farmers by using structured questionnaires. Risk attitudes of farmers were elicited by using the modified Neumann-Morgenstern model. Logit model was used to explore the factors influencing agricultural insurance motivation. Research results showed that the level of buying agricultural insurance contract was not satisfactory level. The most important reason for not having agricultural insurance was limited content of the insurance policy. Lack of trust, unclear content of insurance policy, high level of bureaucracy, limited information on insurance, high premium, presence of small farm size and long waiting period for claim were other barriers to adoption of agricultural insurance. Research findings also showed that nearly half of farmers were eager to buy agricultural insurance policy. Farmers were ready to pay 29,5t for insurance contract of hazelnut, while that of peach contract was 18t. The variables of family size, schooling, and experience and farm size affected the willingness positively and all of them were statistically significant. However, the variables of awareness of government support for insurance, credit use and the amount of the support payment affected the farmers' willingness to pay for agricultural insurance negatively. Designing farmers' extension education program focusing on agricultural insurance to enhance farmers' information may accelerate the dissemination of agricultural insurance. Simultaneously, revising the content of the insurance policy and reducing bureaucracy may increase the farmers' interest in agricultural insurance. In addition, long waiting period for claim should be shortened via reducing bureaucracy. Agricultural insurance promotion activities should focus on the educated farmers having large farms.

**Keywords:** Risk attitudes, insurable risk, willingness to pay, agricultural insurance, Turkey



# **Sustainable Operations Management Practices And Firms Competitive Advantage**

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Sustainable operations management practices are can be explained environmental initiatives with the quest for social, economic and environment objectives within and beyond the operations of a given firm. It extends the scope of sustainability evaluation beyond manufacturing as it keeps in mind all relevant aspects of operation to obtain the utmost possible payback from sustainability practices. The purpose of this paper is to do an empirical and theoretical literature review on the area of sustainable operations management practices and competitive advantage so as to identify research gaps for consideration for future research. Despite the role played by green innovation to green issues and business success, a review of these studies revealed that little has been discussed in connection to the strategic role played by sustainable operations technologies. The literature is limited on the information regarding sustainable operations management practices in industry. In addition, few attempts have taken a simultaneous approach to describe the three elements of sustainability (economic, environmental and social). In explaining the link between environmental management and firm competitiveness, little is known about the mediating effect of sustainable organization performance on the link between the two variables. Furthermore, the assessment of the probable direct relation between environmental consciousness and firm competitiveness in literature has resulted in mixed outcomes. Whereas some studies have found a positive connection, others do not make out a positive link of environmental proactivity and competitiveness. The lack of the consensus on these links brings out a research gap in literature. These gaps in the literature are very important hence need to be filled.

Keywords: sustainable operations management practices, sustainable organization performance, competitive advantage

## **1. INTRODUCTION**

The contemporary human consumption of natural resources is unsustainable, leading to major environmental challenges. Climate change, resource exhaustion, biodiversity loss as well as air pollution impact greatly on many people and the earth, which calls for behavior change. There is a need for movement towards sustainable development which “meets the needs of the current generation without compromising the ability of future generations to meet their own needs” (Brundtland, 1987: 8). The limited and semi renewable nature of numerous world resources plus the constrained ability of the ecosystems in absorbing of contaminants has been recognized for some time. The drivers at the core of the concept of sustainability as a management challenge include population and per capital consumption growth, the narrow nature of resources and sinks as well as the responsibility and exposure of organizations in resultant ecological risk and cost (Kleindorfer, 2009).

A rising expectation is being experienced by both the consumers and stakeholder on the need for organizations to be responsible for both the operations and portray good environmental and ethical conduct (Ashby, Leat & Hudson-smith, 2012). Manufacturing activities consume considerable amounts of resources which are non-renewable and are energy intensive, emits toxic wastes and contaminate the natural

environment leading to negative environmental challenges including acid rain, global warming, poisoning of biosphere and climatic change in addition to raising concerns regarding depletion of natural resources. Sustainable developments represent an opportunity to a firm, as action towards eco-sustainability can be a basis of competitive advantage as it leads to reduction in operational costs and operational expenses, organization further gain from environmental improvement via product marketing ( Roos & Roos, 1997).

In spite of the current efforts, sustainable efforts are yet to merge into the mainstream of operations management research (Gavronski, Paiva, Teixeira, & de Andrade, 2013). Company's operations management decisions forms part of the key contributors to the anthropogenic impact on ecosystem sustainability. If appropriately addressed, sustainable operations have likelihood of becoming crucial to competitive advantage and a solution to the problems experienced, this is because the distribution and manufacturing constitutes a vast section of human activity and a huge improvement margin exists (González, Perera & Correa, 2003). Sustainability calls for sustainable practices because of the central position of companies in the world economy (Esty & Winston, 2006).

Sustainable operations management practices can be explained as the quest for social, economic and environment objectives within operations of a given organization and operations beyond the organization to encompass the communities and supply chain. Sustainable organizational performance can be explained as a result related term that measures the intersection of the economic, environmental as well as social dimensions (Paulraj, 2011). While competitive advantage can be explained as the ability of a given firm to improve the quality offered in the market, ensuring healthy cash flow, reduction in costs and enlargement of its share in the market.

## **2. METHODS**

The relationship between sustainable operations management and competitive advantages is grounded on four major theories. These are: resource based view, institutional theory, stakeholder theory, resource dependence theory. The principal idea of the RBV is that for an organization to achieve competitive advantage then it all depends on its heterogeneous resources, which are inimitable, rare, valuable and non- substitutable (Barney, 1991). If an organization has intangible assets like knowhow or culture of being sustainable, it gives it mileage from its competitors because for them to acquire these resources, it requires time to catch up and by the time they catch up, the organization will have moved on to a different level hence this becomes a source of competitive advantage. Institutional theory recommends that companies can only gain legitimacy through reduction of their impact to the environment and being responsible socially, hence adopting sustainable operations practices (Bansal & Clelland, 2004). The primary idea of the theory is that "organizations must match to the established rules and norms of main institutions in order to gain support and be perceived as legitimate" (John, Cannon & Pouders, 2001: 151). Customers try to push organization into being conscious of the environment by supporting and promoting organization that have measures to take care of the environment and are ready to pay premium prices for their environmentally friendly products. This gives a firm a sustainable competitive advantage, as they will always strive to please all the parties.

The stakeholder theory offers that any entity is not only obliged to attend to the interests of its owners, but also those of their consumers, labor force as well as the local community (Piacentini, MacFadyen & Eadie, 2000). If the operations are sustainable and take care of the environment, health, safety and quality of life, this will be serving the interest of the stakeholders. It will portray a good image of the organization, making it reputable, increase its sales and returns to its shareholder and at the same time leading to competitive advantage. Resource dependence theory assumes that the firm cannot be independent with regard to critical resources for its survival. It depends on outside parties' resources to be competitive, thereby developing a need to manage this dependence with other organizations for sustainable development (Wathne & Heide, 2013). Sustainable operations practices require firms' partnerships to ensure performance benefits, where partnership and resource sharing are important for environmental and productivity improvements, it leads to diffusion of environmental practices between the partners and competitive advantage (Sarkis, Gonzalez-Torre & Adenso-Diaz, 2010).

### **3. RESULT AND DISCUSSION**

Past variations of the climate were associated mainly to natural processes, presently the observed changes are as a result of anthropogenic causes especially increased emissions of greenhouse gases, causing global warming and shift in rainfall patterns (Watson & Albritton, 2001). Operational decisions of the company determines technologies and systems designs, efficiency of material consumption, the form and the rate of waste injected into the eco system. Therefore sustainable operations management potentially plays a critical role in contribution of solutions for sustainability challenges faced by humanity as it forms part of the key contributors to the anthropogenic impact on ecosystem. Despite its importance and ongoing efforts it has not yet fused into the mainstream of operations management research (Gavronski, Paiva, Teixeira, & de Andrade, 2013) as very little has been discussed on the strategic role played by sustainable operations technologies within the industry (Stonebraker, Goldhar, & Nassos, 2009). Improvement in awareness in this area has the potential to enhance better implementation of sustainable operations practices. This gap in literature is significant and hence the focus of the research.

Sustainability as defined, rests on three constituent categories based upon the TBL. However, previous studies (Adebambo, Ashari & Nordin, 2015; Aigner & Lloret, 2013; Longoni & Cagliano, 2015; Esty & Charnovitz, 2013) paid attention on some of the aspects of sustainability and less of them present a simultaneous approach that takes into account the three dimensions of sustainability. Manufacturers should consider economic gains alongside responsible social and environmental behaviours in order to attain greater sustainability (Gimenez, Sierra & Rodon, 2012). Although this point is often neglected, they are tangled and reconnected to the meta-constituent of "Planet Earth" and they reinforce each other, hence need to be addressed in connection with one another (Svensson & Wagner, 2012a). There are, at least few attempts that has taken a simultaneous approach to describe the three elements (Abdul-Rashid et al., 2017). In this regard, considerable work is needed to address this issue. The assessment of the probable direct relation between environmental consciousness and firm competitiveness in writing has brought mixed results. Whereas some studies have found a positive connection, others do not identify a positive link. The lack of the consensus on these links causes a research gap in literature. Hence, this study endeavors to show how sustainable operations practices

accords competitive advantage mediated by sustainable organizational performance, in which the three important dimensions of sustainability are taken into consideration simultaneously to fill the gap and establish the link. From the discussions, the researcher is posing the following question; what are the gaps in the area of sustainable operation management practices and firm competitive advantage?

#### 4. CONCLUSION

Despite the role played by green innovation to green issues and business success, a review of these studies revealed that research on the area of sustainable operations as a whole is limited. Most of the past studies touch on some aspect of operations (sustainable manufacturing and supply chain) but not comprehensively. Furthermore, the studies that touch on sustainability are not all inclusively to include triple bottom line approach and the social measurement suffers most. In explaining the relationship between environmental management and firm competitiveness, little is known about the mediating effect of sustainable organization performance.

The assessment of the probable direct relation between environmental management and firm competitiveness in writings has resulted in mixed outcomes. Whereas some studies have found a positive connection, others do not make out a positive link of environmental proactivity and competitiveness. The lack of the consensus on these links causes a research gap in literature. Therefore, there is a need to conduct a study on the relationship between sustainability and competitive advantage, which will be all inclusive and detailed to establish the link and to aid in proper decision-making plus to extend on the existing knowledge.

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## **Tacit knowledge sharing and public sector performance in Kenya: Is workforce communication and interaction the driver?**

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Knowledge is a crucial component in the growth of any economy and forms a significant fraction of all the resources required for organizational growth. Out of the renowned factors of production, three out of the five factors (60 percent) are human factors (resource) who are actually, the main drivers of knowledge management and tacit knowledge sharing. In the Kenyan civil service, there seems to be ignorance about the amount of knowledge that flows through the service every day. Chief among the reasons for this scenario are strong hierarchy and bureaucracies that impede workforce communication and interactions and consequently, the generation, distribution and sharing of knowledge and information which is crucial for organizational performance. The study sought to establish the role played by workforce communication and interactions as a driver of tacit knowledge sharing, and the consequent effect this has on performance of the Kenya public sector. The study was guided by intellectual capital theory and Nonaka's model of knowledge creation. The study employed use of descriptive research design and targeted all public sector departments in Kenya. Eight counties namely Samburu, Makueni, Kirinyaga, Kilifi, Nairobi, Homa Bay, Bungoma and Garissa, formed the sample of the study. The study adopted purposive sampling and simple random sampling to seek responses from targeted civil servants. Data was collected by use of questionnaires, was analysed and presented using tables and other appropriate presentations. Chief among the conclusions made was that workforce communication and interactions had insignificant influence on tacit knowledge sharing in all the counties under study, save for Garissa, Makueni and Kirinyaga counties. Among the key recommendations, were creation of knowledge repositories whereby crucial information is stored and retrieved at will in order to propagate a knowledge economy. In addition, there should be automation of workflows for ease of work and enhancement of Government service delivery efficiency.

***Key words: Tacit knowledge, communication, public service, knowledge economy***

# Effect of risk retention techniques on theft in public hospitals in Embu County, Kenya

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## Abstract

Majority of Kenyan people receive health services from public hospitals. There is then a need to guarantee security of hospital resources against theft. Theft in public hospitals has become a common problem with statistics showing that hospital theft stands at 61% compared to other hospital crimes in Kenya. Cases of stolen medicine, hospital equipment's and stolen babies are being reported almost now and then. To eliminate or minimize these losses, institutions embrace risk retention techniques to reduce the severity of theft incidences. This paper sought to determine the effect of risk retention techniques on theft in public hospitals in Kenya. The objective of the study was to determine the association of risk retention techniques and theft in public hospitals in Embu County. This study adopted a descriptive research design. Data was collected using questionnaires from 161 junior staff and 56 senior staff who were sampled through stratified sampling from the public hospital in Embu County. Validity of the instruments was ensured through opinions and expert judgments of research experts. A pre-test study was done at Chuka referral hospital and reliability of the instruments tested using split half technique. Chi-square was used to test the hypothesis. The results revealed that there was no significant association of risk retention technique with theft in public hospitals. The study concludes that risk retention techniques has no significant association with theft in public hospitals. therefore recommended that Public hospitals should adopt and fully employ risk retention techniques like captives, borrowing, current expensing and maintaining reserves thus minor losses resulting from theft can be borne by the hospitals without having to interrupt the normal daily activities of the hospitals.

**Keywords:** Risk, Loss, Risk Retention, Captive, Risk Transfer

## 1.0 Introduction

Theft is a worldwide phenomenon that appears to have defied efforts to contain it across the globe. Theft causes damage and fear that affects the life and well-being of people. Theft in Hospitals is common with hospital property and patients falling victim to theft. The scale of theft to personal possessions and hospital property going missing in public hospitals is depressing, and losses run into millions every year (Ministry of Health Report, 2014). When theft occurs it disrupts co-existence and results to poor delivery of health services (Kimama, 2011). Theft is a threat to people's health, government budget, hospital revenues and competition within legal industries (Lindstrom, 2007). Ignoring theft will not make the risk to go away but limits institutions from achieving their set objectives. Risk retention techniques are recommended by Fischer and Green (2004) as the preferred risk financing method when the loss values are relatively low. This implies that the consequences of a loss



will be borne by the party exposed to the chance of loss, often a deliberate risk management decision (Dorfman, 2005).

Hospitals assume risk when loss cost are small and can be funded from the current cash flow, Loss exposure are retained and funded with a cash reserve. An important advantage of using retention is that it encourages hospitals to adopt loss prevention projects, thus reducing the total cost of risk It's important to note that risk retention techniques ensures there is continuity in organization operations. Kallman (2009) observes that to set up a reserve, the hospital places an appropriate amount usually the expected value of loss plus a certain multiple of the standard deviation on the right-hand side of the managerial balance sheet. With an unfunded reserve the claim can be paid for by liquidating any of the hospitals assets. Many hospitals also have a special fund set aside to pay for small cost or claims (current expense funds). The expense of these losses is taken as a tax-deductible expense on the income statement and the system is known as current expensing (Peshawar, 2014). Other retention techniques utilized to cope with risk in hospitals include borrowing and maintaining captives.

In the world, theft in hospitals is a significant problem according to a report by the Global Security Index from the Institute for Economics and Peace 2014. This report indicates that theft cases in Hospitals escalate each year despite various risk control techniques being installed in hospitals. In the united states, united kingdom and Asia along with other Nations, valuable property that have been frequently stolen included wheelchairs, walking sticks, hearing aids and glasses, medicines, Laptops, children and children toys, money among other things. Hospitals in Africa have experienced significantly high levels of theft with Namibia being rated the worst with the hospitals reporting to have fallen prey to thieves who are dressing as hospital workers or service company employees and stealing expensive medical equipment and valuable properties (Lindstrom, 2007).

A majority of Kenya's population receives healthcare services from public hospitals. The range of services provided include preventive, promotive, curative and rehabilitative (Ministry of Health, 2014). Regardless of this, Kenya has remained highly rated in hospital crime with theft being the most common crime recording a 66% which is almost twice the global average of 34% (Vander, 2014). In 2013 the Kenyan government through the Ministry of Health commissioned a survey on theft in public Hospitals to be done in response to the overwhelming theft cases reported in public Hospitals. The worst rated Hospital in Theft included Pumwani Hospital, Kenyatta National Hospital, Embu Level five Hospital and Nandi Hospital. The most reported theft incidents in Kenya were medicine theft, equipment theft, personal property and money. Baby theft cases were also common (Ministry of health, 2013).

The government of Kenya recognized the growing threat of theft in Hospitals in early 2014 after publication of a national wide information report by the Kenya police which stated that 73% of theft incidents were reported in hospitals, followed by city street theft at 20%. According to Ministry of Health survey (2013) the most reported theft incidents in Kenya public hospitals were medicine theft, equipment theft, personal property of patients and money. Baby theft cases are also very common. This survey rated Embu General Hospital among hospitals with most frequent and severe theft incidents. Although adoption of risk retention techniques is on the rise in hospitals, these institutions are experiencing complex theft risks with hospitals losing millions and this is threatening the safety environment in hospitals. The risk retention techniques are designed to detect, prevent, and identify theft thereby minimizing the

risk and loss to an organization. They are expected to offer a safe environment for employees, patients, visitors and hospital property. However risk retention tools can be in an organization but be not effective when they are not properly developed and administered. For this reason, the study therefore sought to establish the effect of risk retention techniques on theft in public hospitals in Embu County. The study was guided by the following hypothesis which was tested at 0.05 level of significance.

*H<sub>01</sub>: Risk retention techniques have no significant association with theft in public hospitals in Embu County.*

## **2.0 Methodology**

### **2.1 Research Design**

Research design refers to a set of decisions that make up the master plan indicating methods and procedures for collecting and analyzing needed information (Kothari, 2004). This study employed a descriptive research design that described the state of affairs at the time of data collection. It involved assessing attitudes or opinions and thoughts about effectiveness of risk control techniques on theft severity and frequency. The research design was able to reveal and measure the strength of the target group's opinion, attitude, and behavior with regards to theft in hospitals.

### **2.2 Location of the Study**

This study was carried out in Embu County which is on the eastern slopes of Mount Kenya. The choice of Embu County Public hospitals is inferred from the 2014 Ministry of Health report that names Embu level five hospital among the hospitals with highest number of reported theft cases. The choice of Embu County was also because its easily accessible to the researcher is able to create rapport with the respondents. An ideal location of any study should be easily accessible to the researcher and should be that which permits rapport with the informants (Singleton, 2003).

### **2.3 Population of the Study**

All items of interest in an inquiry constitute a population (Kothari, 2004). This study targets a population of 1608 hospital staff from all the five public hospitals in Embu County.

Table 33: Population of Study

<b>Description</b>	<b>Senior Staff</b>	<b>Junior Staff</b>
Kianjokoma Sub District Hospital	7	251
Mbeere District Hospital	9	202
Ishiaru Sub District Hospital	6	231
Runyenjes District Hospital	13	280
Embu General Hospital	21	588
Total	56	1552

### **2.4 Sampling Procedure and Sample Size**

A sample is a part of a large population which is thought to be representative of the larger population. It is a subset of the total target population. Sampling is the process of selecting a few cases in order to provide information that can be used to make judgments about the larger population and hence should be a true representative of the population characteristics (Kathuri & Pals, 1993). This research stratified the

population into junior staff and senior staff. Senior staff were selected through a simple census and junior staffs through a simple random sampling. Simple random sampling is preferred because it gives each subject an equal chance of taking part in the study. The simple random sampling was necessitated by guidelines given by Nasiuma (2001).

$$n = \frac{NC^2}{C^2 + (N_1)e^2}$$

Where n = population; C =coefficient of variation which is < 30%; e=standard error which is fixed between 2-5%

Taking a coefficient of variation of 26.8 % and a standard error of 0.02 out of a target population of 1552 hospital staffs, a sample of 161 was obtained.

## **2.5 Data Collection**

A research permit was obtained from the National Commission for Science, Technology and Innovation. The researchers explained the nature of the study to the respondents and pointed out what was expected of them. The researchers assured them of the confidentiality in handling the information provided. Primary data was collected through questionnaires which were distributed to the respondents by the researcher and filled questionnaires were collected two weeks after.

## **2.6 Data Analysis and Presentation**

Data analysis is the process of systematically arranging filed notes, data and other materials obtained from the field with the aim of increasing one's own understanding and to enable one to present them to others (Orodho, 2013). Data was cleaned by being checked for logical consistency and any unnecessary data removed. It was then refined and processed using statistical package for social sciences (SPSS) version 23 for windows. Martin and Acuna (2002) observe, SPSS is able to handle large amount of data given its wide spectrum of statistical procedures purposefully designed for social sciences, it is also quite efficient. Quantitative analysis that entailed analyzing numbers about a situation by choosing specific aspects of that situation was used. The results of data analysis are presented in frequency tables and percentages. Chi-square test was used to show the association between variables and test hypothesis at 5% level of significance.

## **3.0 Results and Discussion**

### **3.1 Adoption of Risk Retention Techniques by Public Hospitals**

The risk control techniques in a hospital are responsible for protection against all manner of risk through reducing the risk frequency and its severity if it occurs. Thus, they are responsible for ensuring a safe environment to the hospital and the people. This study sought to find out the risk retention techniques adopted by public hospitals in Embu County. Descriptive statistics of frequencies and percentages were used to present the data.

Adoption of risk control techniques	Fully adopted		Partially adopted		Not adopted		Mean	Standard deviation
	F	%	F	%	F	%		
Reserves	30	20.3	81	54.7	37	25.0	2.0473	.67345
Captives	15	10.1	17	11.5	116	78.4	2.6824	.64983
Current expensing	44	29.7	84	56.8	20	13.5	1.8378	.63945
Borrowing	40	27.0	94	63.0	14	9.5	1.4595	.66372

**Table 1: Senior staff response on adoption of risk retention techniques**

The results further indicated that risk retention techniques were partially adopted with majority of the senior staffs (66.7%) current expensing and (82.4%) reserves indicating that minor losses could not be taken care by the public hospitals independently.

The junior staff indicated that risk retention techniques were partially adopted represented by a majority (63.0%) borrowing, (56.8%) current expensing and (54.7%) reserves. Senior staff response on adoption of the risk control techniques was similar to that of the junior staff hence these results indicated a true account of risk control techniques adoption in public hospitals.

**Table 2: Junior staff response on adoption of risk retention techniques**

Adoption of risk retention technique	Fully adopted		Partially adopted		Not Adopted		Mean	Standard deviation
	F	%	F	%	F	%		
Reserves	10	19.6	32	62.7	9	17.6	1.9804	0.6161
Captives	12	23.5	10	19.6	29	56.9	2.3725	0.799
Current expensing	14	27.5	34	66.7	3	5.9	1.7843	0.5408
Borrowing	15	29.4	29	56.9	7	13.7	1.8431	0.6441

### 3.2 Employment of Risk Control Techniques by Public Hospitals

The possibility and outcome of any theft incident is highly dependent on the nature of risk control techniques present in a hospital. The 2004 edition of American national standards report indicates that effective employment of risk prevention; retention and transfer techniques will address the protection, mitigation, preparedness, response and recovery from theft incidents. This study therefore sought to find out the level of employment of risk retention techniques by public hospitals. Data gathered was analysed using percentages and the results presented in closed tabulations by table 3 for junior staff and table 4 for senior staff.

**Table 3: Junior staff response on level of employment of risk retention techniques**

Risk Retention Technique	Very Low	Low	Moderate	high	Very high	mean	Standard deviation
	%	%	%	%	%		
Reserves	21.6	31.1	25.0	20.3	2.0	2.5608	1.1018
Captives	54.1	16.2	12.1	11.5	6.1	1.9932	1.2962
Current expensing	27.0	44.6	18.9	8.1	1.4	1.9932	1.2962
Borrowing	18.9	28.4	25.7	24.3	2.7	2.4730	1.2146

Most of the junior staff indicated that risk retention techniques were also not fully employed indicated by a majority (31.1%) reserves, (44.6%) current expensing and (28.4%) borrowing. Captives were rated very low by a majority 54.1% of the junior staffs.

**Table 4: Senior staff response on level of employment of risk retention techniques**

Employment of risk retention techniques	Very Low	low	moderate	high	very high	mean	standard deviation
	%	%	%	%	%		
Reserves	9.8	27.5	23.5	31.4	7.8	2.4706	1.1891
Captives	23.5	31.4	17.6	13.7	13.7	2.8235	1.2760
Current expensing	31.4	19.6	13.7	15.7	19.6	3.0784	1.3090
Borrowing	13.7	43.1	3.9	33.3	5.9	3.2353	.9074

**techniques**

Majority of the senior staff also indicated that public hospitals lacked the capacity to retain theft risks indicated by majority (43.1%) borrowing and (31.4%) current expensing who felt hospitals had low employment of risk retention techniques. The senior staff responses were similar to those of the junior staff.

**3.3 Effectiveness of Risk Retention Techniques**

Young (2014) in his research on security risk noted that most organizations including hospitals already have risk retention techniques that aim to minimize the destruction of property and loss of life. However, these risk retention techniques can be in an organization but also may not be effective. It's for this reason that this study sought to find the effectiveness of risk control techniques in reducing theft frequency and severity. Descriptive statistics of frequencies and percentages were used to analyse the data collected and the results presented in tables 5 for senior staff and table 6 for junior staffs.

**Table 5: Senior staff response on effectiveness of risk retention techniques**

Effectiveness of risk retention techniques	Very effective		Fairly effective		Not effective		Mean	Standard deviation
	F	%	F	%	F	%		
Reserves	9	17.6	14	27.5	28	54.9	1.6275	.7735
Captives	12	23.5	14	27.5	25	49.0	2.2549	.8208
Current expensing	11	21.6	12	23.5	28	54.9	2.2549	.8208
Borrowing	28	54.9	12	23.5	11	21.6	1.6667	.8165

Risk retention techniques were also rated not effective by a majority (54.9%) current expensing, (54.9%) reserves and a 49.0% captives. Borrowing was considered to be the most effective risk retention technique in reducing theft severity by a majority 54.9 %. Responses from the senior staffs were considered to be more reliable therefore it was concluded that risk retention techniques were not effective in reducing theft severity therefore the working environment was not conducive for coexistence.

**Table 6: Junior staff response on effectiveness of risk retention techniques**

Effectiveness of risk retention technique	very effective		Fairly effective		Not effective		Mean	Standard Deviation
	F	%	F	%	F	%		
Reserves	28	18.9	48	32.4	72	48.6	2.2973	.7689
Captives	8	5.4	20	13.5	120	81.1	2.7568	.5423
Current expensing	32	21.6	49	33.1	67	45.3	2.2365	.7856
Borrowing	30	20.3	40	27.0	78	52.7	2.3243	.7929

Risk retention techniques were rated not effective in minimizing theft severity as indicated by majority (48.6%) reserves, (81.1%) captives and (52.7%) borrowing. Findings from the junior staff were similar when compared to those of senior staff indicating public hospitals need to review their implementation levels if effectiveness of risk retention techniques has to be improved.

### 3.4 Severity of Theft in Public Hospitals

Most public hospitals learn how to respond to theft incidents only after suffering severe attacks that result to significant losses. Risk retention and risk transfer techniques are meant to reduce severity of losses. When theft severity is high, risk retention and transfer techniques are considered not effective and vice versa is true. This study therefore sought to determine the severity of theft incidents in public hospitals. Descriptive statistics of frequencies and percentages were used to analyse the data and results presented in table 7 for senior staff and table 8 for junior staff

**Table 7: Senior staff responses on theft severity in public hospital**

From the findings in table 15, theft severity in public hospitals was rated to be highly

Theft Severity	very severe		Severe		not severe		No incident		Mean	Standard deviation
	F	%	F	%	F	%	F	%		
Burglary	12	23.5	24	47.1	10	19.6	5	9.8	1.9216	1.0362
Larceny	18	35.3	19	37.1	11	21.6	3	5.9	2.2549	.8681
Shoplifting	3	5.9	20	39.2	26	51.0	2	3.9	1.6275	.7735
Medical identity theft	18	25.3	22	43.1	10	19.6	1	2.0	1.8824	.7911
Robbery	12	23.5	28	54.9	8	15.7	3	5.9	1.7255	.9397

severe. This is because most of the senior staff (47.1%) burglary, (37.1%) larceny, (43.1%) medical identity theft and robbery (54.9%) indicated that when theft occurred it resulted to severe losses. Severity of shoplifting was classified not severe by a majority 51.0%.

**Table 8: Junior staff response on theft severity in public hospitals**

Theft severity	very severe		Severe		not severe		no incident		Mean	Standard deviation
	F	%	F	%	F	%	F	%		
Burglary	56	37.8	64	43.2	23	15.5	5	3.4	1.7905	.82687
Larceny	24	16.2	88	59.5	30	20.3	6	4.1	1.6892	.93205
Shoplifting	28	18.9	36	24.3	74	50.0	10	6.8	2.4459	.87508
Medical identity theft	48	32.4	74	50.0	23	15.5	3	2.0	1.8716	.74029
Robbery	33	22.3	99	66.9	15	10.1	1	.7	1.4459	.70261

Results presented in table 16 shows that majority of the junior staff (43.2%) burglary,(59.5%) larceny,(50.0%) medical identity theft and (66.9%) robbery

indicated that theft incidents were severe when they occurred. Half of the junior staff (50.0%) indicated that shoplifting incidences were not severe. These results were similar with those of the senior staffs. This implied that risk transfer and risk retention were not effective in reducing theft severity in public hospitals. Public hospitals should therefore focus on employment levels of these techniques if they are to be effective in reducing theft severity. These results on theft frequency and severity were consistent with Henrich triangle that puts forth if the frequency of theft incident is high, the severity is low and vice versa is true (Dorfman, 2005).

### 3.5 Association of Risk Retention Technique with Theft Severity in Public Hospitals.

Risk retention techniques are designed to lessen the severity of theft incidents once they occur. This study sought to find out the association of risk retention techniques with theft severity in public hospitals. To measure the association of risk retention techniques with theft severity a retention index (RI) was computed. The retention index comprised of four (4) variables representing the four most adopted retention techniques as given by (Dorfman, 2005). The variables were borrowing, current expensing, captives and reserving. These variables were scored on a likert scale of 1-4 with 4 representing the highest scores implying theft had never occurred and 1 representing the lowest score meaning theft losses were very severe.

$$RI = \frac{BT+CT+CET+RT}{4}$$

With BT= borrowing technique, CT= captives technique, CET= current expensing techniques and RT= reserve technique. The results are presented in Table 9.

**Table 9: Association of risk retention techniques with theft severity in public hospitals**

	Theft Severity				Totals
	Very Severe	Severe	Not severe	No Incident	
Not sure	2.01%	4.02%	0.50%	0%	6.53%
Not effective	16.08%	35.68%	2.01%	0%	53.77%
Moderate effective	3.52%	25.13%	3.52%	0%	32.16%
Effective	2.01%	2.51%	2.01%	0%	6.53%
Very effective	0%	1.00%	0%	0%	1.00%
<b>Total</b>	<b>23.62%</b>	<b>68.34%</b>	<b>8.04%</b>	<b>0%</b>	<b>100%</b>

Chi-square=11.932, df=12, p=0.167

The findings in table 19 shows that majority (53.77%) indicated that risk retention techniques were not effective in reducing theft severity. Among them majority (35.68%) indicated that theft was severe when retention techniques were not effective. 16.08% rated theft to be very severe when risk control techniques were not effective. Those respondents who indicated that theft in public hospitals was severe (25.13%) also indicated that retention techniques were moderately effective. It's worth noting that none of the respondents indicated that theft had never occurred in the public hospitals .Only (1.00%) of the respondents indicated that risk prevention techniques were very effective when theft was severe.



These findings were further statistically tested for significance using chi-square test at 5% significant level. The computed chi-square value of 11.932 and a p value= 0.167 implied that risk retention techniques had no significant association with theft severity in public hospitals. This study thus failed to reject the null hypothesis ( $H_{01}$ ) which stated that there was no significant association of risk retention techniques with theft in public hospitals in Embu County. The paper therefore find that risk retention techniques are not effective in reducing theft severity in public hospitals. The findings are consistent with Mwenda (2015) findings that risk control techniques in a hospital may not be effective when matters of theft are taken casually.

#### **4.0 Conclusion**

This paper evaluated the effect of risk retention techniques on theft in public hospitals in Embu County. The main focus of this study was on Reserves, Captives, Current expensing, Borrowing and their effect on theft severity. Results on Risk retention techniques studied revealed that borrowing, reserves, and current expensing were adopted by the public hospitals. It emerged that captive were not adopted by the public hospitals. Further the findings revealed that employment of risk retention techniques by public hospitals was very low. Risk retention techniques were also found not to be effective in reducing theft severity in the public hospitals. The paper therefore concludes that risk retention techniques had no significant association with theft in public hospitals. It was therefore concluded that public hospitals that had not adopted and fully employed risk retention techniques were vulnerable to high levels of theft severity. The paper recommends that public hospitals should adopt and fully employ risk retention techniques like captives, borrowing, current expensing and maintaining reserves thus minor losses resulting from theft can be borne by the hospitals without having to interrupt their daily activities. This will therefore reduce the severity of theft in the public hospitals.

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# **Influence of Market Orientation on the Relationship Between Customer Relationship Management Practices and Performance of Large-Scale Manufacturing Firms in Kenya**

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## **Abstract**

The main objective of the study was to measure the influence of market orientation on the relationship between customer relationship management practices and firm performance of large-scale manufacturing firms in Kenya. The population of the study comprised large-scale manufacturing firms that were members of the Kenya Association of Manufacturers (KAM). A descriptive cross-sectional survey was used. The target respondents were three top managers in each firm, and aggregated single scores were computed to lessen single source response bias. Data was analyzed through descriptive statistics and regression analysis. The results revealed that market orientation was a strong statistical predictor of firm performance. In addition, the moderating effect of market orientation on the association between CRM practices and performance ( $F=9.138$ ,  $P\text{-value}<0.05$ ) was found to be statistically significant. The study supported findings of previous studies on the influence of CRM practices on firm performance. In addition, the study found that both CRM practices and market orientation had a positive and significant influence on performance. Further, the findings of the study support the theoretical link between CRM practices, market orientation and performance.

## **Influence of Knowledge Management systems on performance of commercial banks in Nyeri**

Wachira A. K. & Sang A.W.

Knowledge management is an emerging force and by extension KMS, that is creating an edge to the organization over the competition if managed effectively and efficiently. This is quite applicable in commercial Banks which play a crucial role in empowering the banking sector in the nation and create an edge over competition. The objective of the study was to determine the influence of knowledge management systems on the performance of Commercial banks in Nyeri town. The study adopted a descriptive research survey. The target population comprised of 48 staffs working in commercial banks in the Nyeri town that include managers, operation managers, credit managers and customer care managers and thus a census study was undertaken. Primary data was used and collected using questionnaires. Quantitative data was collected and analyzed by the use of descriptive statistics such as mean, median, standard deviations, and inferential statistics like regression analysis, correlation analysis and frequencies using SPSS. The information was then presented by use of bar charts, pie charts, tables and percentages. The study showed that knowledge management systems had a significant effect on the performance of the commercial banks and thus can be used as an essential strategy towards achieving competitive advantage amongst the commercial banks. Based on the findings of this study, the researcher concludes that Banks need capitalize on their KMS in order to improve their performance. The researcher recommends that the banks invest in modern KMS's such as CAM as a strategy to be used towards achieving their overall objectives. The researcher recommends further study to be done on the influence of knowledge management systems on the service delivery of public institutions.

Knowledge, knowledge management systems, Commercial Banks

## **Analysis of capital structure financing levels on financial performance**

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### **ABSTRACT**

SACCO societies have more complex financial structures given the localization of capitalization and liquidity albeit mutual guarantee capital structure. In this case, the aim of this study was to analyze the influence of equity capital financing levels, debt capital financing levels and tax as a controlling variable on financial performance of SACCO Societies in Kikuyu Sub County. The study adopted a cross sectional research design which captured the views of SACCO Societies owners and managers at a specific time. The population of the research consisted of SACCOs in Kikuyu Sub County which were 27 SACCO societies. The study used secondary data from SACCOs accounting records for the period 2013 to 2016. Data collected was presented and analyzed quantitatively using content analysis, regression and analysis of variance. According to the study, equity financing was applied depending on the contribution of members. Debt capital was not applied by SACCOs compared to equity capital in the study period. There was an increase in SACCOs Financial Performance whenever there was an increase in Equity. The study results showed that, share capital and retained earnings had a significant influence on financial performance in SACCOs in Kikuyu Sub County. This was compared to debt capital which had less or no influence. The study recommended that Sub County Co-operative officers should conduct trainings to the Central Management Committee Members and the Executive Managers on capital financing in order to enhance retained earnings as well as improving members share capital. A new phenomenon from the research findings, is that, share capital is a new practice by the SACCOs in order to enhance their capital base. However, members have not embraced the idea and hence proper sensitization by the Sub County Co-operative officers is also encouraged.

**Key words:** equity capital, debt capital, financing levels, financial performance

# The Influence of Entrepreneurship Capacity on Innovation Efficiency

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## **Abstract:**

The purpose of this paper is to examine the relationship between entrepreneurship capacity and innovation efficiency in all countries captured consistently in the Global Entrepreneurship Monitor and Global Innovation Index between the year 2010 and 2014 with the view of adopting best practice in Africa. The work is anchored on innovation diffusion theory. Longitudinal design was used and secondary data provided a trend analysis of 29 countries across the world with the aim of benchmarking. Weighted averages, bivariate correlation and ordinal regression techniques were used to analyse the data. The study found that there is a positive significant influence of entrepreneurial capacity on innovation efficiency. The study recommends establishment of appropriate entrepreneurship education and its integration in the education system in Africa. There should also be collaboration between governments, researchers, policy makers and industry players. Further studies should be geared towards enablers of innovation commercialization.

**Keywords:** Innovation, Entrepreneurship, Commercialization and Efficacy

## **Introduction**

Innovation and entrepreneurship play an important role in the social economic development of a country. Entrepreneurship activities support innovation performance by recognizing existing opportunities, assembling the necessary resources, taking risks and establishing enterprises that enhance commercialization of innovation. This study is aimed at examining the influence of entrepreneurship capacity on innovation efficiency with a view of demonstrating the relationship therein. The paper is anchored on Roger's (1995) innovation diffusion theory.

The theory stipulates that innovation that is geared towards addressing the needs of the society are embraced faster than complicated ones that seems alien to a community. The theory led to the development of innovation decision process model. The model examines the prior conditions, knowledge levels, perceived characteristics of innovation, adoption or rejection, implementation and confirmation. The relevancy of the theory in this paper is that its model looks at the process of commercialization of innovation which depends on entrepreneurial efficacy which can be enhanced by strengthening entrepreneurial capacity which improves the rate of innovation adoption and thus increasing innovation efficiency.

## **Innovation Efficiency**

Dominant economies in the world like the United States of America, Japan and Germany have been propelled by their innovative capacity to their current status. China, for example, is in the league of the fastest growing economies in the world propelled by its proactive innovation which is causing jittery in western countries as a result of upsetting the status quo (Samuelson, 2010).

The innovation efficiency of the country has provided important lessons to both developed and developing countries. Innovation has been defined as a process of creating a new product, new enterprise, or enhancement of existing product, new process and new enterprise (Gerguri, 2011).

The prosperity of nations in the contemporary times is driven by knowledge economy which is manifested through innovation. There has been a paradigm shift from past ways of evaluating the success of product efficiency from 1960 to 1970 and total quality management from 1980 to 1990. These have been replaced with focus on knowledge economy that thrives on innovation performance and efficiency. However, African countries are still struggling with poverty due to low levels of entrepreneurship. The ratio of entrepreneurs to workers in Africa is 1 to 52

while in most developed countries is 1 to 10 (Acs, 2009). This has made many African countries be net importers of technology that disadvantage them in international trade and thus aggravating their predicaments.

Innovation efficiency parameters in this study are the ratio of innovation input and output. The ratios have been adopted from the Global Innovation Index (GII). Innovation inputs parameters comprises the role of research and development organisations, the education system, the supporting environment in the context of creativity and the prevailing market conditions. Innovation output parameters, on the other hand, are knowledge, technology and creativity.

### **Entrepreneurship Capacity**

Entrepreneurship in Africa can accelerate innovation, bring about value creation, increase productive activities and create the elusive employment opportunities which lead to economic growth and sustainable development. Entrepreneurs utilize the available scours resources to create and seize up opportunities that add value in peoples' life. Entrepreneurship has been defined as a tool for innovators to commercialize their innovations (Donovan, 2013). Entrepreneurship capacity can be gauged in terms of Entrepreneurship Self-Efficacy (ESE). The key drivers that can

provide the required resilience, optimism and dynamism are tolerance to ambiguity, risk taking, proactiveness, opportunity identification and innovation which constitutes an ESE of an entrepreneur. However, the antecedents of ESE still perturb entrepreneurship researchers (Urassa, 2015).

The study adopted the Global Entrepreneurship Monitor (GEM) index to demonstrate entrepreneurship capacity. The index focuses on social cultural and political factors as the inputs that feed on the general national framework of a country. The general national framework conditions lead to improvement of entrepreneurship profile and establishment of firms. Entrepreneurship profile involves improvement of entrepreneurship attitude, activity and aspirations. These result in a social economic development which includes job creation, innovation and social value (Slavica, 2015). The study therefore considered entrepreneurship activities, the perception of opportunity, social cultural and political factors as the antecedents of entrepreneurial capacity as depicted by GEM.

### **The Study Objective and Hypothesis**

The paper examined the relationship between entrepreneurship capacity and innovation efficiency in all countries captured consistently



in GEM and GII between the year 2010 and 2014 with the view of adopting best practice in Africa. The study hypothesized that;  $H_0$ : Entrepreneurship capacity has no significant influence on innovation efficiency of a country and  $H_1$ : Entrepreneurship capacity has an important impact on innovation efficiency of a country.

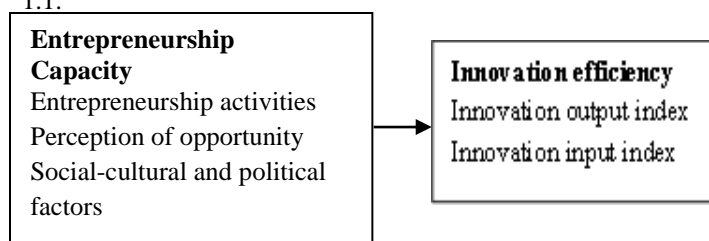
### The Theoretical Underpinning in the Study

Mark Casson's (1945), economic theory attempted to address the relationship between entrepreneurship and innovation. The theory posits that entrepreneurship is a result of conducive economic environment and argues that demand for enterprise arises from the need for change. Cassons defines an entrepreneur as one who specializes in taking judgmental decisions about the scarce resources and coordinate them, motivated by self-interest and creativity. The theory also addresses risks, uncertainties and break even points. However, the theory is of the view that the core capabilities of entrepreneur are difficult or impossible to learn. Innovation is one of the innate competences and the notion of limited cognitive ability in Mark Casson's theory can be investigated by establishing whether there is a relationship between entrepreneurship capacity and innovation efficiency.

### The Conceptual Framework

The elements of entrepreneurship capacity are depicted as the independent variable which includes; entrepreneurship activities, perception of opportunity, social cultural and political factor. Innovation efficiency, on the other hand, is the dependent variable whose antecedents are innovation output index and innovation input index. This is illustrated in the conceptual framework as shown in figure

1.1.



Independent variable  
variable

Dependent

Figure 1.1: The conceptual framework.

The conceptual model shows how entrepreneurship capacity is related to innovation efficiency.

### Methodology Used

Longitudinal design was used to examine the relationship between the study variables. Quantitative secondary data was used to conduct a trend analysis of entrepreneurship capacity for five years from GEM index and for innovation efficiency from GII for all the 29 countries across the world which had

consistently been included in both indexes between 2010 and 2014. These countries included South Africa, Belgium, Bosnia, Brazil, Chile, China, Colombia, Croatia, Finland, France, Greece, Hungary, Ireland, Japan, Malaysia, Mexico, Netherlands, Norway, Peru, Portugal, Romania, Russia, Slovenia, Spain, Sweden, Switzerland, Trinidad and Tobago, United States of America and United Kingdom.

The GEM index is constituted through a survey based on primary data collected on attributes that either promotes or hinder entrepreneurial activities. The GEM survey covers over one hundred countries across the world. Data is collected using standardized tools which can be used to design evidence-based policy intervention. On the other hand, GII measures the innovation index of different countries. Innovation efficiency was obtained by establishing the ratio of innovation output and input. Weighted averages, bivariate correlation and ordinal regression techniques were used to analyse the data in order to find the association between entrepreneurship capacity and innovation efficiency.

### Findings and Discussions

Entrepreneurial capacity was obtained by determining the average score for the five years under review. The same was done for

innovation efficiency for the similar period. A correlation between the two variables was then conducted. This was done at 5% level of significance shown in Table 1.1

**Table 1.1. Correlation between EC and IE**

Model	R	Adjusted R Square	Estimation Error
1	.37 <sup>a</sup>	.135	.08606

The value of R square was positive and hence a positive relationship between the two variables was confirmed. The two variables were then regressed to show the relation between entrepreneurial capacity and innovation efficiency. This was done at 5% level of significance shown in Table 1.2

**Table 1.2. Regression between EC and IE**

Model	Log Likelihood	'hi-Square	df	Sig
Intercept Only	191.144			
Final	186.159	4.985	1	.026

The value of P was 0.026 which is less than 0.05 hence the rejection of the null hypothesis and acceptance of the alternative hypothesis. This means that there is a significant positive influence of entrepreneurial capacity on innovation efficiency.

The model deviance and test the goodness of fit of the regression model was obtained using the Pearson deviance at level of significance as shown in Table 1.3.

**Table1.3. Test of Goodness of Fit of the Model**

	Chi-Square	df	Sig.
Pearson	757.579	728	.217
Deviance	184.773	728	1.000

The p-value at  $\chi^2_{HL} = 757.579$ , is 0.217 which is greater than 0.05 and at  $\chi^2_{HL} = 184.773$  the p-value is 1 which is less than 1.96 hence the model is good.

**Conclusions, Summary and Recommendations**

It was concluded that entrepreneurial capacity significantly influences innovation efficiency positively. Capacity building of potential and practicing entrepreneurs is therefore paramount in promoting innovation efficiency. The study recommends the establishment of suitable entrepreneurship education programs in Africa to inculcate and enhance their entrepreneurial capacity and promote lifelong learning. Experiential learning should be encouraged as it develops competences to successfully engage into entrepreneurship which enhances commercialization of innovation. There should also be an integration of entrepreneurship education in various study disciplines in institutions of

higher learning in Africa to enhance the entrepreneurial capacity of graduate so that they can be propelled into innovation prowess. Collaboration between research and development agencies, policy makers, governments and industry players should also be encouraged to develop seamless and supportive infrastructures that facilitate innovation efficiency in Africa. Further studies on how to promote commercialization of innovation should be carried out.

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# **Improving the Performance of Coffee Cooperatives through Diversification**

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## **Abstract**

Coffee is a widely traded commodity grown in over 50 countries. It is mainly grown within the tropics and mainly consumed in the US and Europe. In Kenya coffee is grown by both small holder farmers as well as large and medium estates. The coffee grown by small holder farmers is managed through cooperative societies. Kenya used to experience high production of coffee until 1989 when the international prices declined due to collapse of coffee trade quota system. This negatively affected the performance of coffee cooperative societies. Though there has been some improvement in coffee production the country is yet to produce the coffee as produced before 1988. This study proposes diversification as a means of improving the performance of coffee cooperatives in Kenya. Data was collected from 283 of the 1052 coffee factories in Kenya. The factories were from both East and West of Rift Valley in Kenya. The data was collected using a structured questionnaire and analysed using SPSS and STATA. The study found a correlation between level of diversification to non-coffee businesses and the performance of a coffee cooperative society. An increase in revenue from diversification of 1 unit causes the performance of the coffee cooperative to improve by 3.4 units.

**Keywords: Bag of coffee, Coffee, Cooperative, Diversification**

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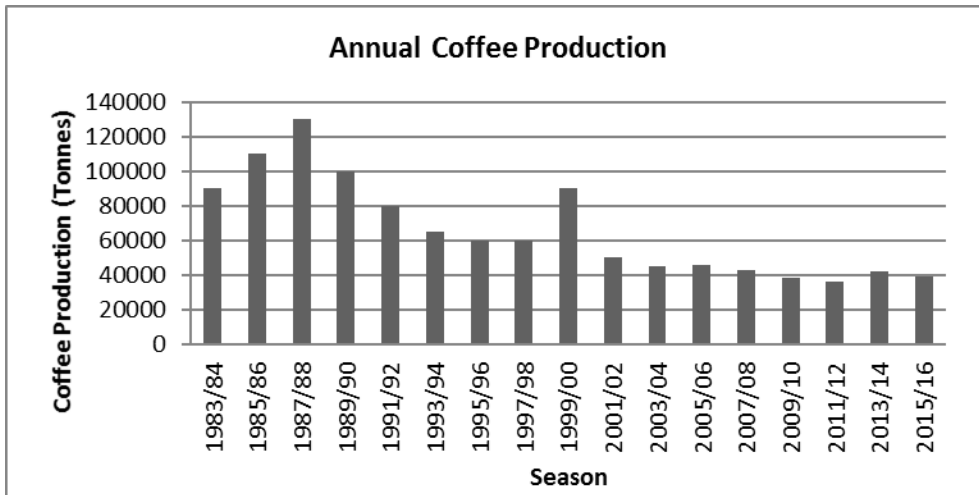
## **1. INTRODUCTION**

Coffee is a widely traded commodity in the world where it is grown in over 50 countries (International Coffee Organization, ICO, 2010). Every year over 400 billion cups are consumed (Bagel, 2013.). Coffee is the source of livelihood for over 25 million families and hence supports over 100 million people (Ponte, 2002). The commodity is produced in three regions; America, Africa and Asia and consumed mainly in Europe, America (ICO, 2014). In Africa coffee is mainly grown in Ethiopia, Uganda, Ivory Coast, Tanzania, Rwanda and Kenya. The continent used to produce 33% of all the global coffee produced annually in 1970s (ICO, 2013) This decreased to an average of 16% in 1990s and further to 13.1% in the 2000s. This decrease in production has resulted in decline in the performance of farmers' organizations (ICO, 2015). In Kenya coffee was introduced in 1893. The sector employs 30% of all staff in agriculture and supports 700, 000 families and over 5 million people are engaged in coffee business (AFFA, 2016). The country has 434 cooperative societies and 4000 estates (Kenya Coffee Traders Association, KCTA, 2015).

Before independence small scale farmers were not permitted by the government to grow coffee. This was until the year 1934 when the British Colonial Board in London permitted some minimal small scale farming of coffee. This was restricted to 100 trees

and not on more than  $\frac{1}{4}$  an acre (Gachanja, Obere & Thuku, 2013). The farmers had to be members of cooperative societies and had to do the farming away from the white settlers' estates. By 2008 cooperatives share had grown to 128000 hectares from 13000 hectares in 1964. The estates had some 33000 hectares the same time. Currently the cooperatives command about 75% of the total area under coffee.

Coffee was the leading export crop in Kenya from Independence to 1988 (Kabura & Doppler, 2009) contributing 40% export value. After the coffee crisis of 1989 the situation changed and by 1992 its contribution to export value was a mere 9%. The prices also declined. The average price for the period 1976 to 1986 was 141.66 US cts per gallon and by 1992 the price had decreased to 28US cts per gallon (ICO, 2007).



**Figure 1.1: Kenya Coffee production in tonnes; Source: ICO, (2017)**

### 1.1 Coffee Marketing Cooperatives

A cooperative is a peoples' autonomous relationship united willingly to attain their social, cultural as well as economic wants through jointly owned and democratically controlled businesses. A cooperative is user owned, user controlled and user benefitted outfit (Komo & Gumba, 2010). There are seven principles that guide the cooperatives; democratic member control, economic participation of members, voluntary and open membership, independence and autonomy, training and education, collaboration amongst cooperatives as well as concern about the community (Ortman & King, 2007). Agricultural cooperatives play a chief function in a country's economic development (Chloupkova, 2012). These cooperatives offer major services like marketing, supply and specialized services, (Ortman & King, 2007). In Kenya the small scale coffee is marketed through the cooperative societies that are owned by the farmers.

Kenya's cooperative sector dates back in 1908 (Nkandu, 2010). This is when the first cooperative was formed in Lumbwa, Kipkelion area Rift Valley. The enactment of the first legislation on cooperatives was done in 1931. The first national cooperative was Kenya Cooperative Creameries that was formed in 1931. Kenya Farmers Association was formed later that same year. Kenya Planters Cooperative Union was formed in 1932. In 1964 the Kenya National Federation of cooperatives was formed. All these apex

cooperatives have gone under although KCC has been revived by the government (Nkandu, 2010).

The initial threat of agricultural cooperatives occurred in 1950s when people started abandoning the cooperatives to join the war group, Mau (Gamba & Komo, 2010). The post-independence but pre-liberalization era saw the number and capacity of cooperatives grow tremendously (Gamba & Komo, 2010). Beginning early 1980s Kenya, just like in other Sub-Saharan African countries started the structural adjustment programmes – Kenya developed the Sessional Paper number 6 of 1986 that guided the liberalization. This same liberalization led to splits and mergers of cooperatives – the overall effect was the split of profitable cooperatives into small uneconomic units. This decline saw the production of coffee decrease by 50% between 1988 and 1998. Tea and horticulture sectors, that are not managed through cooperative movement were not affected and had remarkable increase in their contribution to GDP.

In Kenya the coffee cooperatives' performance has declined in performance primarily due to two scenarios; The collapse of coffee quota system that depressed prices and the introduction of structural adjustment programmes by the World Bank and the IMF. The quota system in coffee trading had been introduced by the International Coffee Organization to mitigate fluctuations of global coffee prices.

With the collapse of the quota system, the Kenyan coffee farmer absorbed the full shock of the plummeting world prices. The production of coffee in Kenya decreased from 130, 000 metric tonnes to 37, 000 metric tonnes in the next 25 years (KIPPRA 2014). This greatly affected the coffee farmers' cooperatives performance. The decline in coffee cooperatives' earnings was made even worse by the poorly implemented Structural Adjustment Programs (SAPs) supported by the World Bank and the International Monetary Fund in 1980s as well as 1990s. The programmes geared towards structural change had been initiated in Africa after leading organizations like cooperatives and parastatals performance started declining after independence (Franz, 2011). The SAPs removed the control of cooperative societies, parastatals and other organizations from the state and were privatized.

Following the decline in coffee cooperatives performance in Kenya, innovative ways are needed to bring the coffee sector back to where it was and even beyond. This research sought to evaluate the effect of diversification on improving the performance of coffee cooperative societies in Kenya.

## **2. MATERIALS AND METHODS**

### **2.1 Study Population**

Population refers to the whole group of events, objects or individuals with common observable characteristics (Mugenda & Mugenda, 2003). The target population included all the coffee cooperatives' factories in Kenya. There are 1052 small holder coffee factories in Kenya according to the Kenya Coffee Traders Association (KCTA, 2016). The factory, as the unit of observation, was selected after an evaluation of how cooperatives operate. A cooperative society may have one or more factories. It was realized that all the variables being measured were different in factories belonging to the

same cooperative. For example, the income earned is per factory not for the entire society. Different factories of the same cooperative society could have different incomes. Different factories of the same coffee cooperative could have different performance levels. The factory manager was the respondent since he is the senior most employee of the factory. Each factory has a factory manager who is responsible to the cooperative's executive management.

## 2.2 Sampling Technique and Sample Size

Sampling refers to the process of choosing a number of objects from the population under study in such a way that the chosen objects represent the population being studied (Mugenda & Mugenda, 2003). The study applied stratified sampling first. Stratification refers to the process of partitioning the entire population into small groups called strata. The advantage of this is that it capitalizes on homogeneity of the stratum and so a small sample can be used to study the population. This was combined with simple random sampling as follows;

Kenya has two main regions where coffee is grown, East of Rift Valley and West of Rift Valley. Each of the two regions was included in the sampling. East of Rift Valley has 782 factories out of the 1052 and as such 74% of the sample were from the East and 26% from West of Rift Valley. East of Rift Valley has 9 Sub-regions (strata). Simple random technique of sampling was utilized to pick 4 out of the 9 strata to take part in the research. In each of the 4 strata again simple random technique of sampling was utilized to pick factories that participated. The same process was repeated in selection of study units for the West of Rift Valley. This technique is also in line with Olaniran (2016), who used a two stage sampling by applying stratified sampling followed by simple random sampling. Makongoso (2016) in a study on collective entrepreneurship in Kenya coffee cooperatives, used multistage sampling technique.

## 2.3 Sample Size Determination

This study adopted Cochran formulae to determine the sample size. This equation was found to yield a reliable sample size as illustrated below.

$$n = Z^2pq / e^2$$

n - Sample size

$Z^2$  - abscissa of the normal curve at 95% level of confidence

$e^2$  - is the desired level of precision – in this case 5%

p – is the estimated proportion of population with a certain attribute - in this case we use 0.5 since we don't have the proportion

$$q = 1 - p$$

Sample size will be;  $1.96 * 1.96 * 0.5 * 0.5 / 0.05 * 0.05$

$$= 385 \text{ factories}$$



If the population is small (less than 10000) then the sample is reduced slightly with the formula;

$$\text{Corrected sample size} = \frac{n}{1 + (n - 1)/N}$$

Where N is the population

$$= \frac{385}{1 + (385-1)/1052}$$

Using the formula, the sample size was 283.

Therefore, the sample size was 283 coffee factories in Kenya who were selected using multistage sampling.

**Table 2.1: Distribution of sample size**

Region	Rift Valley & West of Rift Valley	East of Rift Valley
Total number of factories	270	782
Number of strata	9	9
Strata selected using simple random sampling	4	4
Factories selected using simple random sampling	73	210
=No of factories/1052 * 283		
Percentage	25.8 %	74.2%

## 2.4 Data Collection Tools and Procedure

The study involved document review to get the necessary secondary data. The secondary data included panel data for the years, 2014, 2015 and 2016. This was combined with cross-sectional data. A combination of panel data and cross-sectional data enhances the quality and quantity of data (Gujarati, 2003). Primary data was gathered via single factory visits and holding interviews with the factory managers. Structured questionnaires were administered to respondents by enumerators. A respondent was the factory manager in charge of a factory. A study unit was a factory since the data being collected belonged to factory not individual farmers or the cooperative society. Questionnaires were designed by use of a 5 point Likert continuum scale (Very low, low, moderate, high, and very high,); this was in tandem with (Azadi, Hosseinnia, Zarafshani, Heydari & Witlox, 2010).

## 2.5 Measurement of Variables

The variables in this study were performance and level of diversification to non-coffee businesses Performance was measured in terms of earnings in shillings per kilogram of clean coffee whereas level of diversification was measured by determination of the percentage of annual income earned from non-coffee business.

## 2.6 Data Analysis

After collecting data using questionnaires, it was prepared to make it ready for analysis by handling blank responses, coding, editing, categorization as well as keying into Statistical Package for Social Sciences(SPSS). Analysis of data was done by use of correlation analysis, panel regression analysis as well as descriptive statistics. This was also supported by the STATA (for panel data) and SPSS software (for cross-sectional data).

The data was then subjected to a linear regression analysis and an optimal regression model developed. The model revealed an association between the dependent variable, the independent variable as presented below.

$$Y = b_0 + b_1X + e$$

## 2.7 Ethical Considerations

To ensure ethical standards, informed consent, privacy, anonymity, openness, honest disclosure of the information was practised. The enumerators signed a bond to abide to these regulations.

## 3 RESULTS AND DISCUSSIONS

This section consists of interpretation, analysis of data, discussion and results summary the findings were presented in charts as well as tables.

### 3.1 Rate of Response

The questionnaires which were issued to the coffee factory managers were 283 and a total of 252 questionnaires were correctly filled and returned. Some of the respondents returned the issued questionnaires half-filled while others refused completely to return them in spite of several follow up. The findings of response rate are presented in Table 3.1.

**Table 3.1: Response Rate of Respondents**

<b>Response</b>	<b>Frequency</b>	<b>Percent %</b>
Returned	252	89.05
Unreturned	31	10.95
<b>Total</b>	<b>283</b>	<b>100</b>

The rate of response was 89.05% as indicated on Table 3.1. The rate of response of greater than 50% is sufficient for a descriptive research (Kothari, 2004). The response

rate is also in tandem with the rate in a research conducted by Abubakar et al (2015) on the factors affecting the cooperatives performance in Malaysia, which was 72%.

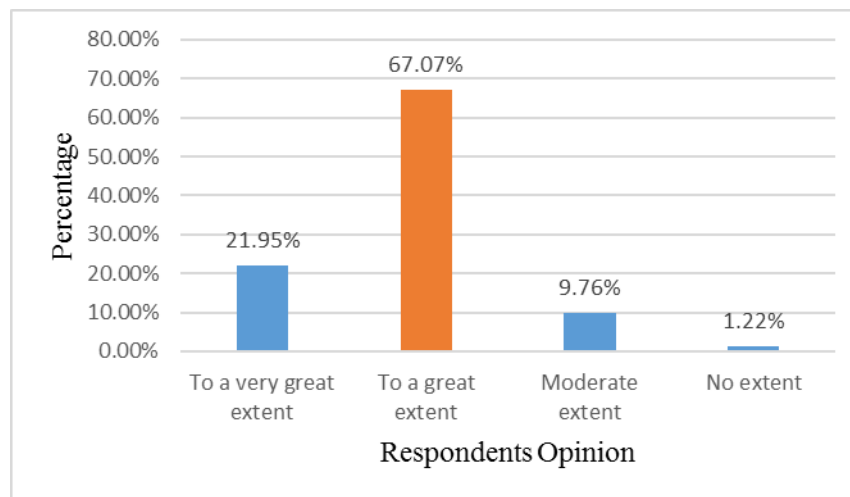
### 3.2 Demographic Characteristics

This part includes the information that explains crucial characteristics for instance age, gender, education level, duration of work in the factory as well as age of the factory. 83% of the respondents were male. 60% were above the age of 55. Only 4% were below the age of 30 years. 41.7 had gone up to college level of education. 51% of the respondents had worked in their respective factories for more than 10 years. Most factories were quite old. Majority of the respondents (71.8%) stated that their factories were over 20 years old.

### 3.3 Diversification and Performance of Coffee Cooperatives

The respondents were asked to give their opinion on effect of diversification to non-coffee business on the performance of coffee cooperative societies in Kenya. Majority of the respondents (85%) believed that diversification to non-coffee business affected the performance of coffee cooperative societies. This implies that the more diversified a cooperative society is the more it is likely to perform better. These findings agreed with that of Culas and Mahendrajah (2005) who argued that performance of a coffee factory is highly affected by the level of diversification to other businesses. Only (15%) indicated that diversification to non-coffee business would not affect the performance of coffee cooperative societies in Kenya. Diversification expands markets of a company and increases income Chiranibet al (2013).

The respondents were further asked to indicate their opinion on what extent diversification to non-coffee business affected the performance of coffee cooperative societies in Kenya.



**Figure 3.1: Extent Diversification to Non-Coffee Business and Performance**

The results in Figure 3.1 show that majority of the respondents (67.07%) believed that diversification to non-coffee business affected the performance of coffee cooperative societies to a great extent. This implies that diversification to non-coffee business by the

coffee cooperatives is likely to improve the level of performance of the cooperative society. These findings agreed with that of Culas and Mahendrajah (2005) who argued that performance of a coffee factory is highly affected by the level of diversification to other businesses. This is also in tandem with Okibo and Karagu (2014) who stated that cooperatives should introduce more products to remain competitive in the market. Only a small percentage didn't believe of any improvement in performance as a result of diversification.

The study further sought to establish the extent to which the diversification to non-coffee business affect performance of coffee cooperative societies. The results of this study were as depicted in Table 3.2.

**Table 3.2: Diversification to non-coffee business and performance**

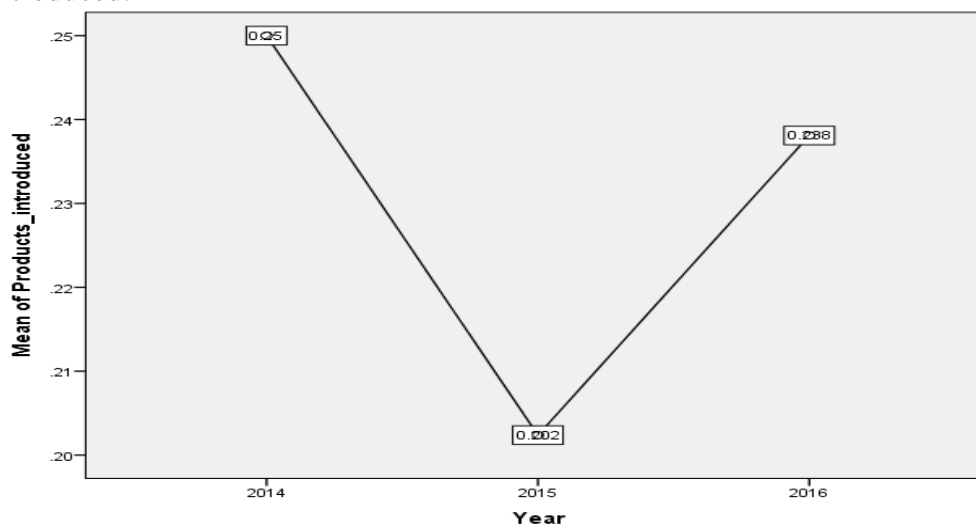
Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Std. Dev.
	%						
Diversification to non-coffee businesses would improve/has improved the performance of our factory	1.2	7.1	11.9	51.2	28.6	4.0	0.9
The diversification strategies in the factory would help/has helped cope with competition	3.6	8.3	10.7	53.6	23.8	4.3	4.5
Risk has been/would be minimal due to diversification	6.0	15.5	19.0	50.0	9.5	3.4	1.1
Farmers have benefited/would benefit from diversification	9.5	6.0	13.1	48.8	22.6	3.7	1.2
<b>Average</b>						<b>3.9</b>	<b>1.9</b>

The results in Table 3.2 revealed that majority of the respondents (79.80%) agreed with the statement that diversification to non-coffee businesses would improve the performance of the factory. This implies that coffee factories that diversify are likely to perform better than those that do not diversify. Most of the respondents showed agreement with the other statements analyzed above that highlighted the importance of diversification. Diversification to non-coffee businesses would increase the income streams of the cooperatives making them perform better. Diversification would also mitigate the risk of low performance due to unfavorable weather. Karagu & Okibo (2014) advises cooperatives to diversify to other products so as to remain competitive. Athar et al (2015) argued that managers diversify in order to get higher returns as well as distribute business risk. When a firm is diversified business units that make losses are able to be supported by the profit making ones.

On a five-point scale, the average mean of the responses was 3.85 which means that majority of the respondents were agreeing with most of the statements that were supporting the positive relationship between diversification and performance; The deviation among the respondents was minimal with a standard deviation of 1.92. This means that there was near consensus that diversification is important in improving the performance of the coffee cooperatives in Kenya.

### 3.4 Non coffee Products Introduced

The number of products that a society was considered to be a measure of diversification in the factory. The figure below summarizes the number of products introduced.

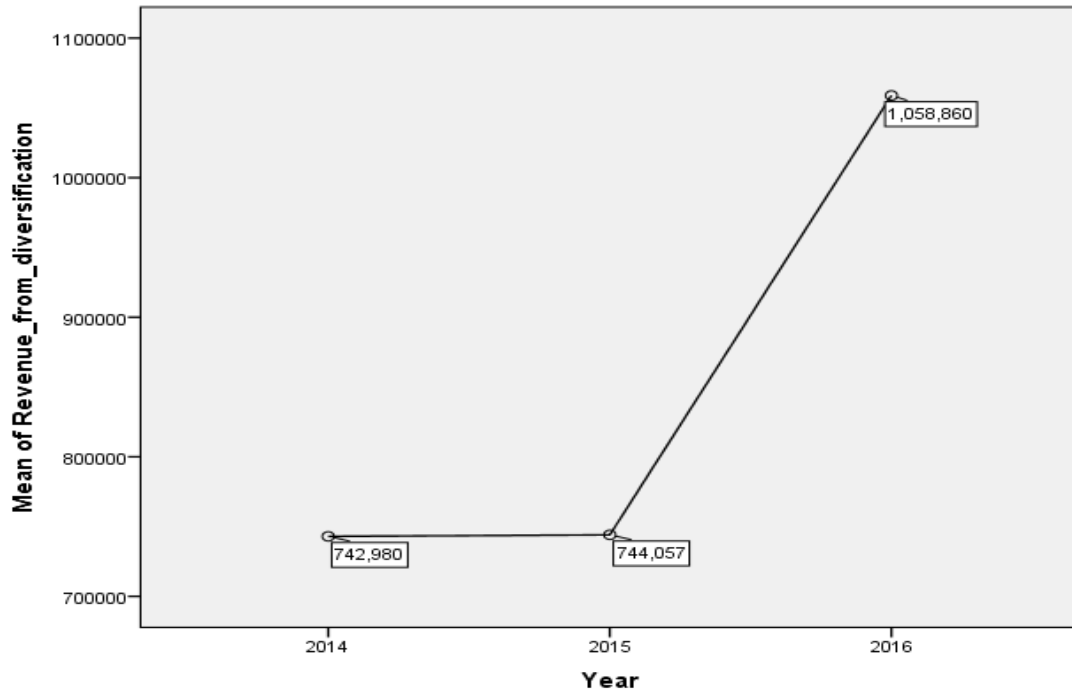


**Figure 3.2: Products Introduced**

The average number of product introduced in the year 2014 was 0.25, the average decreased slightly to 0.2 in the year 2015 and further increased to 0.24 in the year 2016. It is therefore noted that there isn't much change in the number of products introduced across the three years.

### 3.5 Revenue from Diversification

The revenue from diversification activities was calculated and is presented in the figure below.



**Figure 3.3: Revenue from Diversification**

The trend analysis results revealed that average revenue from diversification in the year 2014 was kshs 742, 980. There was only a slight change in 2016. This slight change could be by chance or one society introduced an additional business unit or a new product. The low changes in the revenue from diversification activities meant that the changes in performance as a result of diversification was minimal.

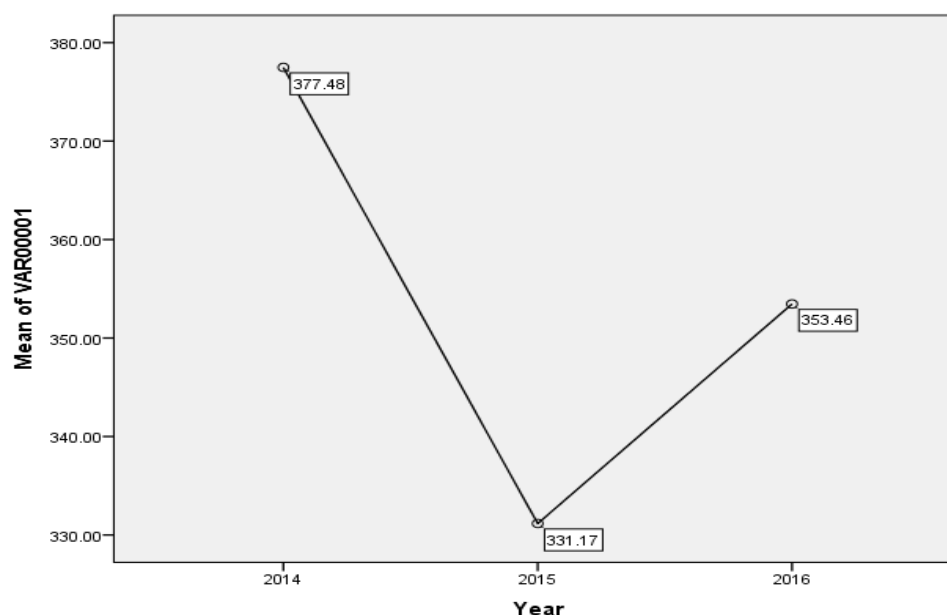
**Table 3.3: Correlation between Diversification and Performance of Coffee**

	Performance	Revenue from diversification
Performance	1.000	
Revenue from diversification	0.9042	1.000
	0.0075	

The results in Table 3.3 revealed that diversification and performance of coffee cooperative societies are positively and significantly associated ( $r=0.9042$ ,  $p=0.0075$ ). This implies that increased in amount of revenue from diversification would lead to improved performance of coffee cooperative societies. These findings agreed with that of Culas and Mahendrajah (2005) who argued that performance of a coffee factory is highly affected by the level of diversification to other business. This is also supported by Kanyua et al (2013) who argued that small holder tea farmers in Gatanga, Kenya diversify due to declined income. They also argued that farmers diversify for economic reasons. In Vietnam, diversification aids in risk management as well as ensuring high income for the farmers, Minot et al (2006).

### 3.6 Performance of coffee cooperatives

Since coffee is sold in dollars per 50 kilogram of clean coffee, performance was measured in the similar terms. The performance of a coffee factory was measured in US dollars per kg of clean coffee. It was also easy to obtain the information since the sales records at the factory are in dollars while farmers' payments records are in Kenya shillings.



**Figure 3.4: Income to the Factory**

The trend analysis results revealed that average income per kilo of clean coffee in the factories didn't vary much across the years studied. Decline in the average income per kilo of clean coffee from factories in the Kenyan cooperative societies would mean decline in performance of cooperative societies in Kenya. The changes in quality of coffee due to factors like weather, farm and factory operations may also cause changes in payment rate.

### 3.7 Regression Analysis for Diversification to non-coffee business

The results between diversification to non-coffee business and performance were presented in the Table below.

**Table 3.4: Model Fitness**

Indicator	Coefficient
R	0.52
R Square	0.2704
Adjusted R	0.2682

Diversification to non-coffee business was found to be a satisfactory variable in determination of performance of coffee cooperative society. This is supported by coefficient of determination also known as the R square of 27.04%. This means that diversification to non-coffee business explain 27.04% of the variations in the dependent variable which is performance of coffee cooperative society.

**Table 3.5: Analysis of Variance**

	F	Sig.
Regression	8.19	0.021

Table 3.5 provides the results on the analysis of the variance (ANOVA). The results indicate that the overall model was statistically significant. Further, the results imply that the diversification to non-coffee business is good predictor of performance of coffee cooperative society. This was supported by an F statistic of 8.19 and the reported p value (0.021) which was less than the conventional probability of 0.05 significance level.

**Table 3.6: Regression Analysis for Diversification to non-coffee business**

<b>Performance</b>	<b>Coef.</b>	<b>Std.Err</b>	<b>z</b>	<b>P&gt; z </b>
Revenue from diversification	3.4	0.00114	2.03	0.006
_cons	56.10	2355.97	2.38	0.017

The results in Table 3.6 showed that revenue from diversification had a positive and significant relationship with performance ( $r=3.4$ ,  $p=0.017$ ). This implies that increase in revenue from diversification by 1 unit would lead to increase in performance of coffee cooperative society by 3.4 units.

$$Y = 56.10 + 3.4 X \dots\dots\dots 4.3$$

Where

Y is Performance of the coffee cooperative society

X is the Diversification to non-coffee business

#### **4.8.3.1 Hypothesis testing for diversification to non-coffee business**

The hypothesis was tested by using multiple linear regression (Table 3.5, above). The acceptance/rejection criteria were that, if the f calculated is greater than f critical, the  $H_0$  is rejected but if it's less than f critical, the  $H_0$  fails to be rejected.

The null hypothesis was that there is no significant relationship between quality of coffee and performance of coffee cooperative societies. Results in Table 3.5 above show that the f calculated was 8.19 which was greater than the f critical which was 3.94. This indicated that the null hypothesis was rejected hence there is a significant relationship between diversification to non-coffee business and performance of coffee cooperative societies. These findings agreed with that of Culas and Mahendrajah (2005) who argued that performance of a coffee factory is highly affected by the level of diversification to other businesses.

## **CONCLUSION**

Diversification to non-coffee businesses has a positive and significant effect on performance of coffee cooperative societies in Kenya. The hypothesis results revealed that diversification to non-coffee businesses had a significant effect performance of coffee cooperative societies in Kenya



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## **The role of website usability on customer satisfaction in commercial banks in Meru County**

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This study sought to evaluate the role of website usability on customer satisfaction in commercial banks in Meru County. The website, being the 'virtual counter' from which customers' access on line services, is an important component of internet infrastructure. Infrastructure is a key component of Kenya's vision 2030 which envisions a deeper and broader financial sector that contributes to improving the livelihoods of majority of Kenyans. In order to increase profitability, many banking institutions depend on the internet infrastructure, which is presumed to be adequately developed for optimal customer experience. No research has been done to evaluate the role of website usability on customer satisfaction regarding online services. This study combined correlation and descriptive survey designs. Systematic random sampling was used to pick a sample of 355 respondents from selected banks. Structured questionnaires were administered to respondents at their convenience in the banking hall while waiting for services, and others at their business premises. 280 questionnaires were successfully completed, making a return rate of 79 percent. Logistic regression was used to test the relationship between variable at 5 percent level of significance. From the research, it was found that a significant relationship existed between website usability and customer satisfaction. Choice of language, font sizes and types, Icon sizes and associated colour choices, in addition to live chat facility were identified as important aspects of website usability. Where a website was easy to use, customers were more likely to be satisfied compared to where the website was not easy to use. It is recommended that banks widen language alternatives by integrating key ethnic languages, incorporating live chats, and tailoring programs to induct customers on web access and usage.

*Key words: website usability, virtual counter, Customer Satisfaction, Profitability*

# **Stakeholder Participation and Effective Implementation of Projects Within Tana Water Services Board In Kenya**

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## **Abstract**

Kenya experiences numerous challenges due to increased strain on available water resources affecting provision of safe, clean water and basic sanitation. Stakeholder participation has been pointed as a key factor that would enhance project implementation for sustainable development. The study sought to investigate the extent of stakeholder participation in implementation of water projects within the water sector in Kenya. This study specifically investigated the participation of end water users, county governments, donors, and staff in the water projects. The study employed a descriptive survey research design and targeted projects supervised by Tana Water Services Board (TWSB) for the last five years. Stratified random sampling was used to select a sample of 30 projects from the entire set of projects. The respondents were 48 staff. The study incorporated triangulation method through the use of both primary and secondary sources of data to establish concrete findings. Primary data was gathered using a questionnaire while secondary data was gathered through review of published journals, periodicals and reports. The primary data was analyzed using descriptive statistics and the results presented in form of percentages, figures and tables. The study found out that stakeholder participation was critical for effective implementation of water projects. However, it was established that end water users, county governments and staff in Water Service Providers are partially involved in the implementation of water projects. Staff in TWSB and donors were found to be fully involved in the implementation of water projects. The study recommends that all stakeholders should be involved right from the planning stage all the way to the implementation of the water projects to ensure that the country meets its overall objective of 'water for all'. This will enhance acceptance and promote sustainability of the water projects.

**Key words: Stakeholder, Critical Success Factors, Project Implementation, Water Service Board**

## **INTRODUCTION**

Water supports human life and enterprise and thus economic development. A United Nations Development Program (UNDP) report indicates that around 40% of the

inhabitants of the world are affected by water scarcity. Further, the report notes that 83% of rural dwellers live without access to clean drinking water sources (United Nations, 2013). Provision of accessible and safe drinking water and basic sanitation remains one of the challenges for achieving sustainable development in the world.

At the global level nearly two billion people are affected by lack of access to safe water, the main driver of poverty, (Marshall, 2011; United Nations, 2013; UNDP, 2015). In Kenya, millions of people rely on agriculture and livestock for daily upkeep and these are threatened by water scarcity. Thousands of people die each year due to thirst and hunger. Contaminated water resources also cost lives of people through water-based diseases such as malaria and intestinal worms, water-borne diseases such as typhoid fever, diarrhea, cholera and dysentery as well as water-washed diseases such as eye infections and skin diseases, (Kulinkina, Shinee, Herrador, Nygård, & Schmoll, 2016). High mortality rates due to water related problems have an adverse effect to the economy. Failure to have irrigation schemes in Arid and Semi- Arid Land contributes to the rising levels of hunger, unemployment, and consequently poverty. The rising unemployment rates again contribute to a slowing economic growth. Provision of safe water and improvement in sanitation improves the health standards of people, reduces illiteracy, and increases productive employment in any given country. These and others contribute to sustainable development and improvement in lifestyles of people, eradicating extreme cases of poverty and work towards empowering women and the youth, (Marshall, 2011).

A United Nations report (2013) indicates that Kenya as a country suffers from water scarcity. The water sector in the country continuously carries out water projects to improve the situation. While bringing new projects to the stream, the sector lays out a set of goals and objectives that seek to address the challenge of water scarcity among Kenyan households. The projects are aimed at ensuring that the citizens have access to clean, adequate and reliable water systems and sanitation services. Principally, provision of clean water is one of the seventeen Sustainable Development Goals (SDGs) adopted by the world leaders during a United Nations' summit in September, 2015 and which are aimed at having been attained by the year 2030. The layout of Kenya's vision 2030 projected an improvement in water and sanitation facilities to ensure that all citizens access safe, clean water. This was to be done through construction of multipurpose dams, rehabilitation of the hydro-metrological network, rehabilitation and expansion of urban water supply and construction of the Tana Delta Project among other projects, (GOK, 2007). Further, the African Union Commission, (2015) Agenda 2063 intends to put in place the necessary water infrastructure in order to ensure equitable and sustainable management of water resources by the year 2063. Indubitably, management of water resources will play a major role towards attainment of the government's big four agenda -food security, affordable housing, manufacturing and affordable health care for all within five years. Irrigation schemes will enable the country utilize the arid and semi arid lands through food production.

The Kenyan water sector has gone through radical phases since independence due to the political, environmental and economical arenas prevailing within the years but above all due to the rise in population growth. In 1999, Kenya initiated a process of water sector reforms aimed at improving water services and prudently managing the water resources. The reforms culminated into the Water Act 2002, (Moraa, Otieno, & Salim, 2012). Among the major reforms of this Act was decentralization and more engagement of stakeholders and water resources users in making decisions regarding designs and plans of water projects, (Danida, 2010). The purpose of the water Act was

to harmonize and streamline management of water resources, water supply and sewerage/sanitation services. The Ministry of Water and Irrigation (MWI) spearheaded the implementation of the Water Act 2002 processes by enhancing and conserving sustainable water resources through decentralized services system, (Moraa et al., 2012). Through the reforms, the country was divided into 8 regions that constitute the 8 Water Services Boards. The Water services Boards (WSBs) took over all the water and sewerage assets previously managed by various Ministries. They are mandated to regulate water and sewerage services, develop and maintain quality standards and issue licenses to the Water Service Providers (WSPs). After 14 years, the Republic of Kenya, (2016) in a gazette notice passed into law the Water Act 2016 that among other reforms emphasizes the dire need to continuously consult the stakeholders in decision making in the water sector.

### **Project implementation**

The project implementation phase, also commonly known as project execution, is the third of the four phases of the project life cycle. This is where the bulk of the work is done (Westland, 2006). In this phase, plans formulated in the planning phase are operationalised. As the project managers actualize the plans, far-reaching management decisions are made as they in an effort to monitor and control the project output and outcomes. It is at this phase that the project is launched, project teams are managed, communication channels managed, issues and risks are addressed and the organizational capacity tested. The project implementation phase is therefore the longest in terms of duration, the most tasking and the most expensive. It is the most complex phase and requires simultaneous attention in terms of human resource management, funds management, as well as technical variables, (Westland, 2006). Due to the complex nature of the implementation phase, how well a project is implemented can result to either success or failure of the entire project, (Munns & Bjeirmi, 1996).

Project deliverables of scope, time and cost must achieve a certain performance level in terms of quality and meet the expectations of the key stakeholders. Each of these factors tend to affect other factors, (Horine, 2009). The challenge for project managers is to identify the critical factors that need to be given priority and emphasis for the project's deliverables to be achieved while balancing the competing demands of the project. Project managers should therefore identify the factors that cause poor project outcomes and eliminate them. They need a better understanding of the factors that are very critical to ensure project success as well as factors that can lead to failure of projects and explore ways to measure them.

### **Projects Undertaken by Tana Water Services Board**

Tana Water Services Board (TWSB) serves six counties in the Central Region of Kenya. These are Nyeri, Kirinyaga, Embu, Meru, Murang'a and Tharaka Nithi Counties. TWSB strives to increase access to safe, adequate and sustainable water and sewerage services that boost socio-economic growth for its stakeholders. This is in accordance to its philosophy: *Accessible quality water and enhanced sanitation for improved livelihood*. The board ensures that the communities it serves are able to get safe water and sanitation services by developing, rehabilitating and managing water related infrastructure in its area of jurisdiction. It also monitors the performance of WSPs by ensuring that proper regulations on water services tariffs are adhered to. Further, the board is concerned with leasing of water sewerage facilities, (Tana Water Services Board, 2012).

TWSB undertakes major water projects. Currently, there are projects that are completed, some are ongoing and some that have been proposed. The completed projects include Ragati Dam project and Hombe Dam project, Kiawambeu Treatment works in Embu, Mboone Treatment works in Meru, Nyambene Hospital Treatment works and Kiamugongo Community Project which are the main projects. Others include Kinyona water treatment, Chuka water supply intake, Tharaka projects, and Meru water supply intake. It, however, delegates some smaller projects to the Water Service Providers (WSPs) that it supervises. Currently, TWSB supervises 24 Water Service Providers (Tana Water Services Board, 2012). To ensure they meet their vision and mission, the WSPs undertake Water and Sanitation Projects that are normally funded by Water Services Trust Fund (WSTF). The role of WSTF is to pool funds for use in development of water services particularly among the disadvantaged and rural communities. A huge amount of funds are invested in water projects and therefore it is important for project managers to speed up the process of project implementation to ensure that there are no failed or sluggish projects and that the funds are committed to the specific use for which they are targeted. This study identifies the County Governments, the staff of TWSB and WSPs, the donors and the end-water users as the main stakeholders of TWSB. The donors were identified as the Government of Kenya, UNICEF, JICA, Cooperzone Italiana, the World Bank and the African Development Fund.

### **Statement of the problem**

The water sector reforms highlight the need for participation of key stakeholders in planning and decision-making. However, the authorities concerned fail to consider stakeholder participation as a key factor that should be given worthy attention for water projects to be implemented effectively. Failure to involve stakeholders in design and implementation of projects leads to a mismatch between stakeholders' needs and the project objectives. Ultimately, this thwarts project acceptance and ownership by the key stakeholders, and thus unsustainable project's deliverables. Unsuccessfully implemented water projects pose a threat to the Kenyan population. With scarce water supply, agricultural and infrastructural developments are jeopardized. The proportion of the population that use contaminated water faces threats to their health due to water-based diseases, (Marshall, 2011). The threats posed by these water related problems raises hospital admission rates and mortality rates, hence imposing adverse effects to the economy.

Poorly implemented water projects are also a threat to the realization of some of the goals Kenya Vision 2030, which aspires for a country well interconnected with water and sanitation facilities among other infrastructure. Kenya being a water scarce country requires high quality water supplies for it to achieve the economic and social developments it anticipates in its vision 2030, (GOK, 2007). Similarly, the government cannot achieve its four areas of priority within the next five years without its citizens having accessible to clean water and sanitation facilities.

### **Study objectives**

This study sought to establish the extent of stakeholder participation as a CSF for effective implementation of water projects within TWSB. Specifically, the study investigated the participation of end water users, county governments, donors and staff in the water projects.

### **Significance of the study**

The water problems in the country and the deliberate efforts by consecutive governments to deal with water shortages leads us to the question this study wishes to answer: To what extent is stakeholder participation considered a critical success factor for effective implementation of water projects in Kenya? Answers to this question will enable the Ministry of Water, Environment and Natural Resources to develop policies aimed at enforcing the outlines of the Water Act 2016 regarding involvement of stakeholders in design, decision and execution of water and sanitation projects. The findings will also strengthen the role of stakeholders in TWSB and the WSPs and management will have a better understanding and perspective of the important role played by stakeholders while they are actively engaged. This research adds to the existing knowledge on critical success factors and stakeholder participation particularly in the field of project management. However, it has brought new knowledge on stakeholder participation as a critical success factors for effective implementation of projects within the water sector as most of the studies done in the water sector have mainly focused on reforms within the sector. It is, therefore, expected that this report will serve as a scholarly reference material for future studies and research work in other organizations that are project-oriented.

### **Organization of the study**

The study is organized into three sections. Section one offers a clear background of the study exploring the statement of the problem and defining the question that the researcher needs to answer. It also highlights the significance of the study. Further, the section covers a discussion of the project implementation phase and theories used in the research. Section two covers the methodology used to conduct the research. Section three presents the research finding discussing the significance of these findings, conclusions drawn from the study and recommendations given.

### **Stakeholder Theory**

The stakeholder theory was first introduced by Richard Edward Freeman in 1984. He first defined a stakeholder as “any group or individual who can affect or is affected by the achievements of the organization’s objectives.” (Freeman, 1984). However, in 2004, he described shareholders as those groups that are vital to the survival and success of the organization. His second definition introduced the idea of sustainability of a corporation’s outcome that can only be achieved through addressing their myriad wishes, concerns and expectations, (Eslerod, Huemann, & Righhofer, 2015). Using Freeman’s work as a foundation, Sen & Cowley, (2013) defined stakeholders as the people and groups affected by the project or in a position to influence it. These groups can be either directly or indirectly involved in the execution of the project. Initially, stakeholders were just grouped into four, i.e. the shareholders, the employees, the customers and the public. But his later definition added the local community, suppliers and distributors as other key stakeholders that must be engaged constantly to ensure survival and success of an organization and hence sustainability. He argued that stakeholder management was an important aspect of the organization and that an organization ought to give the stakeholders attention and involve them in decision-making, (Fontaine, Haarman, & Schmid, 2006).

Stakeholder disappointment has also been identified as a major cause for unsuccessful projects, (Eslerod et al., 2015). Eslerod & Huemann, (2013) observed that there is considerable amount of projects that fail due to stakeholder mismanagement leading to dissatisfaction hence lack of cooperation. The duo argues that lack of stakeholder participation brings about prolonged and unnecessary tension. These could be stirred



by a lack of proper project communication mechanisms and obliquitous information flow. Further, project managers fail to identify the most relevant stakeholders, identify their information needs and negotiate and link their expectations to the project objectives. This would increase chances of acceptance. However, the project managers should be careful not to dwell on stakeholders' interests and forgo the project objectives.

The critical role that project's stakeholders play in the design, execution and sustainability of any project has been overlooked over the years. In fact, Danida, (2010) noted that the concept of stakeholder management has not been considered much in project management but maybe given much more attention in the general management and sustainable development. There is need to consider stakeholder participation and involvement in project as a critical success factor.

### **The Critical Success Factor approach**

“Success factors” were brought into perspective by a research team led by Daniel Ronald of McKinsey & Company in 1961 with the objective of addressing issues in management of information in organizations, (Caralli, 2004). Their research propounded that for a company to be successful, it should turn its focus to working excellently well on three to six key factors in the area of organizational planning, (Moore, Ellison, & Linger, 2001).

In 1979, organizations were going through tremendous growth in information systems, yielding considerable amount of information that needed the attention of analysts and key organization decision makers. However, even with the enormous information, the high level managers were not able to make the kind of decisions that would move their enterprises forward, (Caralli, 2004). This scenario called for a new strategy that would help the senior managers understand clearly the information needs for business success. It is from this point of view that Rockart, (1979) and a team from the Massachusetts Institute of Technology (MIT)'s Sloan School of Management expanded the idea introduced by Daniel Ronald and introduced the Critical Success Factors (CSFs). Their endeavor was to help senior executives to not only deal with issues in management of available information but to clearly and articulately define their information needs. This approach was then introduced in a Harvard Business Review article entitled “Chief Executives Define Their Own Needs”, (Rockart, 1979).

According to Rockart, (1979) the CSFs approach requires managers to choose and determine their limited and narrow area of focus and attention. These could be three to six areas cautiously and systematically identified as drivers of success. The approach also asserts the need for the identified factors to receive careful and continuous management scrutiny. Managers need to develop a good measure for these factors and they can therefore seek periodic reports on each measure. Through this approach, an organization is able to define articulately the amount of information that must be collected, which saves organizations from the trap of building reports around readily available data. This approach places emphasis on giving attention to overlooked information or areas and which could presumably contribute to the success of a project.

Researchers and authors are linking the concept of Critical Success Factors to the field of project management although the concept has not gained widespread popularity in this field. Some of the studies that link this approach to project management include Baker, Murphy & Fisher, (1974) who carried out a research on

factors contributing to project success. Crawford, (2000) conducted a study whose findings observed stakeholder management as critical to project success. Li Fang (2005) concluded that top management support, business process reengineering, project team and change management as well as effective communication were critical success factors for effective Enterprise Resource Planning (ERP) implementation. Although the concept has not been widely used in the field of project management, it has integrated in other management fields, (Caralli, 2004; Forster & Rockart, 1989; Sharma 2010). This study therefore uses the CSF concept together with the Stakeholder Theory to emphasize the need for stakeholder participation for effective implementation of projects.

### **Research Gaps**

Previous researches in the Water Sector have focused on establishing the status of water and sanitation projects or affirm the scarcity of the water resources. Others have narrowed down to investigating status of proposed reforms in the Water Sector. Findings of such studies have noted quite a number of challenges but the challenges are yet to be effectively addressed. This research noted that stakeholder participation in the water sector has not been given strict attention as a Critical Success Factors for water projects' implementation. Identification of and stringent focus of Stakeholder participation as a Critical Success Factors in the water sector is therefore a research gap that has to be bridged. This research therefore aims at establishing the extent of stakeholder participation as a Critical Success Factors that if given attention could ensure effective implementation of water projects.

### **Research Methodology**

#### **Research design**

The study adopted a descriptive survey design due to its formalized and typically structured nature as advanced by Cooper & Schindler, (2014). The study sought to answer a clearly stated investigative question.

#### **Sampling techniques**

The study targeted 151 projects under the supervision of TWSB for the last five years. These included 17 projects that were under direct supervision by TWSB and 134 projects undertaken by WSPs licensed by TWSB. Using 20% of the total projects, stratified random sampling was used to select 30 projects that were studied. Projects under direct supervision of TSWB and those that were supervised by WSPs formed the strata. The respondents were the CEO and staff from TWSB and WSPs from the Technical, Finance, Planning & Strategy, ICT, Human Resource and Administration departments. 24 staff from TWSB and 24 staff from Water Service Providers were targeted.

#### **Data collection methods**

This study used triangulation method by incorporating multiple methods of data collection and different perspectives. Both primary and secondary data were used to collect data relevant for this study. Primary data was collected using self-administered, structured questionnaire with both open-ended and close-ended questions to collect qualitative data. Quantitative data was collected using a Likert Scale with responses ranging between one and five. Secondary data was gathered by reading through published ministry's reports, journals and periodicals on water sector

and projects implementation. The researcher employed the test retest technique to determine the reliability of the questionnaire. The researcher sampled six respondents from TWSB and isolated their filled questionnaires. After four weeks, the researcher administered the new but similar questionnaires to the six respondents again. The responses from these two questionnaires were compared for reliability. A correlation coefficient was computed at 95% significance level and the findings were that at 95% significance level, the tests were not significantly different. The study made use of content validity where experts' opinions were used to establish the validity of the questionnaires. The questionnaire was developed guided by the objectives of this study. The questions were designed in a simple, easy to understand language and avoided the use of technical terms. The questionnaires were presented to a group of lecturers from Kenyatta University who cross-examined the questionnaire and their suggested areas of improvement factored in.

### **Data Analysis**

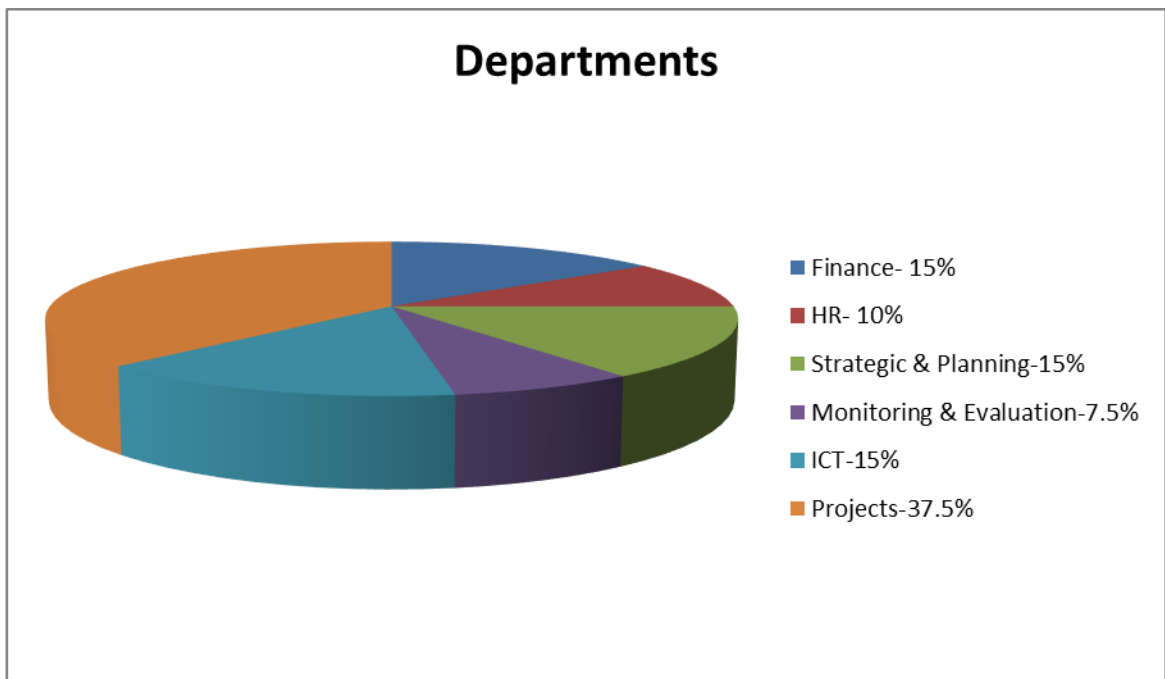
The data collected was analysed using a number of methods. The raw data collected went through a process of field and then central editing. This was done to be assured of data accuracy, consistency and uniformity. The data was then coded where answers were put in a limited number of categories or classes. This was done to ensure efficient analysis by using a computer programme. In the analysis of data, Statistical Package for Social Scientist (SPSS) was used. Descriptive statistics such as the measures of central tendency, measures of dispersion and frequency distribution were used to summarize the coded data to enable in describing and making comparisons of the findings from the units of analysis of the study. The analysed data was presented in percentages, pie charts and frequency distribution tables.

### **Ethical Issues**

The researcher endeavored to collect quality research. A research permit was obtained from Kenyatta University School of Business. Before administering the questionnaires, the researcher introduced herself and explained the purpose of the study and benefit to TWSB, and to the WSPs. The researcher treated the information gathered from the organization and respondents with utmost confidentiality.

## **RESULTS AND DISCUSSION**

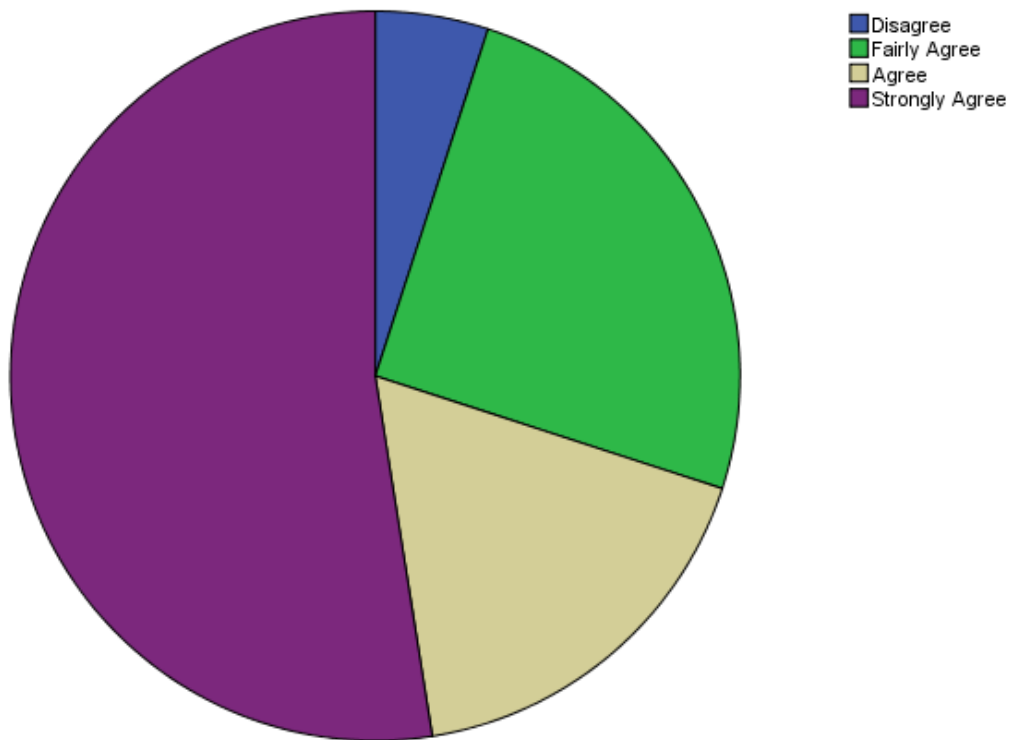
Out of 48 questionnaires administered to the respondents, 40 questionnaires were returned, giving a rate of 83.3%. Figure 3.1 presents departments from which questionnaires were collected.



**Figure 0.50: Departments from which respondents were drawn**

The study sought to establish the extent of stakeholder participation as a critical success factor for effective implementation of water projects. The respondents were asked to indicate whether stakeholder participation was a CSF from their standing point as persons who were either directly or indirectly involved in projects implementation. Their results indicated that majority strongly agreed that stakeholder participation was a CSF. As Figure 3.2 indicates, only a handful felt that stakeholder participation was not a CSF for effective implementation of projects. These results support the argument

### Stakeholders participation

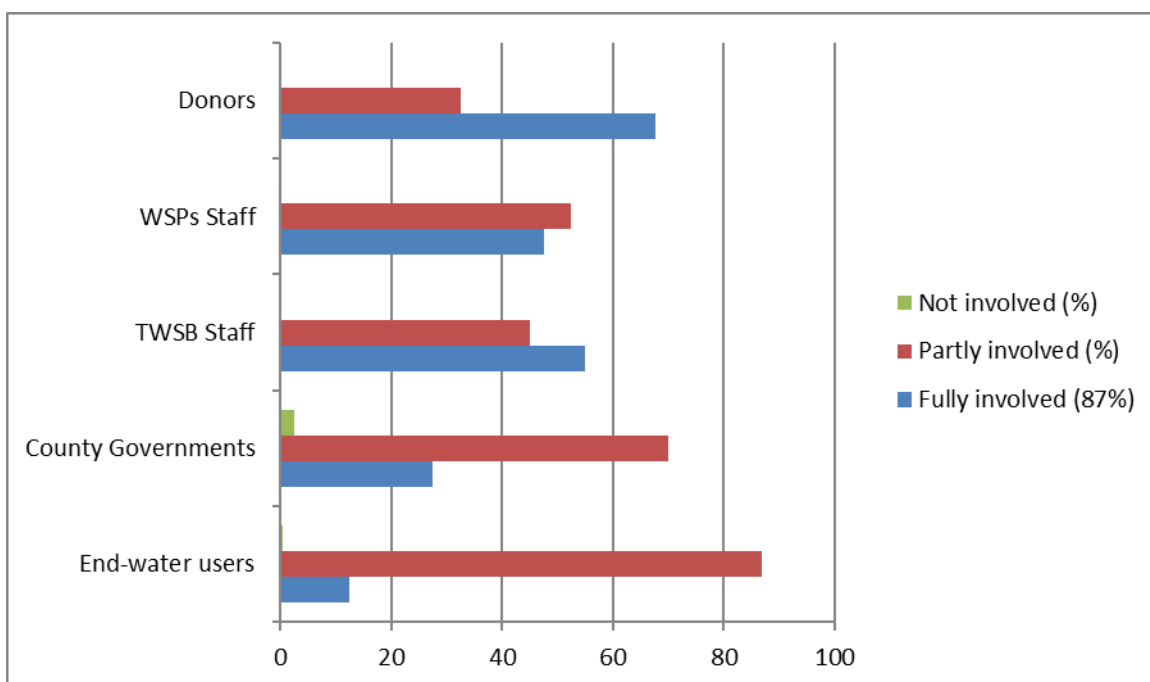


**Figure 0.51: Report on stakeholder participation as a CSF**

The respondents were asked to indicate the extent to which they believed that stakeholders' participation is critical for effective implementation of water projects and the extent to which the end-water users, the County Governments, staff both in TWSB and WSPs and the donors are involved in the implementation of water projects. 95% of the respondents agreed that stakeholder participation is critical. Further, 87% of the respondents felt that end-water users were only partly involved in implementation of projects while only 12.5% indicated that end-water users are fully involved. These results depict a gap in projects implementation. Failure to involve end water users completely bars project acceptance and cooperation by the stakeholders. The end water users who are the consumers tend to value and own the projects when they understand the benefits and when any negative consequence is handled promptly they also appreciate constant dialogue and communication. Only then are the projects able to produce the desired outcomes.

The findings indicated that the County Governments are not fully involved in the implementation of projects. 70% of the respondents indicated that the County Governments are only partly involved while 2.5% felt that they are not involved at all. 27.5% of the respondents indicated that the County Governments are fully involved in the implementation of water projects. As one of the major stakeholders in water systems management, TSWB should consider actively engaging the County Governments through constant consultations and internalization of their water plans and interests into their projects as recommended by Eskerod & Huemann, (2013). Water providers should work closely with County Governments in order to develop sustainable systems to ensure all citizens have access to clean, safe drinking water.

County Governments may be potential donors and in cases where they are not fully involved, they may not prioritize funding of the water projects.



**Figure 0.52: Extent of Stakeholder Participation**

The results further revealed that TWSB staffs are fully involved in project planning and implementation. 55% indicated that staffs in TWSB are fully involved while 45.0% indicated that they are partly involved. On the other hand, staffs in WSPs are relatively involved in the implementation of projects. 47.5% indicates that they are fully involved while 52.5 % indicates that they are partly involved. Staffs need to be fully involved. If they are, they will feel as part and parcel of the operations of the organization and this will enhance their participation in generating inventive ideas.

The findings of the study pointed out that donors are involved in the planning and implementation of water projects. 67.8% indicated that they are fully involved while 32.5% indicated that they are partly involved. Donors play a major role in the success of a project. There are times where the project budget exceeds the funds released. In this case, water providers will need to ask for more funds from the donors. If they have not been actively involved in the implementation of the projects, they may be suspicious of misappropriation of funds and may withdraw their funding for the water projects causing projects failure.

## CONCLUSIONS

As observed in the Stakeholder Theory, stakeholders play a very critical role in the design and execution of projects. Reforms in the water sector highlight the need for involvement of stakeholders in planning and design, decision-making and implementation of water projects. The study notes that stakeholder participation has received attention in other management fields but limited attention in the field of project implementation. This research further notes that stakeholder participation is very critical for effective implementation of projects within the water sector.

However, the research established that end water users, county governments and staff in WSPs are only partly involved in the implementation of water projects. It was also established that staff in TWSB and donors are fully involved in the implementation of water projects. The study concludes that the Water Sector mostly uses the stakeholders selectively depending on their level of participation in the project. For example, project donors were found to be fully involved presumably because of their financial role in the projects. The staff in TWSB were also fully involved most likely because they are directly involved in the water projects. It is important for authorizes concerned with implementation of water projects to ensure full participation of all key stakeholder during the implementation of projects regardless of their standing in the project either as beneficiaries, project team or financiers.

### **Recommendations**

This study acknowledges the fact that there are very many factors listed in the Water Act 2002 and 2016 that requires urgent reforms. However, stakeholder participation is very vital and authorities in the water sector need to grant it priority in their implementation plan to achieve transformation in the manner in which water projects are implemented. The study recommends the use of the CSF approach during implementation of water projects. This will allow project managers concentrate on key areas that will ensure success and sustainability of the water projects.

### **ACKNOWLEDGEMENT**

I acknowledge the support that I received from staff from TWSB and the Water Service Providers. They gladly welcomed me into their offices and filled the questionnaire without coercion or feeling bothered. I would also like to appreciate the support of Kenyatta University Lecturers led by Dr. Rosemary James for their guidance in making my research work a success. Finally, I want to appreciate a former student of Dedan Kimathi University of Technology who assisted me with coding and data analysis.

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## WEG

### **Environmental Safety of Geothermal Power Plants: A Case Study of Eburru Geothermal Wellhead Power Plant**

Dr. Paul K. M. Sang & Philip J. Barasa

#### **Abstract**

Recent complaints from residents living near Eburru Geothermal Power Plant regarding various aspects of safety to the environment prompted this research. The broad objective was therefore to investigate potential environmental risks of Eburru wellhead geothermal power plant on the local community. Primary data on perception of the local community towards the potential risks was collected through focus group discussions, interviews and administration of structured questionnaires. The questionnaires were administered to ninety five (95) households residing in four villages neighbouring the power plant in Eburru location, Gilgil sub-county. Historical data on brine chemistry, noise and hydrogen sulphide (H<sub>2</sub>S) gas was also reviewed and analyzed. Brine chemistry, noise and hydrogen sulphide gas data was analyzed by making a comparison with the relevant environmental standards. Any parameter that exceeded the maximum recommended limit was considered to present an environmental risk. Results of this study indicated that the local community consider Eburru wellhead power plant to impact on them negatively. In terms of severity of the impacts, the highest ranked risk was associated with hydrogen sulphide gas odour, followed by noise emission, atmospheric venting of geothermal fluids and brine discharge. The chemistry of the brine does not meet the recommended limit for effluent discharge into the environment. The ambient H<sub>2</sub>S gas levels measured outside the boundary of the power plant exceeded the 24 hour average tolerant limit of 0.0355 ppm up to a distance of 100 m in the northern direction. Ambient noise levels exceeded the tolerable limit of 35 dB(A) up to a distance of 1100 m from the boundary of the power plant. The ambient noise levels however does not warrant hearing impairment. Atmospheric brine spray can cause damage to the surrounding vegetation due to elevated levels of boron. The area within a radius of 1.5 km was found to be of highest risk and relocation of affected persons is recommended. Other measures include use of engineering measures to reduce noise, H<sub>2</sub>S and atmospheric spray of brine, installation of a reinjection system and stepping up education and awareness among the locals. Precautionary approach should be considered in the initial design of future geothermal power plants. Further research should consider studies on diurnal variation of H<sub>2</sub>S gas emission, epidemiological studies to determine real impacts of noise and H<sub>2</sub>S on the health of the locals and an experiment to determine the fall out area of atmospheric brine spray and deposition.

## The assessment of primary productivity of Lake Baringo amidst sudden hydrological changes.

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### Abstract

Lake Baringo has experienced hydrological changes that may have affected its ecology. The current study assessed the status of primary productivity of L. Baringo amidst sudden hydrological changes. Nine sampling stations were delineated on a transect taking into consideration the different ecological characteristics they displayed. They were: the southern zone comprising of S1, S2 and S3; central zone C1, C2 and C3; and the northern zone N1, N2 and N3. Physico-chemical parameters, phytoplankton and primary productivity were determined using standard methods. Chlorophyll a differed significantly between the sampling stations ( $p < 0.05$ ). The lake average gross primary production stood at  $1000 \text{ mg C M}^{-3} \text{ h}^{-1}$  whereas the net production was  $600 \text{ mg C M}^{-3} \text{ h}^{-1}$ . Although, high primary productivity was observed in stations along the river mouths, there were no significant differences observed between the sampling stations. However, production levels were generally higher compared to the previous years. Changes in phytoplankton abundance were observed with Diatoms taking the lead (34%) from the previously Cyanobacteria dominated lake. Phytoplankton bio-volume showed its maxima at C3 and N3 ( $> 35 \text{ mm}^3 \text{ l}^{-1}$ ), whereas, S1, S2, S3 and N2 recorded  $< 5 \text{ mm}^3 \text{ l}^{-1}$ . In addition, there were lower values ( $< 1 \text{ mm}^3 \text{ l}^{-1}$ ) generally recorded at S1 and N2 stations. Changes observed in the lake were attributed to increased water levels due to changes in the catchments bringing in a lot of nutrients and improved water clarity thus enhancing light penetration. For reliable data, continuous monitoring of water quality as baseline information to guide stakeholders and to ensure sustainability for the lake ecosystem health and for productivity purposes is recommended.

**Key words:** *water quality, physico-chemical parameters, plankton, primary productivity.*

# **Floods Monitoring and Exposure Damage Assessment Using Synthetic Aperture Radar Data in Tana Delta Flood Plains, Kenya**

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## ***Abstract***

Recently the country has experienced a wave of floods owing to heavy rains occasioned by the early onset of the March-May 2018 long rains. People have been displaced, properties destroyed and lives lost in these deluge. Although flooding has occurred in several parts of the country, Tana River Delta is one of the regions experiencing seasonal and severe flooding with the highest number of affected persons. Constant out bursting of River Tana banks expose several inhabitants to threats of inundation across the vast Tana River flood plains. Therefore, there is a need to use extra-terrestrial data and quick mapping techniques to process spatial data to get near-real time information for eventual floods disaster management. This work demonstrates the utility of Synthetic Aperture Radar (SAR) imagery in flood and exposure mapping since it is can collect data in unfavorable weather and ecological settings. The study was able to delineate flooded zones, population affected by the floods as well as Land Use Land Cover (LULC) within the flood plains. This applications has succeeded in showing the importance of integrating radar remote sensing in disaster management and emergency response

Key Words: SAR, LULC, Floods, Exposure, Tana River

## **1.0 Introduction**

Globally close to a billion people currently live in high risk flood inundation zones exposing their lives and properties to threats of flooding. Flooding has been identified as one of the natural hazards contributing many deaths compared to other natural disasters worldwide (Knight, 2006; Jonkman, 2005).It is anticipated that with the increasing population and climate change uncertainties, the number of persons faced with the risks of flooding will double by the year 2050 (Bogardi, 2004). Given the upward increase in global occurrences of hydrological disasters, focus now is shifting from protection to management of floods to avert loss of life, displacement of persons and damages to local economies (Schumann & Dibaldassarre, 2010; Mostert & Junier, 2009). In order to offer support services to population affected by floods, spatial knowledge on which areas of a given locality are flooded and geographic extent of the floods is essential. Currently several approaches are used in understanding and monitoring flood dynamics such as flood flow predictions and hydrologic modelling. Though these techniques are effective, they are often limited by unavailability of accurate information and relevant parametric model input data. To address these uncertainties, use of remote sensing has gain popularity in flood inundation studies especially flood modelling and risk assessment (Sergii et al, 2014; Grimaldi et al., 2016; Bates, 2004). Satellite remote sensing provides large geographical area coverage and less costly multi-temporal data useful in determining the extent of flooded areas, quick flood damage assessment and monitoring of the floods onset and cessation (Clement et al, 2017; Marcus & Fonstad, 2008; Dewan et al, 2006).

Although many studies have shown the utility of optical remote sensing in flood risk management (vander Sande et al, 2003; Taubenbock et al, 2011), their optimal efficiency in mapping flooding is limited by the fact that they are passive and therefore unable to penetrate through clouds resulting to no images captured during flood events (Gan et al.2012; Biggin & Blyth,1996).Flooded areas are often overshadowed by clouds and heavy rains making data acquisition difficult. Since SAR is not affected by clouds and precipitation, the use of radar remote sensing in flood monitoring and damage assessment has increased substantially for it uses pulses of backscattered artificially generated active long wavelength microwave energy to illuminate target features. Specifically the use of Synthetic Aperture Radar (SAR) for flood events mapping is due to its unique characteristic capability of imaging in all weather, with high spatial and temporal resolution and in near real time (Matgen et al, 2007;Cossu et al, 2009; Twele et al., 2016). These tools provide update data required for accurate real time prediction of floods and planning of counter flood measures to use by rescuers essential in averting further loses.

A review of research work done on the application of SAR in flood studies have indicated that it is effective in delineating the extent of flooded areas. However in most of these studies, SAR has been used to complement existing modelling approaches. For instance, Clement et al, 2017 used Sentinel-1 SAR data with Change Detection and Thresholding (CDAT) methodology to determine the extent of flooding in Yorkshire, United Kingdom. Their findings showed that SAR remote sensing was able to delineate flooded areas within the flood plains of Yorkshire and those not captured in the Environment Agency Flood Maps for Planning. In another study, ERS-2 and ENVISAT satellite data were used for rapid flood risk mapping where velocities flow and actual flood depths were excluded with event specific hazard map derived from observation other than approximations from hydraulic modeling (Schumann & Dibaldassarre, 2010). Stephanie et al, 2014 using CDAT method together with ENVISAT/ASAR and Radarsat2 SAR data was able to evaluate spatial variation in flooding within Chobe flood plain, Namibia using statistics of each set of differenced SAR images. His study succeeded in mapping the extent of seasonal floods in Caprivi areas of Chobe floodplain in Namibia. Many other studies on flood inundation dynamics have focused on calibration and validation of hydraulic models using SAR and optical sensor data.

There exists in literature different techniques for flood detection using Synthetic Aperture Radar data. The choice of an appropriate technique depends largely on the topography, soil characteristics and location of the region of interest in reference to the latitude (Henry et al, 2006; Mason et al, 2011; Pricope, 2013). Shortcomings of most flood detection techniques have widely been cited in other studies as being suitable for flood monitoring within the temperate and high latitude zones. This limits extensive application of such approaches to flooding assessment in the tropics and equatorial regions. As pointed out in another research (Stephanie et al, 2014), few studies have been done on flooding in Sub-Saharan Africa, a region where seasonal floods and droughts are natural hazards impacting on many population and economies. In Kenya for instance, attempts to apply SAR as been in the domains outside flood monitoring and modeling such as; mapping of diseases (Ross et al, 2002) and land use Change studies (Mubea & Menz, 2012).The few existing studies relating to hydrologic and flood mapping in Kenya have utilised optical sensors (Mutiso, 2011; Swenson & Wahr, 2009).This means the extensive cloud cover over the flooded areas cause obstruction returning no data signal from the flood surfaces to the sensor. Incomplete data and misclassification of features lead to uncertainties in the use of resultant products for flood planning, rescue and evacuation missions. To

address these problems, this baseline study used Sentinel-1A SAR images to assess the extent of flooding, the population and land cover at exposure risk from the seasonal flooding of Tana River in Tana Delta floodplains, Tana River County.

## 2.0 Study Area

Tana Delta region is located on South eastern shoreline of Indian ocean along the flood plains of River Tana(Figure.1). Tana is the largest river in Kenya covering over 400km in length starting on southern slopes of Mt. Kenya and draining into the ocean. This river is important for hydro electricity, fishing, wildlife and irrigation. The area receives limited amount of rainfall on average less than 800mm per annum being in the arid and semi arid land. Communities found here consist of the pastoral oromo and the agricultural pokomo. When River Tana swells, it floods a massive portion of the flood plain claiming lives and properties

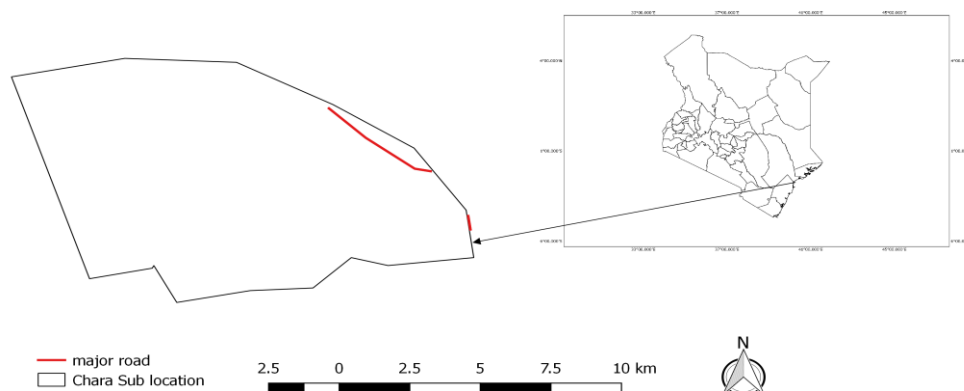


Figure 1: Location of the study Area

## 3. Data and Methods

### 3.1 Datasets and Softwares

The study used 2 Sentinel-1A SAR images collected over Tana River Delta region on 22<sup>nd</sup> April 2018 and 4<sup>th</sup> May 2018 to delineate flooded areas (Table.1). The Sentinel-1A uses C-band (5.407GHz) frequencies and Interferometric Wide swath (IW) as default acquisition mode over land (Geudtner et al., 2014). VV co-polarized C-band backscatter wavelength was used because they can accurately and consistently delineate flooding with Sentinel-1 data (Twele et al, 2016). The SRTM DEM data used for geometric correction of the flooded regions was downloaded from Earth explorer (<https://www.earthexplorer.usgs.gov>). The dataset used in this study was that of sentinel-1A Path 159, Frame 1173 of Tana River delta region. Two Sentinel-1A radar datasets for the months of April and May was used. Devastating floods were experienced in the area between April and May 2018. Latest Population data of 2015 was downloaded from the world population website (<http://www.worldpop.org>). Population data was important in understanding the number of persons affected by the floods and those at risk of inundation. Land use and land cover (LULC) data formed another crucial dataset for flood exposure mapping. The land cover data for Kenya was downloaded from the Global Land Cover portal (<http://www.gadm.org>). Radar data images were then processed in SNAP (SeNtinel Application software). Spatial Analysis was then done in QGIS, open source GIS software.

Table 1. Datasets used , sources, the date and software used in processing

<i>Data Name</i>	<i>Site and Date Downloaded</i>	<i>Software used</i>
S1A_IW_GRDH Desktop	Alaska Facility Portal, 12/6/2018	SNAP
SRTM DEM Desktop	Earthexplorer Data website, 16/09/2018	SNAP
Population Essen 64bit	WorldPop Website, 9/7/2018	Quantum GIS version 2.14
Land Cover Data Essen 64bit	Globeland 30 portal, 23/6/2018	Quantum GIS version 2.14

### **3.2 Method**

#### *3.2.1 Flood Extent delineation*

The two Sentinel SAR images of April and May 2018 were subsetting using the region of interest vector shape file (Figure.3). Resultant images were then radiometrically calibrated and saved in dB scale. This was done in order to relate the digital pixel values of the image to radar backscatter of the scene. Speckle noise reduction was then done through Multilook processing using Lee Sigma filters. To separate water from non-water, histogram thresholding technique was applied. A threshold value was determined from the valley in between the peaks. In this regard, low values of backscatter corresponded to water while high values corresponded to non-water. Since two SAR images were used in flood exposure assessment, each was processed singly and thus two threshold values of  $1.85E-2$  (April image) and  $1.98E-2$  (May image). Image segmentation was carried out using band arithmetic equation of  $[255 * (\text{calibrated image} - \text{determined single image threshold value})]$  in SNAP desktop to get a Boolean image of 1 (Water) and 0 (Non-water). To compensate for topographical variations and radar sensor tilts, geometric terrain using Range Doppler Terrain Correction module was done for the two Multi temporal radar images. Resultant images were now re-projected from sensor geometry into geographic projected and exported to QGIS for exposure damage assessment.

#### *3.2.2 Exposure Assessment*

It was important to assess the number of people at exposure risk to inundation when river Tana broke its banks. This would inform the land cover and population affected by the deluge. Flood and population data were projected into UTM coordinates. Then Flood raster image was converted to vector shape file. Zonal statistics was used to delineate population data based on flood vector data. Total population within Chara Sub-location (region of interest) affected by the recent floods was calculated through summation of all 100x100 m population data pixels intersecting the flooded zones. This done for each of the two flood months of April 2018 and May 2018 respectively. This was achieved through clipping of the land cover raster data to the extent of the flooded regions. Clipped land cover data was then polygonised. To determine the type of land use/cover, the size of each polygon was added to the vector data and land cover labels associated with each geometry gotten.

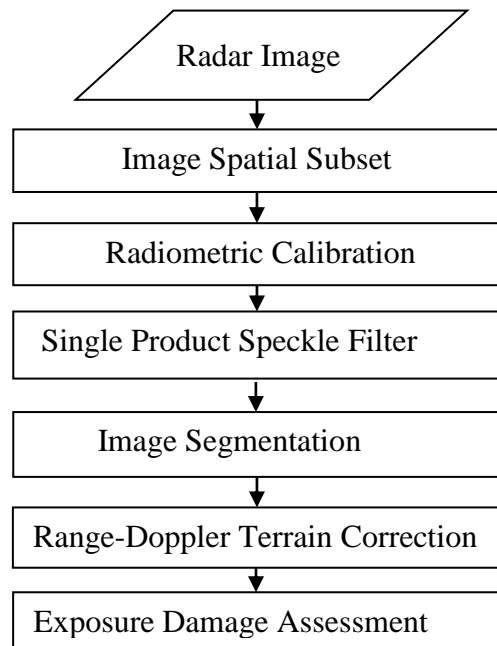


Figure 3: Flow chart used for Floods mapping and Exposure Damage Assessment

Given fact that floods are natural phenomena which are not consistent daily events, validation of flood maps and associated information is often faced by uncertainties emanating from data, modeling and measurement methods (EXCIMAP,2007).To minimise these uncertainties, this study employed a scientific based recommended good practice for flood mapping by UN-SPIDER(United Nations Spatial Information for Disasters and Emergency Response)

## 4. Results and Discussion

### 4.1 Flooded Area Extraction

In mapping floods dynamics at Chara Sub location, Tana river county, radar images for the months of January, February, March, April and May were used. Visual inspection of flood maps showed the months of April and May 2018 experienced more than normal flooding. For this reason April and May months were chosen(Figure.2a &2b). More flooded areas were observed on north western parts of the sub location. To delineate areas covered by flood water, dry month image of 16<sup>th</sup> December 2017 was taken and compared to the flood image (Table.2). Then flood image was subtracted from the dry image to get flooded zones. This can be explained by the low elevation and land cover that is susceptible. Total area flooded in April was 268.54 Km<sup>2</sup> and this was majorly low laying flood plains in north and south east parts of the region. The month of May recorded an increased flooded area of 749.13 Km<sup>2</sup>. This was attributed to heavy rainfall in the area and especially in Tana river catchment areas leading to increased river water volume discharge. Presence of low natural levees and sand plains explains the spilled from the ox-bow river course. Minimal vegetation cover and human habitation along the river banks in the area has also resulted to erosion of the banks enhancing overland flow.

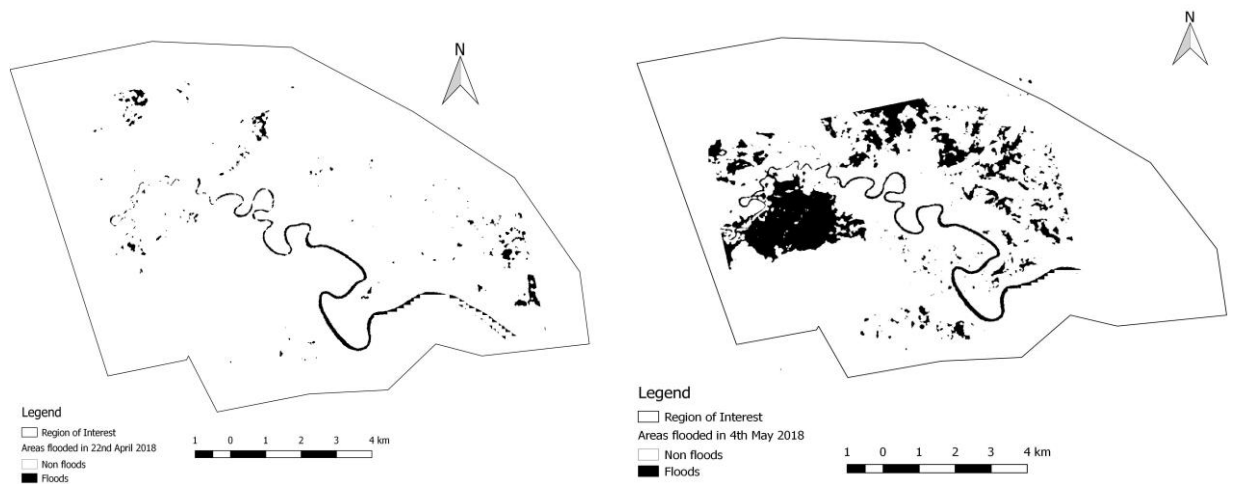


Figure 2(a).Flooded areas on 22<sup>nd</sup> April 2018. 2(b) Flooded Areas on 4<sup>th</sup> May 2018

Table 2. Spatial area of the Chara Sub-location covered by floods and likely cause

<i>Month of Flooding</i>	22 <sup>nd</sup> April 2018	4 <sup>th</sup> May 2018
<i>Area Flooded (km<sup>2</sup>)</i>	268.54 Km <sup>2</sup>	749.13Km <sup>2</sup>
<i>Trend of floods</i>	Increase in size of the area covered by floods (749.13Km <sup>2</sup> - 268.54Km <sup>2</sup> )	
<i>Cause of the floods</i>	Rainfall, Terrain, Nature of the river course, Land cover type	

#### 4.2 Inundation Exposure

Intensity of flooding in Tana Delta region is cyclic with periods of above average high water levels and below average water levels observed. Changes in seasonal flows of River Tana are due to increased discharge from its numerous tributaries as it drains into the ocean. Risks of inundation in the study area are high given that River Tana forms ox-bow meanders along the flood plains. This makes the river to reverse its direction of flow spilling into the sandy flood plains. From the analysis, the number of affected persons in the month of April 2018 was 123 people and 620 people in May 2018(Figure.2a &2b). To further understand the relationship between man-land interactions in the study area, analysis of land use and land cover was done. It was found that flooded areas were majorly covered by agriculture, vegetation and settlements.



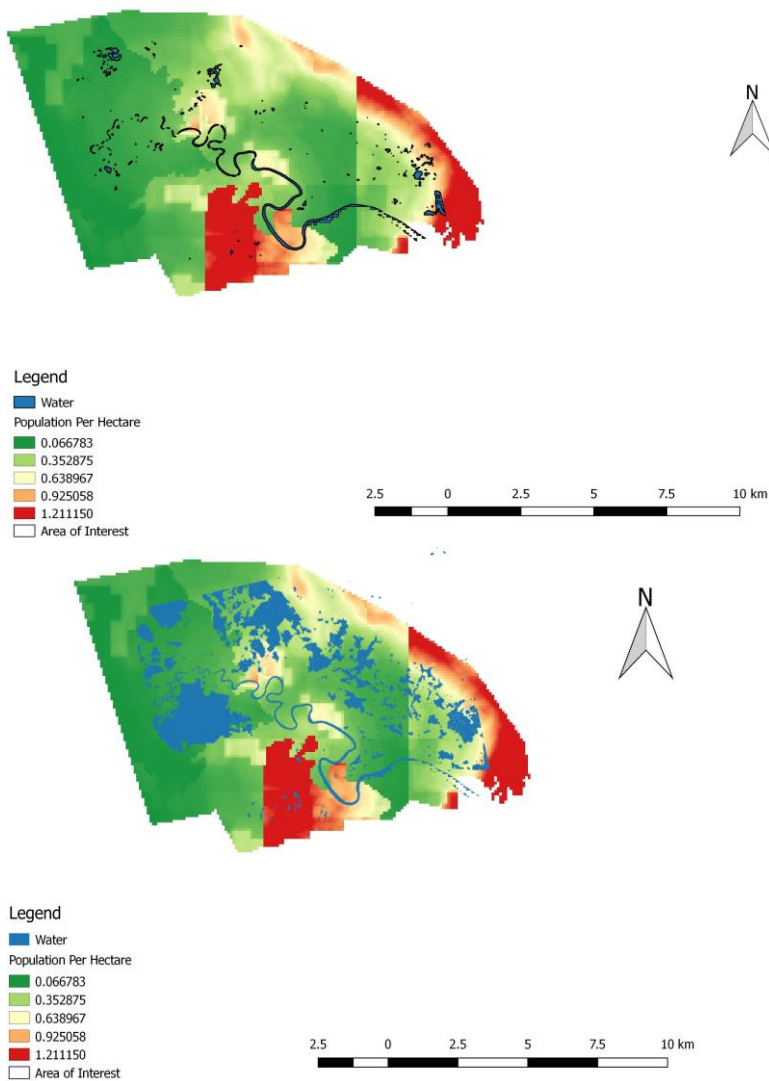


Figure.3(a): Population affected by floods in April 2018  
 May 2018

Figure 2(b): Population affected by floods in  
 May 2018

### Conclusion

Recent flooding in Tana Delta region was evaluated with SAR image from Sentinel-1A platform. Histogram thresholding method of mapping flood used threshold values based on statistics of individual images. The April-May 2018 Tana delta floods showed an increase in inundation of about 480.59 Km<sup>2</sup> and with a population at least 600 per hectare affected in Chara sub location. The limitation of thresholding method is that it requires choice of an appropriate Cut off threshold value to delineate water from non water class. This problem can be controlled through careful selection of threshold value by comparing the flooded image with reference dry image. This attempt to map floods in the ever clouded coastal region has proven successful in monitoring seasonal floods in Tana Delta. Future work can look at apply other flood detection methods and their suitability in monitoring river flooding along the entire river course.

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## **Analysis of Mt Kenya Glaciers Recession Using GIS and Remote Sensing**

Purity N. Mwaniki

### **Abstract**

Glaciers all over the world have been melting away and the glaciers on Mt Kenya have not been spared either. This research analyses the changes in coverage Mt Kenya glaciers in a bid find what has been causing the retreat of these glaciers. Optical Landsat data for 1984 to 2017 and Climatic data of the same years are the datasets that have been used. In order to justify the assumption that the shrinkage of the glaciers coverage has been caused by changes in climate and/or deforestation, correlation of the respective year's glacier area coverage, climatic data and forest cover were done. Then using the historical IPCC climate data predictions for the period 1984-2017 and historical observed data for the same years, bias correction factors were computed and used to correct the future model data for the years (2018-2045). Since the data was extracted for four points, Interpolation was then done to obtain the Precipitation and Temperature for the mountain peak (since the glaciers are found at the peak) using the IDW technique of interpolation. Prediction of glacier area coverage was then done using these interpolated climate data. In order to predict the future glacier cover, linear equations of the form  $y = a_1x_1 + a_2x_2 + b_0$  of the interpolated climate data (for 2018-2045) and computed glacier areas for (1984-2017) were formed. The  $a_1$   $a_2$  and  $b_0$  in the equation are constants obtained.  $x_1$  and  $x_2$  are the predicted Temperature and Precipitation respectively. Prediction was done for RCP scenarios 8.5 and 4.5. The results of prediction showed that the current trend of glacier thinning is going to continue but at a slower rate compared to the rapid melting that was observed for the period 1984-2017. It was found that Mt Kenya glaciers are likely to have completely disappeared by the year 2100. Total disappearance of these glaciers is going to have a tremendous effect on tourism, agriculture, domestic water and hydro-electricity power supply.

**KEYWORDS:** Glaciers, Climate, deforestation, prediction.

## Evaluation of briquettes as an alternative biomass fuel; a case study of mukono central division; mukono district

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### Abstract

A study was carried out to investigate briquettes as an alternative fuel source to conventional sources of Wood and Charcoal. Four fuel samples: Charcoal from *mangifera indica spp.*; Wood from *eucalyptus grandis spp.*, Carbonized and Non-carbonized Briquettes from mixed flora residues were selected for the study. The fuels were analyzed for their physical-chemical characteristics. The fuel properties were analyzed using Water Boiling Test (WBT) protocol version 4.2.3 (GACC, 2013) to simultaneously determine emission levels and energy use parameters while a 6400 Automatic Isoperibol Calorimeter(model 1138, 250mL Alloy 20) was used to determine the amount of heat energy in the fuel samples. To determine the fuel properties, five liters of water was boiled. Laboratory analysis was from Nyabweya Forestry College Biomass Energy Centre and Centre for Research in Energy and Energy Conservation (CREEC) Makerere University, Kampala. The study findings revealed that briquettes are widely known as an alternative fuel source. Usage levels of the briquettes by communities of the study area was however identified to be low. Various factors were identified to be related to this finding which included easy accessibility of conventional sources (charcoal and firewood), time spent to boil, energy values and the cost of the fuel source where briquettes were assumed to be expensive. Boiling test results showed that Wood had the highest energy (9149.82 kJ) and took 16.72 minutes with 563g of fuel while Charcoal had (5009.87 kJ) took 28.87 minutes with 175.66g of fuel to boil. Non-carbonized briquettes had (8897.27 kJ), spent 32.92 minutes with 550.35g of fuel to boil. Carbonized briquettes used the lowest energy (2633.4 kJ), 49.32 minutes and 175.41g of fuel to boil. Carbon monoxide (CO) and Particulate Matter (Pm) emissions from wood were 70.29g and 3177.83mg respectively. Similarly, CO emissions generated while boiling with charcoal and non-carbonized briquettes were 78.89g and 36.71g respectively. Pm emissions for charcoal and non-carbonized briquettes were 514.76mg and 3247.43mg. For carbonized briquettes, emission values were 50.46g for CO and 348.56mg for Pm. Based on the results, the energy to boil was higher in charcoal and wood than briquettes while time to boil was less with the conventional fuel sources. However, in terms of emissions, charcoal and firewood had the highest impacts on the environment. All the fuel sources' emissions however exceeded the 9ppm and 10-24pm range for maximum recommended indoor CO levels and range for possible health effects with long term exposure. The impact of charcoal on the environment reflected in CO and Pm emissions is high and pose health threats to both man and environment. The impact of briquettes on environment was identified to be medium with 41% Coefficient of Variation. There was a positive correlation ( $P=0.001$ ) between charcoal and carbonized briquettes which implied that moisture content in charcoal was directly related to that of carbonized briquettes. The study recommends further research on efficient fuel cook stoves that can contribute to efficient use of fuels. The study also recommends production of standardized briquettes with higher calorific values.

Key words: Energy, Fuels, Briquettes, Moisture Content, Cook stoves



## **Cost –Effectiveness of SMASSE Program in Thika District: A Case of Kamwangi Division**

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### **Abstract**

SMASSE stands for Strengthening of Mathematics and Science subjects in Secondary Education, an In-service training for mathematics and science teachers. Training started in 1998 by the government of Kenya and the government of Japan through JICA. Aimed at; strengthen pedagogy in mathematics and science subjects in secondary schools, to improve performances in these subjects and to achieve the MDG of Kenya industrialization by 2020. This study was out to find, how cost-effective was SMASSE program in Thika District. It employed survey design in data collection and data analysis. Semi-structured questionnaires were used to collect data from teachers. Interviews and Key-informant collected data from SMASSE center organizers and administrators, 210 persons were used and categorized as Center organizers, Mathematics and science teachers, principals/deputy principals from 24 secondary schools in Kamwangi Division, District SMASSE administrators and SMASSE trainers. Simple random sampling methods and cluster sampling were used to select sample schools and teachers. Purposive sampling was used to select SMASSE center organizers and administrators. Data collected was organized, coded, tabulated and analyzed quantitatively and qualitatively. The findings were discussed and explained in line with the cost-effectiveness theoretical and conceptual framework adapted from Alkin M 1970. The findings; SMASSE Program started in Thika in 2004, funded by GoK and JICA, teachers' attitude towards the program was negative, was too expensive and none cost – effective, no direct benefits accruing to teachers, indirect benefit for SMASSE was socialization and interaction among the teachers. It was facing problems like; lack of a method to measure its cost-effectiveness, negative teacher's attitude, poor method of financing it and high cost of maintaining and repairing equipment's and instruments. Recommendations; The program needs to be modified and be decentralized, diversify its financing, only willing teachers to attend, remunerate teachers in attendance and be made competitive by issuing merit certificate.

### **Key words**

Cost- effectiveness, JICA, Program, SMASSE, Decentralization

## **Increasing productivity of small scale farmers using GIS and Remote Sensing technology**

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### **Abstract**

Agriculture accounts for 25percent of the gross domestic product(GDP), provides 18 percent of the formal employment, and 65percent of the country's export. Production, in small scale farming, is carried out on farms averaging between 0.2 to 3 hectares and accounts for 75percent of the total agricultural outputs as well as 70percent of agricultural produce marketed locally. This sector is dominated by small-scale farmers located in high-potential regions in the country. The growth of this sector is hindered by factors such as; climate change, low number of extension services staff, employing outdated technology, pests and diseases, using unsuitable inputs, and poor infrastructure, and as a result, small-scale farmers have continued to experience low yields in their harvest. The availability of cutting-edge technologies, such as smart farming, and precision farming, can be employed to alleviate the setbacks experienced by farmers. Smart farming mobile applications, for instance, enable farmers to keep track of the information pertaining to their farms allowing them to access the important information needed to make critical decisions on their farms. Smart farming technologies, engineered by data collected and analyzed by technologies such as GIS and RS, are very efficient and can help farmers increase harvests and reduce the cost of production. Small-scale farmers in Kenya are yet to incorporate these technologies in their practice. In the absence of such technologies, it is a daunting task, for small-scale farmers, to give a detailed account of how much yield they expect, and also of the resources they have used as inputs. This makes it difficult to determine if the process was a gain or loss. Creating awareness of technologies such as Mobile GIS, in agriculture is, therefore, paramount in easing the challenges that are bedeviling small-scale farming in Kenya.

**Keywords:** GIS, Remote sensing (RS), Smart farming, Precision farming, and Mobile GIS.

## Modelling Land Degradation Trends in Migori County

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Land degradation is an environmental problem which results from various factors. Identification of areas vulnerable to degradation over different seasons is important in the development of natural resource management and conservation activities to safeguard the environment and the society. This requires close interaction with various variables that contribute to land degradation. The objective of this study was to model land degradation vulnerability in Migori County for over 30 year period (1986-2016), through the integration of GIS, RS, and multicriteria analysis. Five types of land degradation variables were identified through previous literature and opinions from expert groups and organizations, such as Regional Centre for mapping, ICPAC, DRSRS, and Ministry of Environment. The variables identified were soil erosivity, soil erodibility, slope length, vegetation cover, and population density. LULC was classified into 6 classes namely open water, wetlands, wooded grassland, open grassland, cropland and other land, using both unsupervised and supervised classification. Change detection was carried out and expansion of cropland by 11.15% observed. To model land degradation, multicriteria analysis was used and the weights of the indicators calculated through pairwise comparison and combined using the weighted overlay tool in ArcGIS. The result showed that land degradation varied from year to year and was classified into very low degradation, low degradation, moderate degradation and high degradation. Changes in levels of degradation showed constant increment in zones experiencing low degradation, (13% in 1986, 34% in 1996, 16% in 2006, and 11% in 2016). Zones experiencing the high degradation showed decreasing trend in acreage (57% in 1986 and 3% in 2016). Given the worsening degradation trends in Migori County, there is need to strengthening local institutions to effectively monitor and manage natural resources in order to maintain and curb land degradation and depletion of forests. This study can be used for prediction of land degradation.

Keywords: GIS, RS, Landdegradation, LULC, Modelling

## 1. INTRODUCTION

Land degradation is a critical issue worldwide, especially in the developing countries. For sustainable development of human society and a health land ecosystems there is need to curb land degradation. Land degradation means a significant reduction of the productive capacity of land. And it involves various factors, including climate changes, land use/cover changes, and human dominated land management [1]

The 2007 Review Report on Drought and Desertification in Africa stated that LD affected at least 485 million people or 65 per cent of the entire African population, and is increasing in severity in many parts of the world, with more than 20% of all cultivated areas, 30% of forests and 10% of grasslands undergoing degradation [2]. He also identified degradation as a potential precursor to widespread desertification, where approximately 30 per cent of Kenya was affected by very severe to severe land degradation.

Studies by [3] indicate that over 20 per cent of all cultivated areas, 30 per cent of forests, and 10 per cent of grasslands have been subjected to degradation where expansion of crop land into marginal lands accounts for much of this degradation [4] identified the marginal cropland in the Lake Victoria basin region as the areas of sharpest decline.

Increasing demands on land for economic development, expanding towns and growing rural populations leads to land use land cover changes and in turn to land degradation. This is a global development and environmental issue, but there have not been serious authoritative measures of land degradation in Migori County

There is the pressing need for mapping land degradation trends to support policy informed decisions for developing food and water security strategies, environmental integrity in sub-counties, counties and national strategies for economic development and resource conservation. The recent development of remote sensing techniques (RS) and geographic information system (GIS) techniques has enhanced the capabilities to obtain and handle spatial information on the heterogeneities of land surface characteristics and hence land degradation.

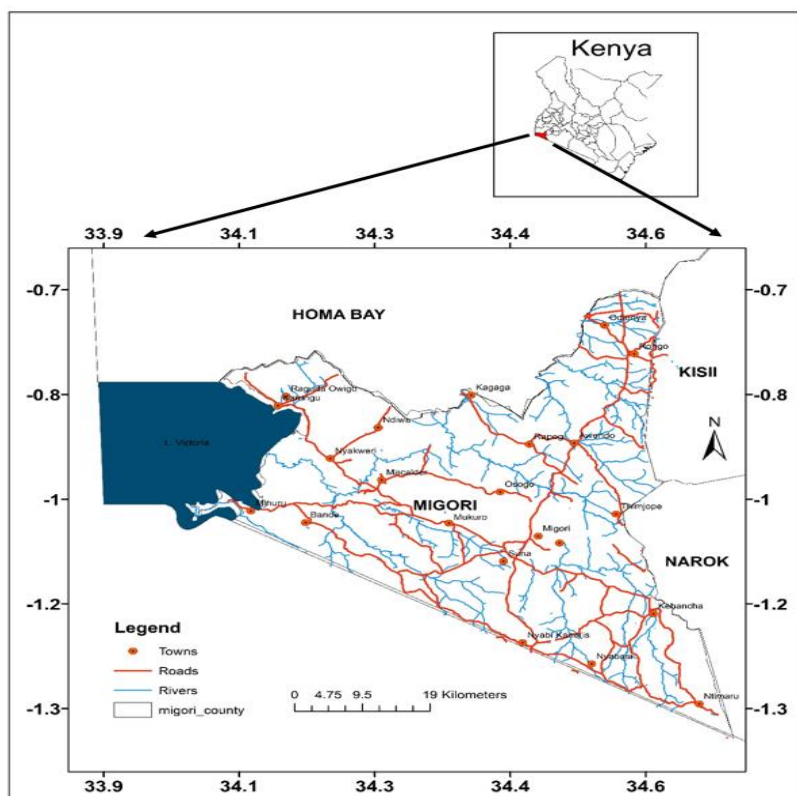
Land degradation is a long-term process indicating the loss of ecosystem function and productivity and it is happening in Migori County, where, clearing of vegetation for firewood and logging deprives the soil of organic matter and low levels of macronutrients and soil fertility necessary for plant growth and crop production. Forest land being transformed into bare land, crop land and grassland means that farming is affected and hence less food production and degraded land. Population density is increasing rapidly exerting pressure on land resources. The majority of the people in the county are small scale farmers located in the rural areas. These farmers depend on the already degraded lands to meet their food requirements especially where such LULC changes have occurred. The poor farmers are trapped in a vicious cycle of poverty and land degradation. [5] Used different indicators such as, soil

physical degradation, soil chemical degradation, loss of vegetation, and land use and used the RUSLE model to prepare soil erosion maps and NDVI for vegetation cover map.

In order to investigate which indicators were most effective in assessing the level of land degradation risks, [6] studied a total of 70 candidate, indicators were selected providing information for the biophysical environment, socio-economic conditions, and land management characteristics. The indicators were defined in 1,672 field sites located in 17 study areas in the Mediterranean region, Eastern Europe, Latin America, Africa, and Asia. [1] integrated NDVI with rainfall data to calculate what they referred to as the rain use efficiency (RUE), and revealed trends in land degradation by separating vegetation declines due to lack of rainfall from declines associated with longer term, and ascertained the long-term trends in the study area as basis for understanding the state and patterns of land degradation. Climate is among the most important determinants of LD [7] low precipitations usually limit the vegetation cover and represent a constraint for crop growth. Models can be used to integrate data on land processes and to validate direct measurements or assessments done using remote sensing.

## 2.METHODOLOGY

### Study Area



## **Figure 1: study area of Migori County**

Migori County is one among 47 counties in Kenya (fig.1). The town measures 2,586 sq. km with a last census population 917,170 in 2009 and a population density of 353 persons per sq. km. It lies between a latitude of -1.35 and -0.77000 and longitude of 34.06 and 34.73. The neighboring counties are Homabay County to the north, Kisii County and Narok County to the east and Tanzania to the south and 368km from Nairobi kenya

Migori county lies in the lake basin of Kenya The altitude varies between 1140 to 1600 m above sea level and 1700 meters with several undulating hills and plains Rainfall patterns in the region vary ranging from 700mm to 1800 mm annually It has one permanent river, Kuja and Migori and L.Victoria.

The total area under forest is about 695.5 ha the main economic activities are agriculture and mining which are contributing factors to land degradation

### **Data Processing**

This study employed a number of processes to model Land degradation in Migori County. Literature from previous studies and organisation that are concerned with land degradation singled out five variables that are used in modelling Land degradation, those are vegetation cover, rainfall erosivity soil erodibility slope and population factor. The Kenya Counties map from Survey of Kenya was scanned, georeferenced and digitized to obtain the Migori County Shapefile. For vegetation cover data, Land sat satellite imageries data was sourced from the USGS website, was used to process LULC classes. The imageries were for 1986 and 1995 Land sat 5 TM was, for 2008, Land sat 7ETM+ and for 2016, Land sat 8 ETM+ OLI. Rainfall data was sourced from e-Station based at Inter Governmental Climate Prediction and Application Centre (ICPAC) as 5km decadal Climate Hazard Group Infrared Precipitation and Station (CHIRPS). Soil erodibility data layer is a composed soil mineralogy and texture. The soil data was sourced from Kenya Soils and Terrain (KENSOTER) databases. Slope was computed from the corrected Shuttle Radar Topographic Mission (SRTM) DEM at a resolution of 30 m. from which slope length were computed. Population density layer was used as an indicator of Population pressure. Human population density layer of 1989, 1999, and 2009 was sourced from the Kenya Bureau of Statistics (population census) and to represent 2016, 2009 data was used due to lack 2019 population census data. The flow diagram (Fig.2) describes the workflow for this study

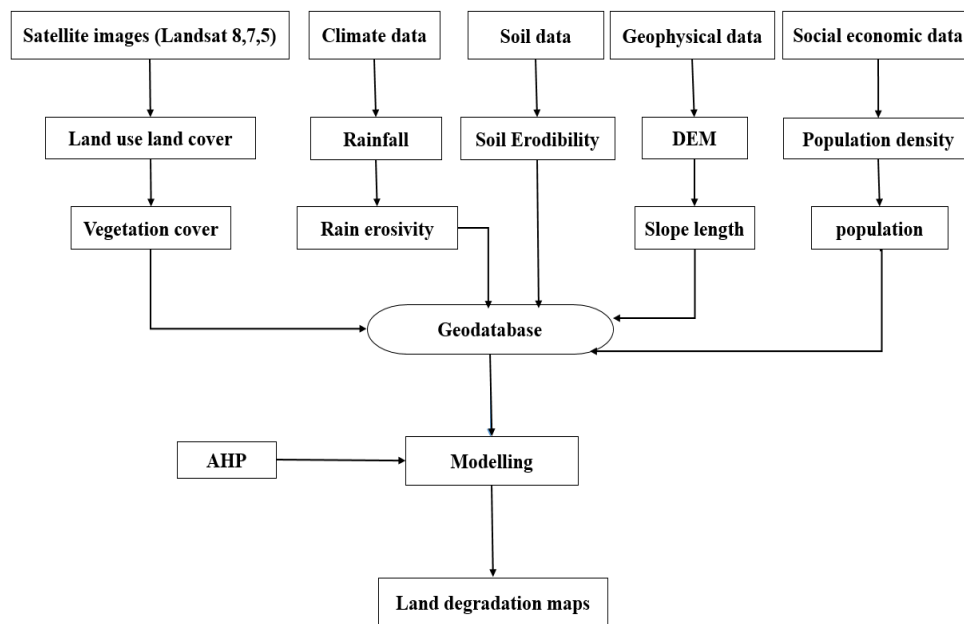


Figure 2: Flow diagram for modeling land degradation

### A. Processing land degradation indicators

According to [8] three basic concepts in multicriteria analysis are standardization, criteria weighting and combination. Standardization is a process of converting criteria to a common unit. In this study, the raster maps were scaled to a value range from 1 to 5 indicating very low and very high vulnerability respectively. Criteria weighting was performed to an indicator to show its significance in relation to other indicators. Pairwise comparison method was used to compare two criteria at one time based on the scale given in [9] Consistency of pairwise comparison was checked using a scripted extension of ArcGIS, known as Analytic Hierarchy Process (AHP). Evaluation was performed (maps are combined) to get the final composite index. Weighted overlay technique were used to combine the criteria maps. Each standardized criterion was multiplied by its weight in the overlay process [10]. The resultant ranking from the experts are in table 1

#### I. The land degradation modelling inputs

1. Population Density -P
2. Rainfall Erosivity-R
3. Soil Erodibility- K
4. Slope Aspect- S

## 5. Vegetation Index- VI



**Table 34: Ranking from expert opinion**

Land degradation input	Team A	Team B	Average Ranks
Vegetation index	3	5	4
Slope aspect	5	5	5
Soil erodibility	2.5	3.5	3
Rainfall erosivity	2	2	2
Population density	1	1	1
Total Rankings			15

### **B. Processing vegetation cover (VI)**

Landsat for the year 1986 and 1995 land sat 5TM, 2008 land sat 7 ETM+ and Landsat 8 ETM+OLI for 201 dry season between January and February. The images were uploaded and radiometric preprocessing was to remove these exogenous effects and standardize the images. This process was done in ArcGIS 10.3 and Erdas 2013 The calibrated image scenes were then clipped against the administrative boundaries of the study area for subsequent processing and analysis. Different color composites were generated by compositing individual bands in a Red, Green, Blue (RGB) combination. True color composites were made by combining bands 3-2-1 in a Red, Green, Blue (RGB) combination for the Landsat TM and ETM+. The standard false color composite (FCC) were derived by combining bands 4-3-2. Other band combinations used included 4-5-3 to visualize different vegetation types and 5-4-1, and bands 2-3-4-5-6-7&11 for Land sat 8ETM+OLI to help visualize agricultural vegetation. Supervised classification methods was used to cluster pixels in a data set into classes corresponding to user defined areas of interest (AOIs) by use of Maximum Likelihood method. Classification accuracy assessment or confusion matrix was performed to give an overview of the preciseness of the classification The resultant matrix displays producer and user accuracies for each class as well as the overall accuracy of the classification change detection was conducted. The good overall accuracy assessment justified the use of the classification to assess LULC changes in the study area. Reclassification was performed according to the susceptibility of each land use land cover class to land degradation (fig 3&4)

### **C. Processing rainfall erosivity (R)**

Rainfall and runoff play an important role in the process of soil erosion, expressed as the R factor. The greater the intensity and duration (depth) of the rain storm, the

higher the erosion potential [11]. The RUSLE rainfall- runoff erosivity factor (R) for a given period was obtained by summing each rainstorm the product of total storm energy (E) and the maximum 40mm intensity [12]. For the computation of R factor two components were computed from the CHIRPS rainfall data, which is Rainfall depth and Rainfall intensity using expression 1 below. The results showing that the higher the R factor the higher the degradation (fig5)

**Equation 1 rainfall erosivity factor where RD is rain depth and RI is rain intensity**

$$RD*0.4+RI*0.6=R$$

#### **D. Processing soil erodibility (K)**

Factor represents both susceptibility of soil to erosion, the amount and rate of runoff. Soil texture, organic matter, gravel content and soil drainage capacity (water holding capacity) determines the erodibility of a particular soil [13]. The K factor reflected the ease with which the soil is detached by splash during rainfall and/or by surface flow, and therefore shows the change in the soil per unit of applied external force of energy [14].the resultant k factor was obtained by combining the four factors using by use of equal weight overlay (fig8)

#### **E. Processing slope factor(S)**

The L and S factors represent the effects of slope length. An increase in hill slope length and steepness results in an increase in the LS factor [14]The longer the slope length, the greater is the amount of cumulative runoff, and the steeper the slope of the land, the higher the velocities of the runoff hence degradation. This study utilized the 30m digital elevation model provided by Shuttle Radar Topography Mission (SRTM) as the input elevation for computation of slope factor (LS). For estimation and processing of the LS factor, this study adopted the expression (2) below, since it is integrated within ArcGIS and enables easier manipulation of the DEM [15] Equation 2 slope length

$$LS=POW ([\text{flow accumulation}] * \text{resolution} / 22.1, 0.4)*POW (\sin (\text{slope of DEM}/0.09, 1.4)*1.4)$$

Where POW (which means power) is a function in the ArcGIS spatial Analyst. The derived LS was then reclassified in the five soil erosion susceptibility (fig 6)

## **F. Processing population density (P)**

Population density one of socio-economic indicators that aggravate the pressure on the land resource. Population numbers were obtained with the name of the sub counties as a text file, then was imported to ArcMap and joined with the shapefiles representing sub counties. Population density for each sub county Then the values were reclassified to a scale of 1 to 5(fig7) which was later used in modelling the land degradation map. In areas of high population density, the pressure on land resource is high, especially areas where livelihood is predominantly dependent on traditional agriculture. Thus, vulnerability to land degradation will also be high.

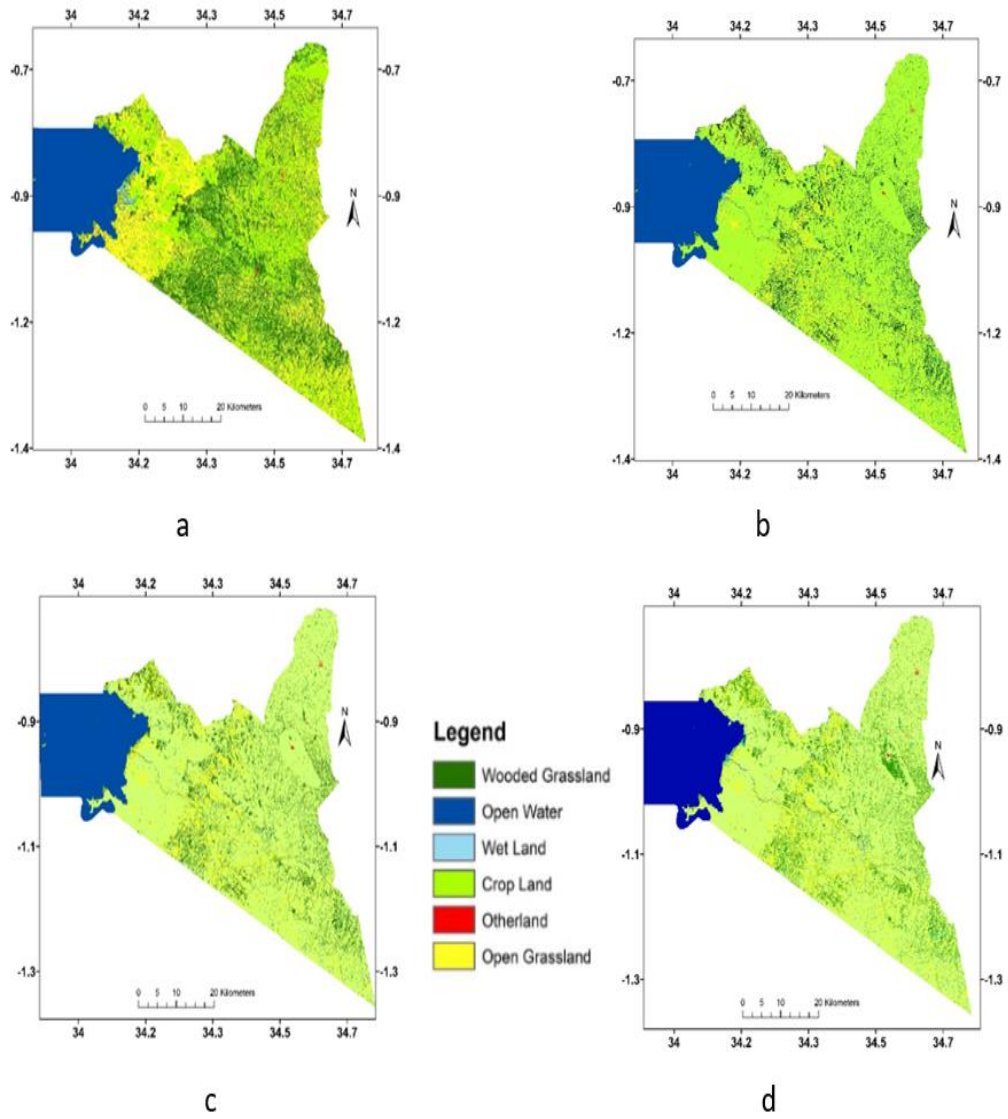
## **Field validation**

Field validation was carried out to establish evidence of degradation. Due to budget limitations and time constraints, field validation was restricted to a small section of Migori County which registered massive land degradation, (Macalder and Mohuru).A note book and pen for writing down the characteristics of hotspots based on observations and a Garmin GPS for picking the coordinates of degraded spots which were compared with the land degradation map prepared and sentinel satellite image for 2016. (Fig 13)

## **3. RESULTS AND ANALYSIS**

### **A. Migori County Land Use Land Cover States of 1986, 1995, 2008 & 2016**

As depicted by the LULC maps of 1986, 1995, 2008 and 2016, this study observed that woodland and cropland are the dominant Land use land cover classes in the study area covering 62.7% of the total area in 1986, 56.7% in 1995, 42.3% in 2008 and 70.8% in 2016.and of this percentage the greatest share goes to crop land which keeps gaining over the years while the other classes lose to cropland indicating that land degradation takes place. Cropland gained by 14.125% in 1986-1995, 4.109% in 1995-2008 and 15.225% in 2008-2016



**Figure3: Land use land cover classification of Migori County 1986,1995,2008,2016**

**Table 35: land use land cover coverage categories by area extend (1986, 1995, 2008 & 2016)**

	<b>1986</b>		<b>1995</b>		<b>2008</b>		<b>2016</b>	
<b>CLASS</b>	<b>AREA (ha)</b>	<b>%A REA</b>	<b>AREA (ha)</b>	<b>%A REA</b>	<b>AREA (ha)</b>	<b>%A REA</b>	<b>AREA (ha)</b>	<b>%A REA</b>
<b>1.OpenWater(OP)</b>	55918.800	17.921	56491.740	18.105	54609.750	17.502	55556.640	17.805
<b>2.WoodedGrassland(WG)</b>	122133.870	39.142	59417.370	19.042	53167.950	17.039	42887.610	13.745
<b>3.CropLand(CL)</b>	73796.760	23.651	117871.740	37.776	153482.220	49.189	178198.740	57.110
<b>4.WetLand(WL)</b>	47434.500	15.202	41983.290	13.455	24552.990	7.869	20467.980	6.560
<b>5.OpenLand(OP)</b>	3529.080	1.131	22959.720	7.358	14825.880	4.751	3995.370	1.280
<b>6.OpenGrassland(OG)</b>	9214.920	2.953	13304.070	4.264	11389.050	3.650	10921.590	3.500
<b>TOTAL</b>	312027.930	100.000	312027.930	100.000	312027.930	100.000	312027.930	100.000

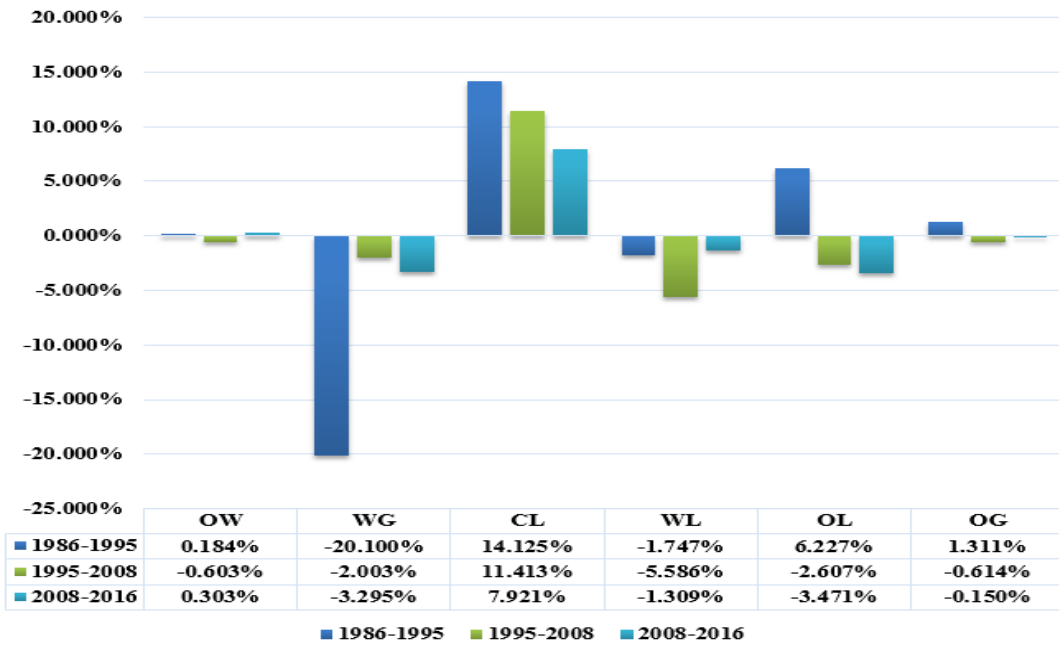
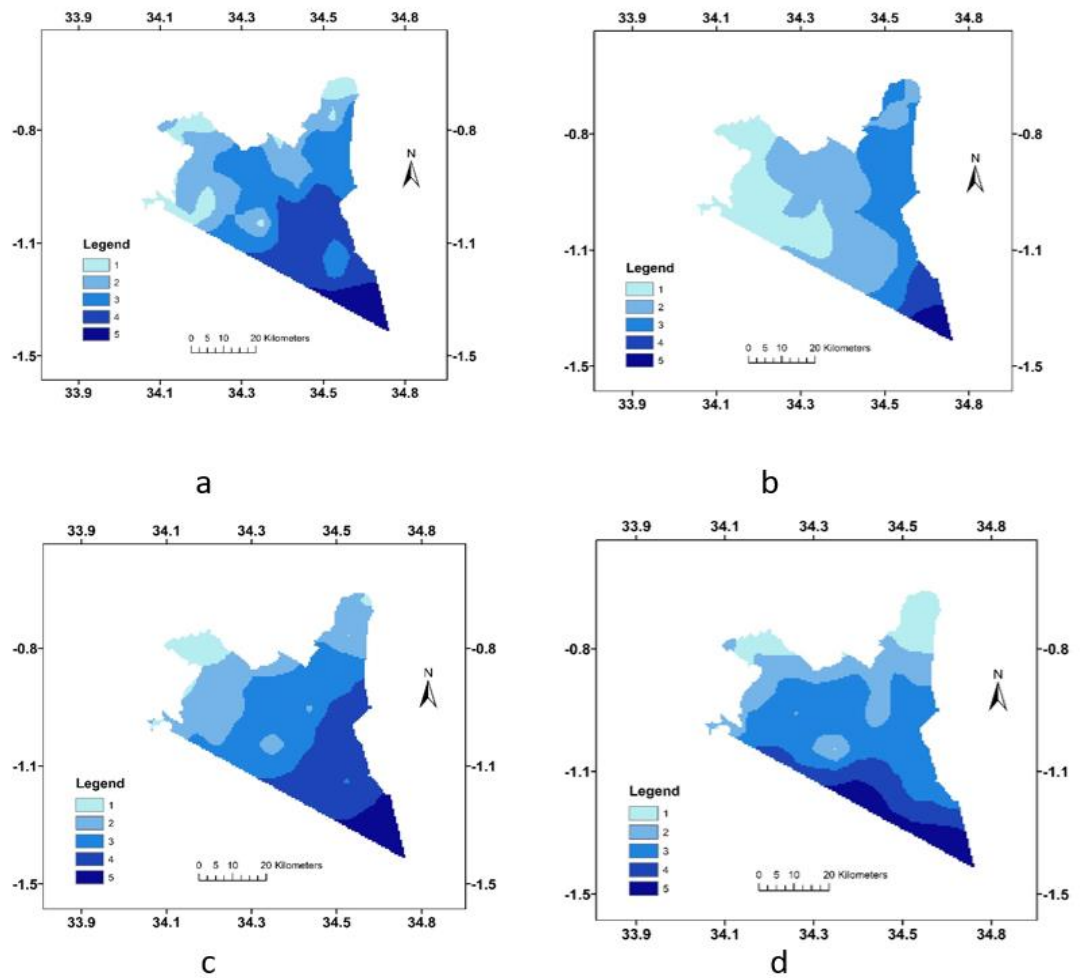
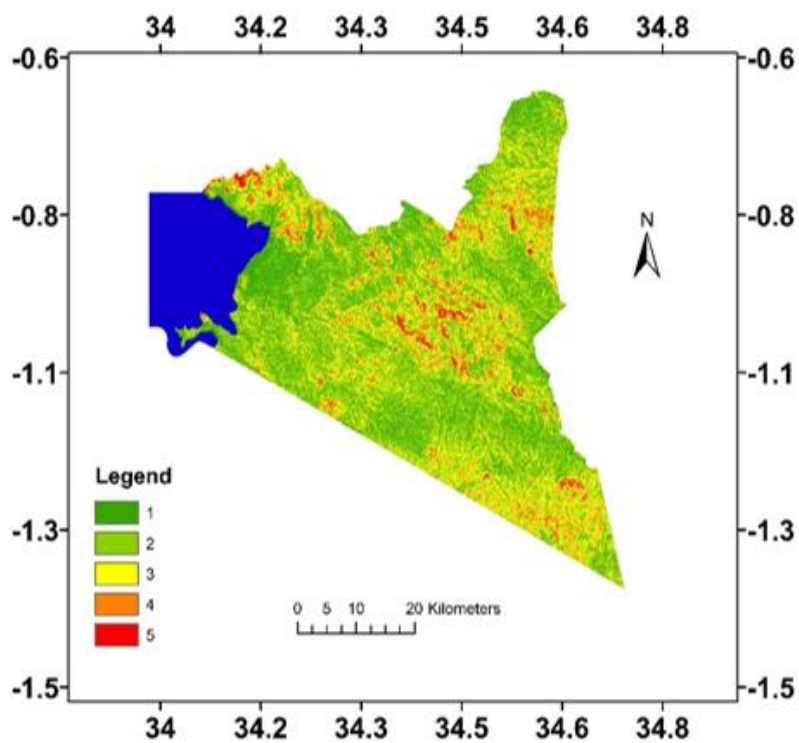


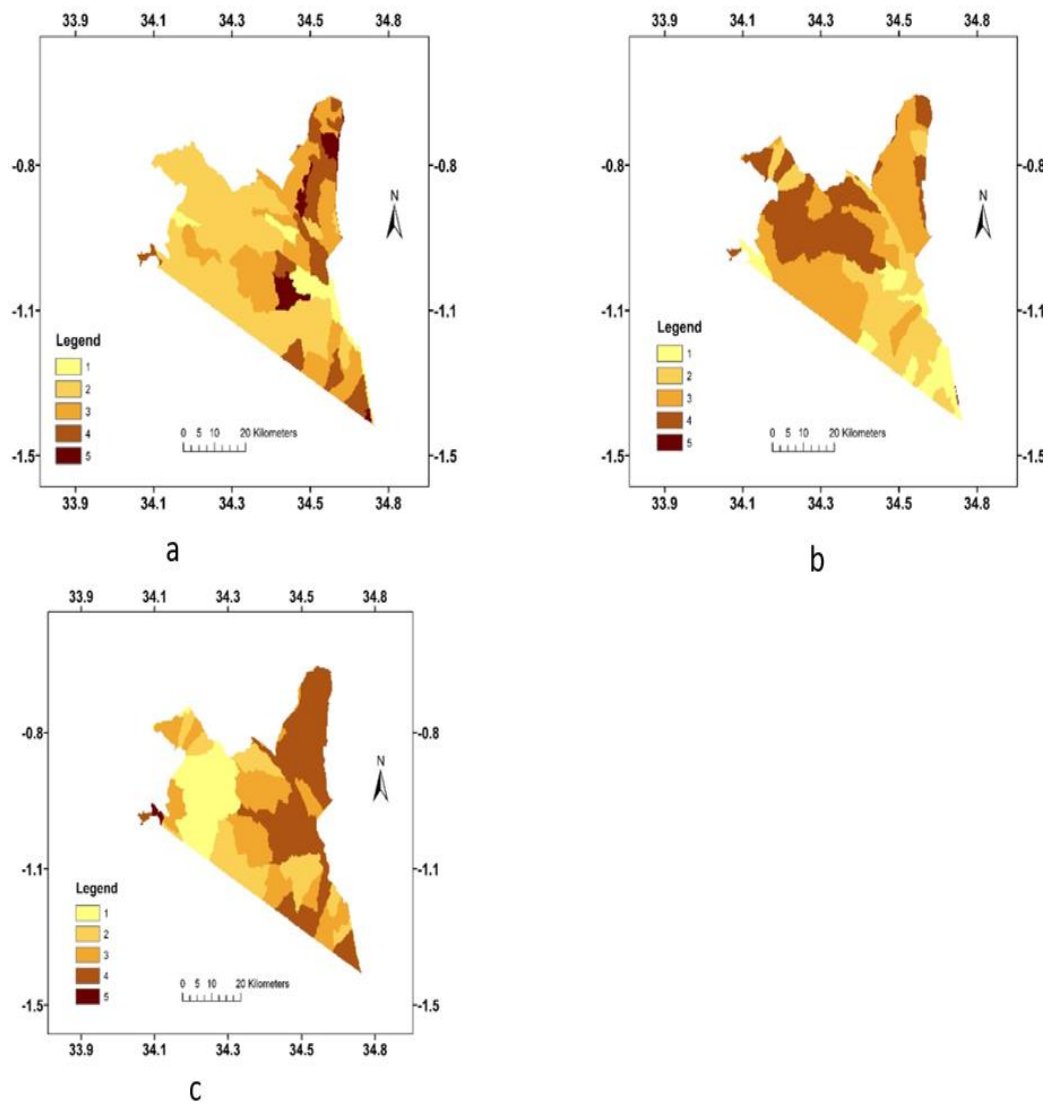
Figure 4: magnitude and nature of detected change, 1986-1995, 1995-2008, and 2008-2016



**Figure 5: rainfall erosivity for the years (a) for 1986, (b) for 1996, (c) for 2008 and (d) for 2016**

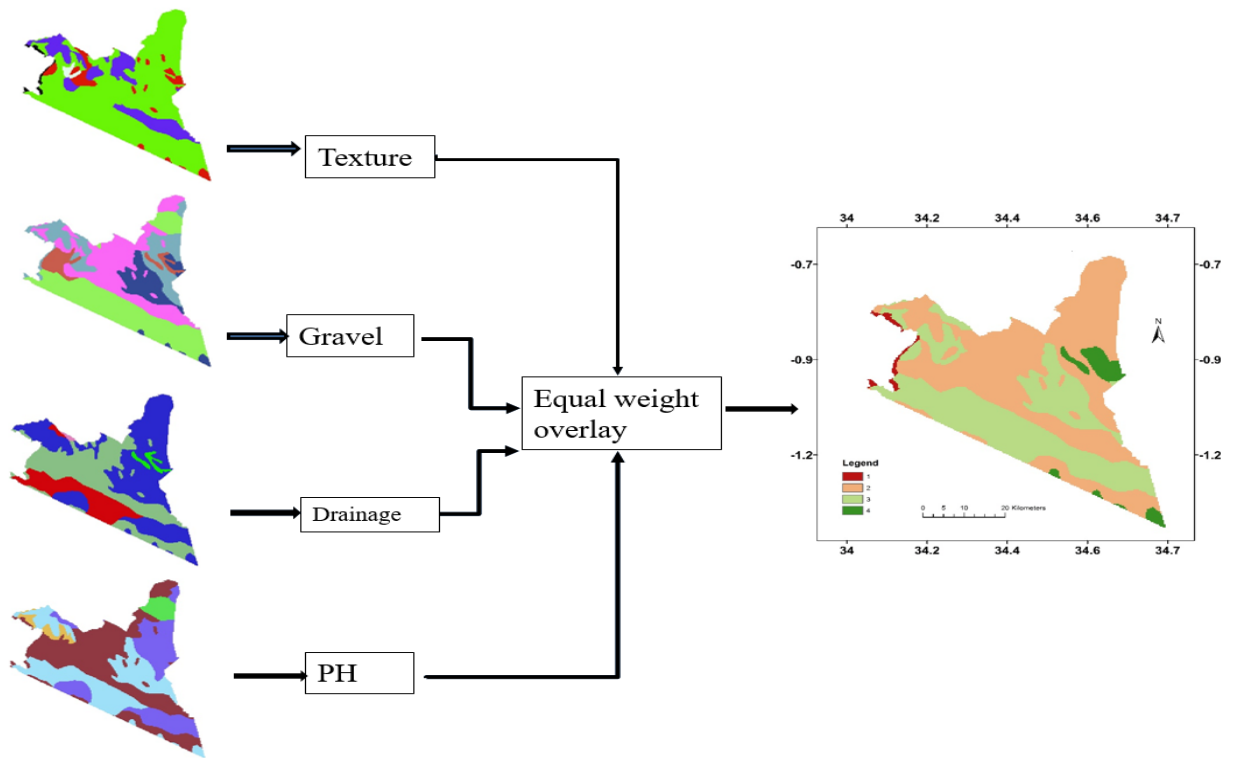


**Figure 6: Classified slope length as obtained from DEM**



**Figure 7: Classified population density for the year (a) 1989, (b) 1999, and (c) 2009**





**Figure 8: showing soil erodibility factor as weighted overlay of texture, gravel content, drainage capacity, soil PH**

The impact of elevation was not significant, while it may suggest that, in the areas with higher elevation, there would be less impacts of anthropogenic factors on the land degradation. The slope had clear significant impacts on land degradation, suggesting that steep slopes would lead to land degradation more easily, as steep slope regions were more vulnerable to severe water-induced soil erosion

Zones with scanty population experienced low land degradation. The population density for more than half of the study area is between 100 and 200 people per square Kilometre. Twenty nine percent of the area has a low population density. Thirteen percent of the County has a high population density that varies between 200 and 500 people per square Kilometre. High population density exerts high pressure on land resource and this increases susceptibility for degradation hence the classification. Increases in the population density would lead to land degradation but not significantly. Previous studies show that the impact of population density on land degradation is ambiguous, while this study results suggested that there would be more serious land degradation in areas with higher population density [16]. Soil erodibility factor which represents both susceptibility of soil to erosion and the amount and rate of run-off is shown. The results of soil erodibility in the county reflect the ease with which the soil is detached.

## B. Assigning weights

To determine the weights to be used in the model Weights were associated with the output from the pairwise ranking criteria (table 1 and table 2) so that the relative ranking from the pair wise comparison is satisfied, two basic constraints on how to assign the weights (RCMRD, 2015) were put into consideration, i.e. the total of all the weights must be 100%, and weights must obey the relative ranking given by the pair wise comparison (table 3). The outcome indicates that experts considered slope to be more significant to land degradation, followed by vegetation index, soil erosivity then population density.

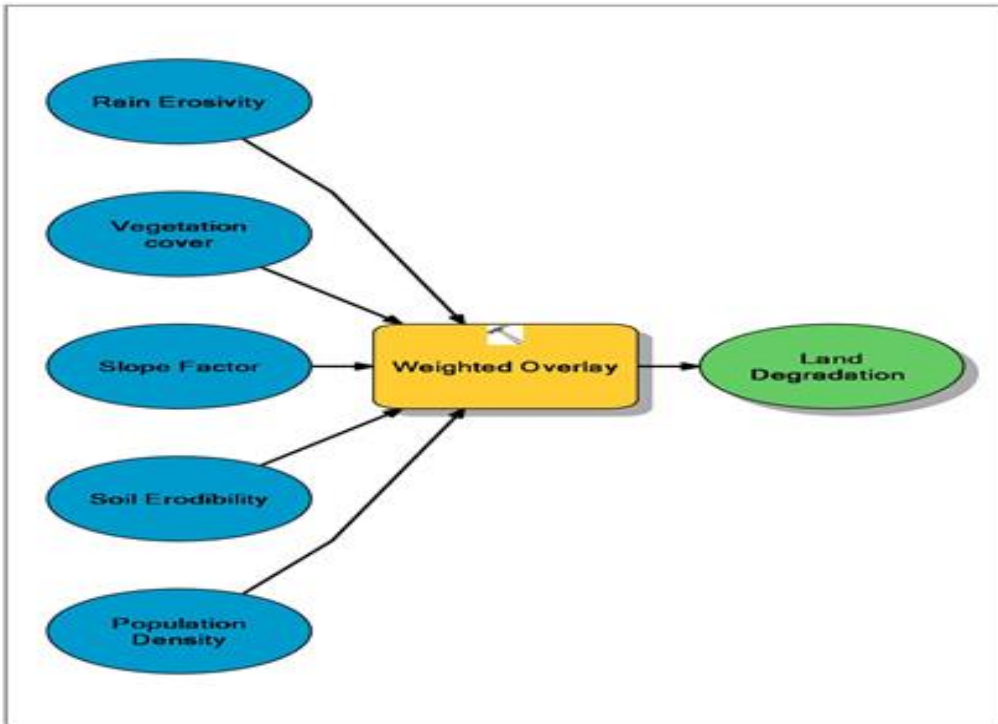
## C. Land degradation vulnerability model

GIS based multicriteria analysis was used in modeling land degradation vulnerability in this study. Different factors contributed differently to land degradation, depending on economic activities, calculating weights for each factor in Migori County was through pairwise comparison method, using the principles of AHP (analytical hierarchy process). The classification was into three level, preparation of indicator maps and analysis of degradation based on each indicator. The Reclassify tool in ArcGIS was used to reclass the indicators on a scale varying between 1 and 5, where 1 corresponds to very low and 5 to very high vulnerability. Then pairwise comparison to calculate weights and prepare an index map for each category was performed. Lastly the Analytic Hierarchy Process was performed to produce a single land degradation map. This was performed on all the study periods to produce 4 land degradation maps. The overall land degradation vulnerability result indicates that 48% of the Migori County is highly susceptible (fig 11&12)

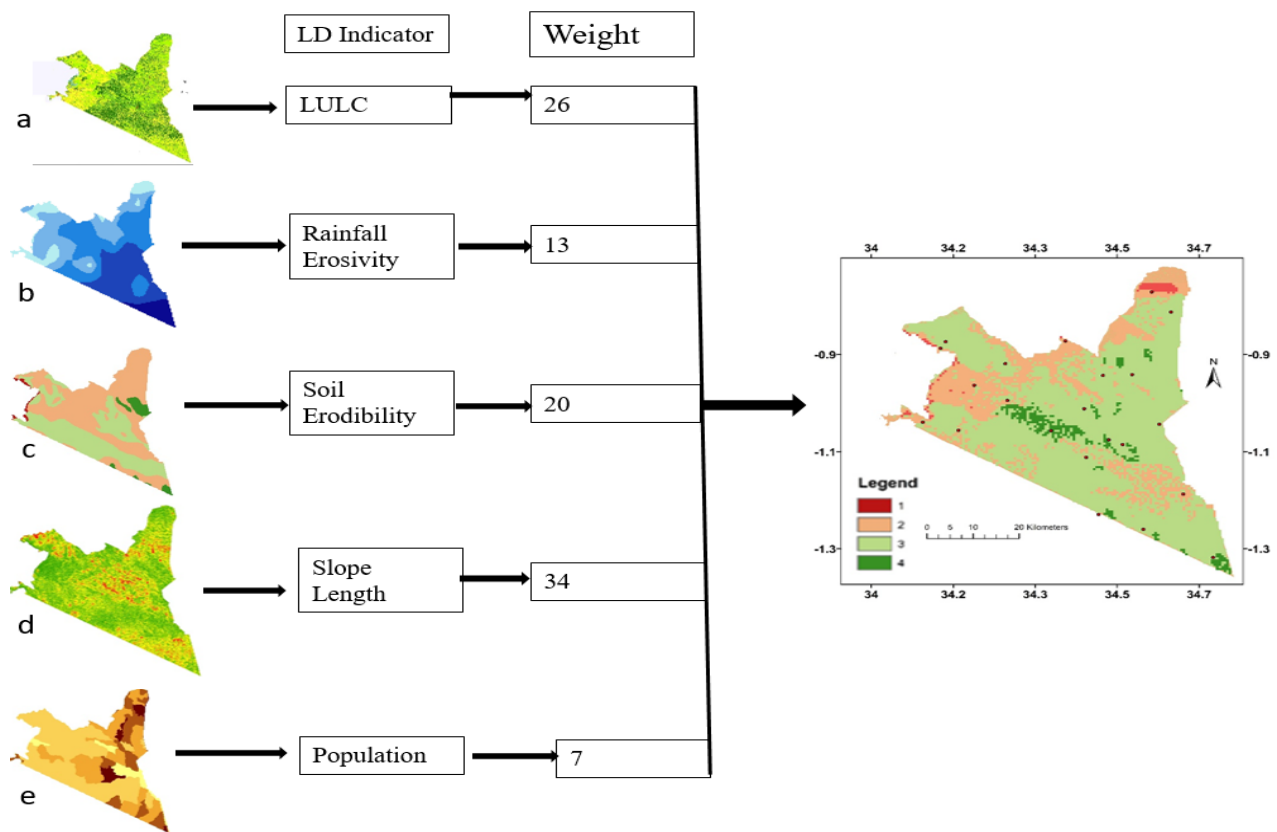
**Table 36: final variable weights from expert opinion for modelling (RCMRD (2015)).**

Land degradation input	calculation	weight
Vegetation index	4/15	26
Slope	5/15	34
Soil erosivity	3.5/15	20
Rainfall erosivity	2/15	13
Population density	1/15	7

Total ranking		100
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**Figure 9: showing weighted overlay model for modelling land degradation**



**Figure 10: land degradation map 1986 from the model above**

This model was used for all the study years to give the resultant land degradation maps below (11)

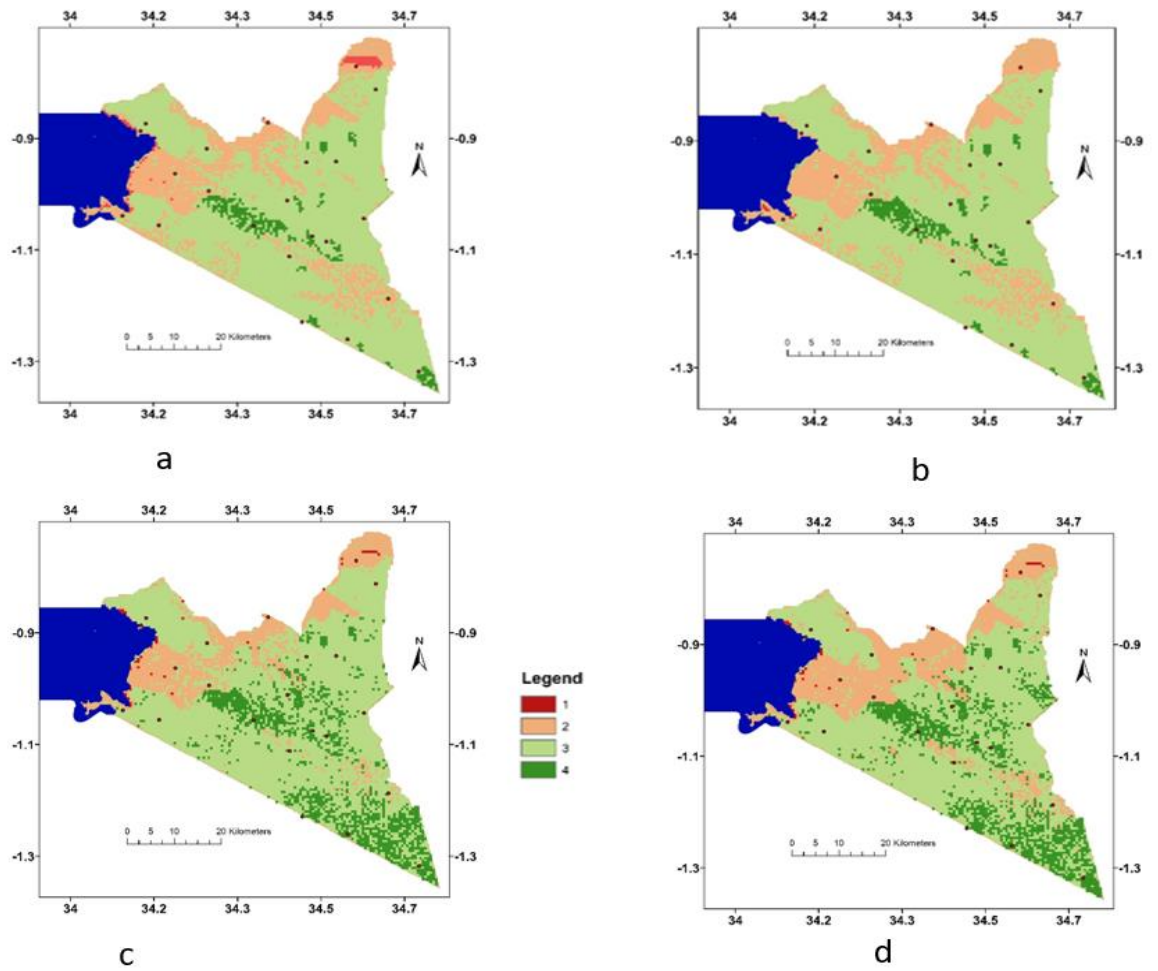


Figure 11: land degradation maps for the years (a) 1986, (b) 1995, (c) 2008, (d) 2016.

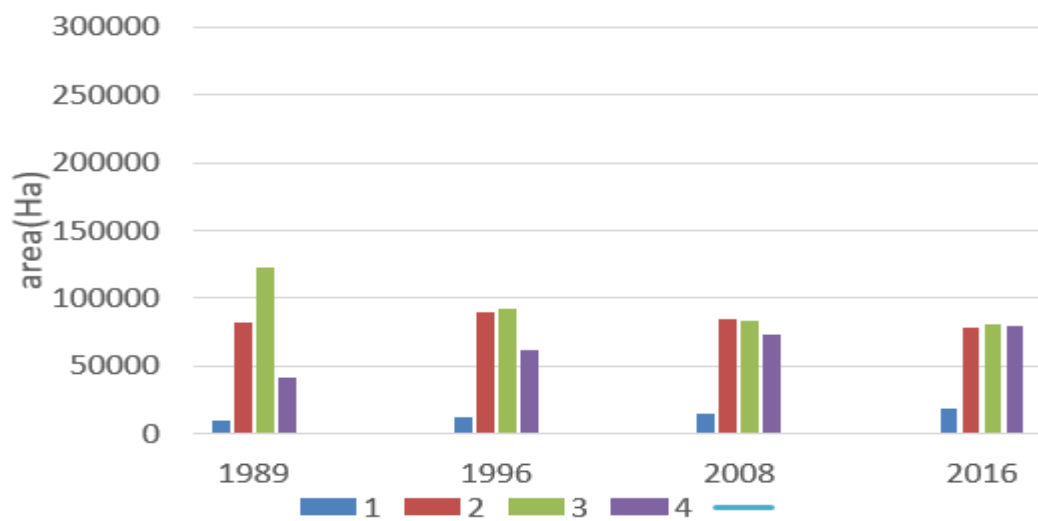
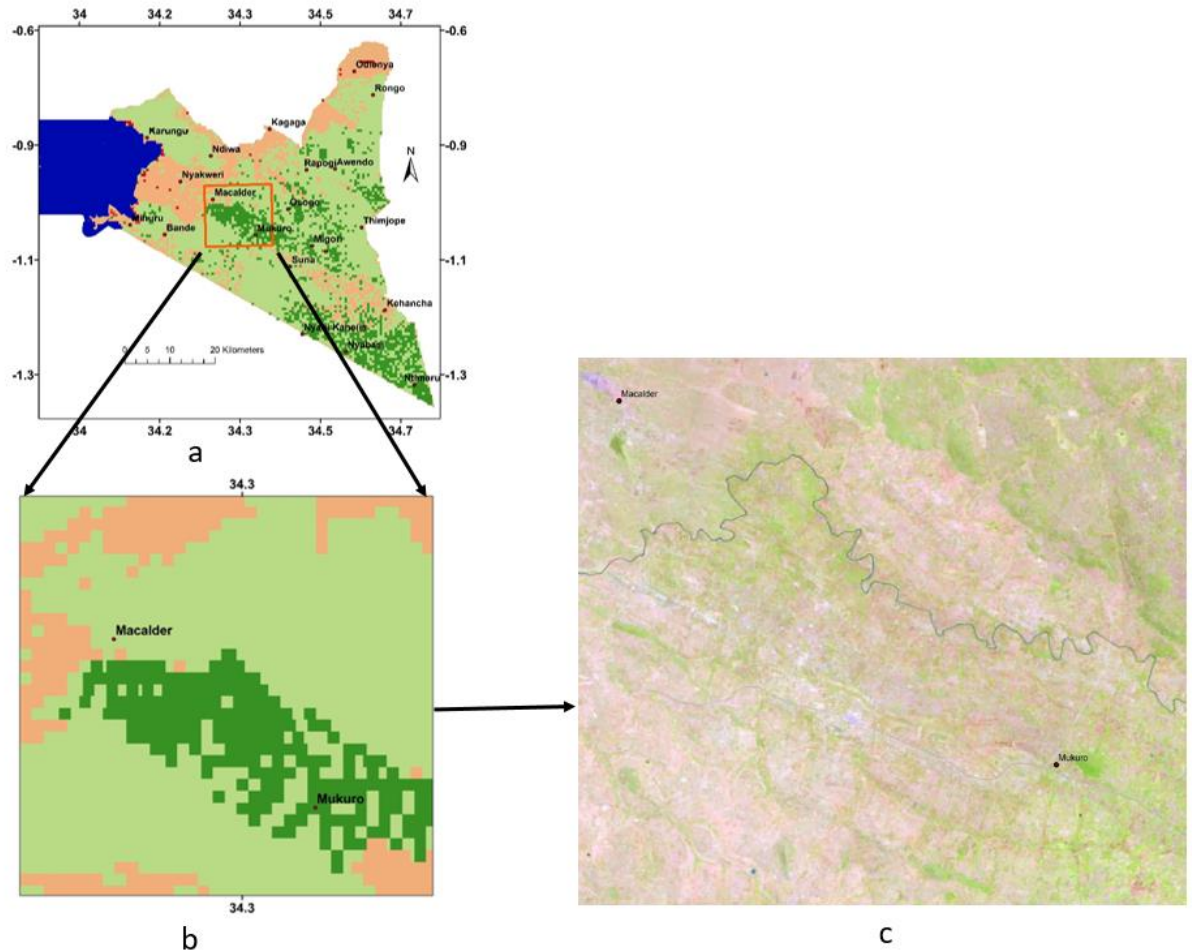


Figure 12: land degradation by area extend



**Figure 13: validation of land degradation using sentinel image (2016)**

## 1. CONCLUSIONS

Several tasks were carried out in this study to assess land degradation vulnerability trends in Migori County. The major tasks were identification of the variables, land use and land cover classification and change detection, modeling soil erodibility, modelling rain erosivity calculating population density and use of multicriteria analysis to assign weights to the variables. The findings of land use and land cover classification show that agriculture is the dominant land use type in Migori County. The main change observed between the 1986 and 2016 was an expansion of crop land at the expense of 11.15% of other land use and land cover classes. The slope analysis show that half of the Migori County falls under steep and very steep gradient classes.

A big proportion of crop land is on moderately steep and steep slope gradients. Cultivation on steep slopes will aggravate land degradation processes.

As many counties are increasing in population, demand for land to provide food, shelter and fibre is also increasing. Forested areas are replaced by crop lands and other lands due to human activities which increase exposure of top soils. The impact of top soil exposure is the loss of organic matter content due to topsoil rainfall runoff hence reducing soil fertility and crop yield [17].

The spatial multicriteria analysis results, reveals that vulnerability to land degradation varies from low degradation levels to high degradation levels in Migori County. Zones with very low degradation changed from 4% in 1986 to 5% in 1996 to 6% in 2008 and finally to 7% in 2016. Zones with low degradation from 32% in 1986 to 35% in 1996 to 33% in 2008 to 31% in 2016. Zones with moderate degradation from 48% in 1986, 36% in 1996 in 32% in 2008 in 31% in 2016. Zones with high degradation from 16% in 1986 to 24% in 1996, 29% in 2008, and 31% in 2016. This indicates that land degradation in Migori is increasing in an upward trend which raises an alarm, and requires urgent measures to curb it.

Generally the integration of GIS, RS and Multicriteria analysis provides a great utility to investigate land degradation vulnerability. The overall results obtained from this study suggests the need for land conservation and management.

Future research should focus on the application of radar differential interferometry and LIDAR altimetry for the generation of high-resolution DEM and DTM required in the temporal analysis of gully erosion and sedimentation.

This study can be used for prediction of land degradation in the future

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## **Comparative study of renewable energy technologies deployment and policies in the East African Community**

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### **Abstract**

With a population of over 150 million people, the East African Community is presently regarded as one of the fastest growing regional blocks globally. What are the common and national energy strategies to sustain this rapid economical growth and what is the role played by renewable energy technologies at both national and regional levels? What impact might have the recent discoveries of conventional sources of energy such oil deposits in Uganda and Kenya, coal in Kenya and large reserves of gas in Tanzania on the future deployment and prospects of renewable energy technologies in the region?

## **An Open Source Web GIS Tool for Analysis and Visualization of Elephant GPS Telemetry Data, Alongside Environmental and Anthropogenic Variables**

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### **Abstract**

The movement and distribution of ecologically important herbivores such as elephants is of great significance to conservation biologist seeking to understand the fundamental triggers that influence their mobility and the extent to which these parameters affect how they utilize their immediate and surrounding resources. This research study explored the use of an interactive web GIS application in mapping and visualization of elephant GPS telemetry data alongside other critical variables such as weather, environmental and anthropogenic factors - that are known to have a direct impact in determining presence/absence of elephants in a particular location. The web GIS approach allowed for the automated processing, analysis, and visualization of Earth Observation data and the integration of the Elephant GPS Telemetry data, thus, permitting the end user to access, query, and visualize the time series datasets in a simple and intuitive graphical user interface. From the web GIS tool, we deduced that NDVI was the main biophysical factor that influenced the immediate movement and distribution of elephant, in comparison to other factors such as temperature and rainfall. The fragmented nature of ecosystem compounded with a high level of encroachment to protected areas also limited free movement of elephant within their home ranges. Female elephant spent more time in protected areas compared to their male counterpart in spite of their periodically visits' to high risk zones at some point in time, most likely in search of vital elements such as salt or clay licks. All the three elephants had their home ranges extending through low elevated areas. There was also evidence of close association between these elephants as a result of their overlapping home ranges and close proximities at various stages such as during the male perennial hyperactivity (musth) episodes which coincided with the wet period. All the three elephants also had their core ranges closely overlapping with the existing riparian zones.

Keywords: Geography, web GIS, wildlife, ecology, time series

# Spatio-Temporal Drought Characterization In Kenya From 1987 To 2016

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## ABSTRACT

Kenya is a drought, famine and hunger prone country, with considerable impact on agriculture, human health and livestock due to its eco-climatic conditions. It contains only a few regions of high and regular rainfall where arid and semi-arid lands cover 80% of the territory, therefore periodical droughts are part of the climate system. Conventional methods of drought monitoring and early warning using station point data is time consuming, inaccessible and tedious. Some drought studies undertaken in Kenya used Standardized Precipitation Index (SPI) which could not fully account for drought severity status as the role of temperature increase on drought conditions was not taken into account. In this study, the Standardized Precipitation Evapotranspiration Index (SPEI), Normalized Difference Vegetation Index Anomaly (NDVI) were applied to characterize drought in Kenya from 1987 to 2016, investigate the drought severity and duration in the same period, assess drought trends together with mapping of spatial distribution of dry months, assessment of Agricultural, meteorological and economic activities. Correlation analysis was done to understand the response of climate and satellite based drought monitoring indices results and the crop yield data. The results and analysis obtained from the study showed that the years 1987, 1998, 2000, 2001, 2005, 2006, 2008, 2009, 2010, 2011 and 2015 were considered as drought years based on their SPEI and NDVI anomaly results. They were classified as extremely dry, very dry and moderately dry for meteorological drought and slight, moderate, severe and very severe for Agricultural drought. SPEI results can be rated as being superior as the element of temperature variation is taken into consideration.

Remote sensing data has proved to be a significant tool in monitoring and detecting drought components. Government agencies and County based Departments can create drought mitigation plans based on drought monitoring data models. This study has discussed the use of remotely sensed data in detection of drought severity and its effects on crop yields.

**Keywords:** Meteorological drought, Agricultural drought, Normalized Difference Vegetation Index and Standardized Precipitation Evapotranspiration Index

## 1. INTRODUCTION

Drought is a water-related, most complex natural disaster which affects a wide range of environmental factors and activities related to agriculture, vegetation, human, wild life and local economies (UNISDR 2009). Drought involves a deficiency of precipitation that leads to reduced soil moisture and diminished plant growth when prolonged over longer periods of time (Crafts, 1968). Drought can also be defined according to meteorological, agricultural, hydrological, and socio-economic criteria, (Mishra & Singh, 2010). Understanding drought occurrences serves as an early warning and provides approaches linked to mitigation of its impacts, (Mwangi et al. 2014).

Globally, drought (7.5 %) is the second-most geographically extensive hazard after floods (11 %) of the earth's land area (UNISDR 2009). The percent of area affected by serious drought has doubled from 1970s to the early 2000 (Nagarajan 2009).

Africa is prone to a variety of hazards especially the occurrence of Hydro-Meteorological hazards (drought and floods). This has increased of recent with devastating impacts and has become more frequent in the 21<sup>st</sup> century in sub-Saharan Africa (SSA) where droughts account for over 80% of the affected population (UNISDR, 2009).

Sub-Saharan Africa has suffered from many devastating droughts in recent history. Among some of the most devastating droughts globally during the past 50 years have been the Sahelian droughts of the 1970s and '80s, which drove famine conditions over much of the region and led to an estimated 600,000 deaths( Benson & Clay 1998; and Mortimore & Adams 2001) and droughts in 1991/92 in southern Africa. Multiyear droughts across the Horn of Africa (Lyon & DeWitt, 2005) led to food shortages across the region and famine conditions in Somalia and northern Kenya.

Kenya being the study area has had drought episodes over the past five decades. The recently documented droughts occurred during 2008/2009 and 2010/2011, hitting the arid and semi-arid regions of the country hard (Zwaagstra et al., 2010)

It is therefore evident that Kenya has had extreme drought events whose spatial and temporal variability has not been understood, especially at regional and sub-regional scales.

The main purpose of this study was to characterize drought in Kenya from 1987 to 2016 using climatic data and satellite images. The study concentrated on the last three decades due to availability of remote sensing data and the interest in the recent developments of drought events in the study area. In this study Normalized Difference Vegetation Index (NDVI) and the Standardized Precipitation Evapotranspiration Index (SPEI) indices were used. NDVI Anomaly was applied to characterize agricultural drought, (SPEI) to characterize meteorological drought whereas maize production data was used to show the effects of climate change on socio economic activities in Kenya from the years 1987 to 2016.

Several researches have been conducted with similar environmental topics using satellite and climate data and showed successful and satisfactory results. Suryabhagavan KV (2017) in his research GIS-based climate variability and drought characterization in Ethiopia over three decades, used the STARDEX indices, and SPI for 1-, 3-, 6- and 12 months' time scales to assess the erratic nature of rainfall in the study region. Agutu NO, A. J. (2017) used remote sensing (rainfall, vegetation condition index (VCI), terrestrial water storage (TWS), reanalysis (soil moisture and TWS), and land surface models (soil moisture). These products were employed to characterize East Africa droughts between 1983 and 2013 in terms of severity, duration, and spatial extent. Changwony, C. (2017) Used GIS and Remote Sensing in Assessment of Water Scarcity in Nakuru County, Kenya. The main objective was to study Land use and Land cover area changes using Landsat satellite image data, standardized precipitation index (SPI) and crop yields.

Most of the studies carried out in Kenya, used Standardized Precipitation Index (SPI), which could not fully account for drought severity status as the role of temperature increase on drought conditions was not recognized. SPI is actually a precipitation-based drought index. This study has tried to fill the gap by using SPEI which includes precipitation, a temperature component and evapotranspiration in its computation. This has allowed the index to account for the effect of temperature on drought through a basic water balance calculation. This in effect has made the research more detailed and a better result.

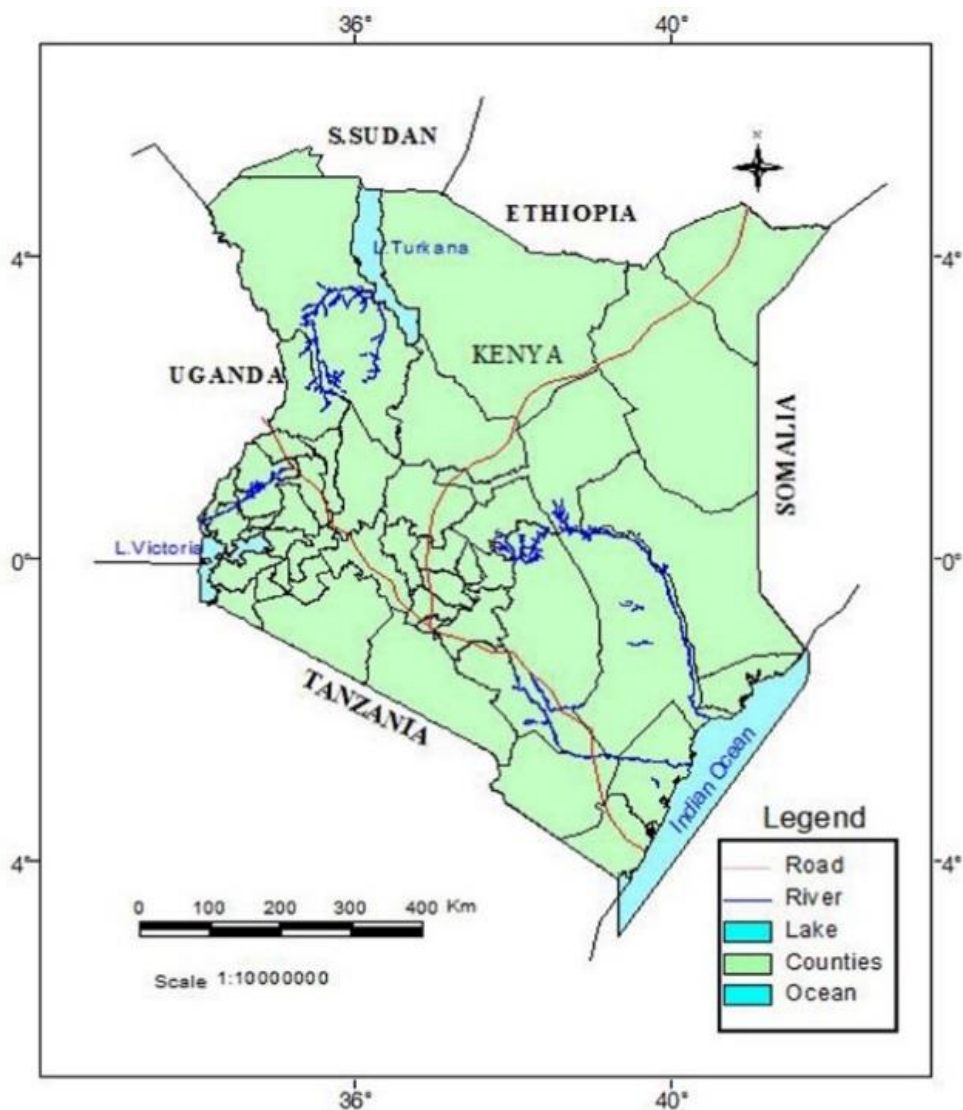
## **2. Method**

### **2.1 Description of the Study Area**

The Republic of Kenya, lies between 5° 7' N and 4° 39' S longitude and is part of the Greater Horn region of Africa along the Indian Ocean (SEDAC, 2005). Figure 1 shows the location of the study area. Kenya has a population of approximately 40 million with nearly 22% of Kenyans living in urban centres (UN, 2009b). It is bordered by Tanzania to the south, Uganda to the west, Ethiopia to the north, Sudan to the north-west, Somalia to the east, and the Indian Ocean to the south-east. Its area is approximately 584,000 square km.

The country has climatic and ecological extremes with altitude varying from sea level to over 5000 m in the highlands. The mean annual rainfall ranges from less than 250 mm in semi-arid and arid areas to greater than 2000 mm in high potential areas.

Soils vary from the coral types on the coast to alluvial, swampy, and black cotton soils along river valleys and plains. The Kenyan highlands have fertile volcanic soils whereas in the semi-arid regions are shallow and infertile. Farming is the primary livelihood of more than 75% of the population, conducted either on subsistence plots in marginal farming areas or on large plantations in the more arable areas (Uwechue, 1996), with less than 4% of people being pastoralists. one third of the total land area of Kenya is agriculturally productive, including the Kenyan highlands, coastal plains and the lake region. The other two thirds of the land area is semi-arid to arid and is characterized by low, unreliable and poorly distributed rainfall, these areas are used for pastoral farming (FEWS NET, 2010).



**Figure 1:** Location map of Kenya

## 2.2 Datasets, Sources, duration and software used.

The first step was to identify the variables needed for Spatio-temporal drought characterization. The variables included climate data (Temperature and Precipitation data), remote sensing satellite data (AVHRR and Modis data) and Socio economic data of which in this case was maize yield data. These variables were obtained from secondary sources and covered the period from 1986 to 2016. The Remote sensing satellite datasets were from The United States National Aeronautical and Space Administration and were on monthly basis over the study period. The monthly precipitation data was downloaded from (CHIRPS) Climate Hazards Group Infrared Precipitation station, Temperature data on monthly basis was downloaded from Climate Research unit (CRU) and crop production data (maize) in statistical form was acquired from the ministry of Agriculture, livestock and fisheries (Kenya). Table 1 shows the type of data used in the study, sources and the duration.

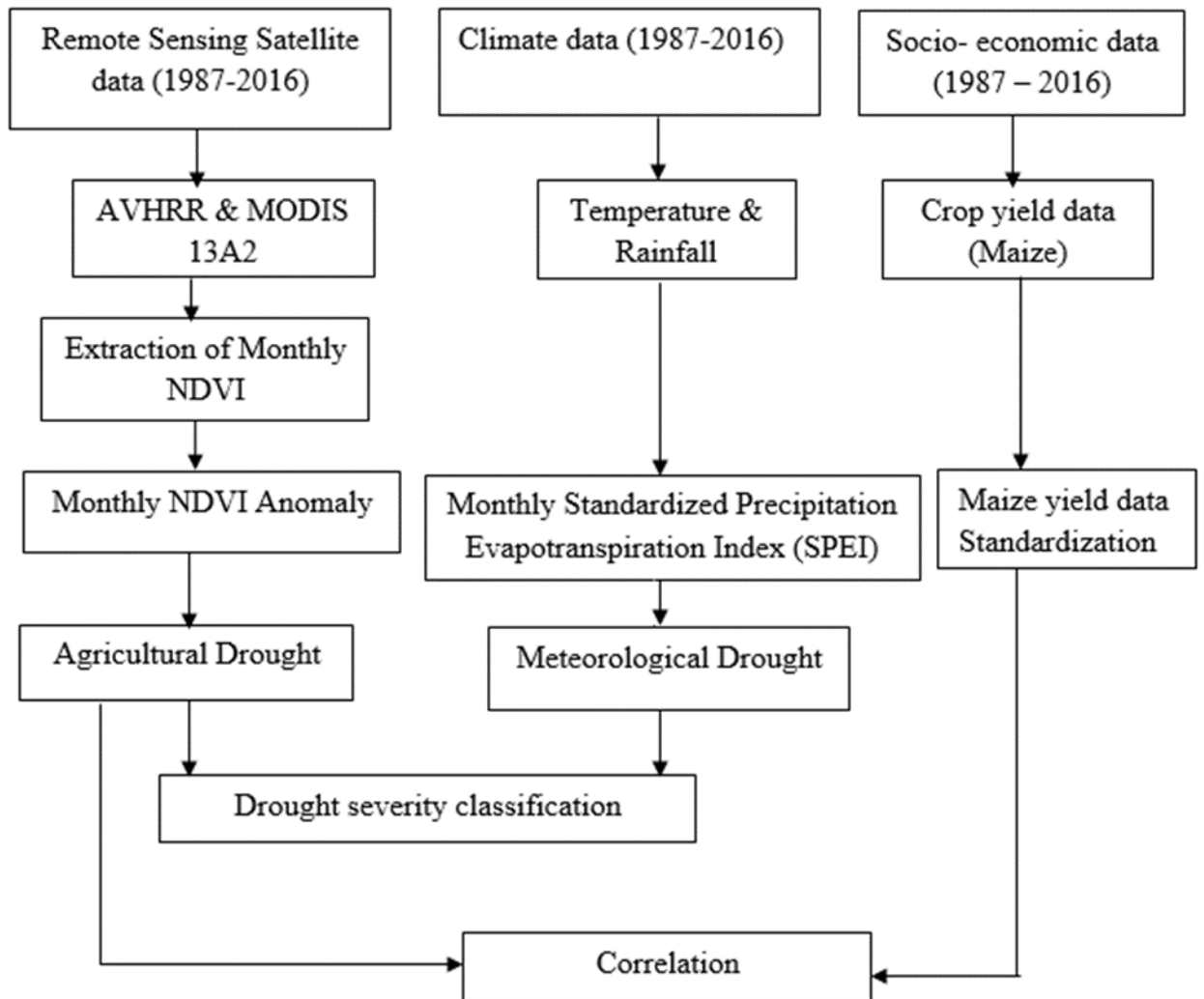
The Software's used in processing the data included: ERDAS IMAGINE 2013, ARCGIS 10.5, R program and R studio and Microsoft excel 2013.

**Table 1:** Data types, Sources and the duration.

S/NO	TYPE OF DATA	SOURCE	DURATION
1	NOAA AVHRR(NDVI)	USGS	1987 - 2000
3	MODIS 13A2 (NDVI)	USGS	2001 - 2016
4	Topographic map of Kenya	Survey of Kenya	
5	Temperature	Climate Research Unit (CRU)	1987 - 2016
6	Rainfall	CHIRPS precipitation data	1987 - 2016
7	Crop yield data (Maize production data)	Ministry of Agriculture, Livestock and Fisheries	1987 - 2016

## 2.3 Research approach

The methodology approached in this study was as shown in figure 2 using GIS and Remote sensing tools.



**Figure 2:** Flowchart illustrating the different steps involved in the drought study

## 2.4 Data processing

### 2.4.1 Climate Data

The climate data used in this study was historical data series of monthly precipitation (P), and monthly temperature which included both maximum and minimum temperature. Precipitation data was from CHIRPS (Climate Hazards Group Infrared Precipitation) for the period 1987–2016. Temperature data was downloaded from CRU (Climate Research Unit), both the data was in raster format, the area of interest Kenya was clipped and then converted to text files format so as to get the average monthly rainfall, the minimum, maximum and average temperature. Trend line was used to understand both the temperature and rainfall trends. The rainfall and temperature data was used to calculate SPEI (Standardized Precipitation Evapotranspiration Index). The procedure to calculate the Index was similar to that used for the Standardized Precipitation Index (SPI), but it included the role of temperature as per Vicente et al., (2010). The SPEI values computed were in turn used to plot the SPEI temporal trends which were used to identify the drought years and months.

### 2.4.2 The Standardized Precipitation Evapotranspiration Index (SPEI)



The SPEI considers the effect of reference evapotranspiration on drought severity. Calculation of the Standardized Precipitation-Evapotranspiration Index (SPEI) was done using a time series of the climatic water balance (precipitation minus potential evapotranspiration) so as to get the SPEI values.

In this study the equation used was Thornthwaite which computes the monthly potential evapotranspiration (PE) according to the Thornthwaite (1948) equation. R program enabled the generation of SPEI timescales values for long term series for Kenya. Moving total time series was constructed from the data computed from precipitation and temperature data. The SPEI graphs were used to categorize drought as per vicente et al (2010) drought categories as shown in Table 2. SPEI was used as an indicator of meteorological drought and then temperature, rainfall and NDVI maps, were generated for the same to show their spatial distribution in the study area.

**Table 2:** Categorization of SPEI for drought severity (Vicente, et al. 2010)

<b>SPEI value</b>	<b>Drought severity class</b>
2.0+	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
0.99 to - 0.99	Normal
-1.0 to -1.49	moderately dry
-1.5 to -1.99	Very dry
-2.0+	Extremely dry

### **2.4.3 Satellite data**

The Normalized Difference Vegetation Index (NDVI) was derived from NOAA AVHRR (National Oceanic and Atmospheric Agency Advanced Very High Resolution Radiometer) from 1987 to 2000 and the successor the MODIS level-3 product, MOD13A2 respectively from 2001 to 2016. The data was downloaded from Earth Explorer USGS site. Only the NDVI band was extracted. The first step was to change the NDVI product from Sinusoidal projection, which is not supported in ArcGIS into usable spatial information. All the images were projected into Geographic system with WGS84 datum. NOAA AVHRR data was on monthly basis and image was clipped to area of interest. MODIS NDVI, covered four images which were mosaicked together, the area of interest Kenya was then clipped and then classified using ERDAS IMAGINE and Arc Map 10.2 software. To get the NDVI values the images were converted to text files so as to get the average monthly values which were later used for further analysis.

### **2.4.4 NDVI Anomaly**

NDVI can be used as an index to assess vegetation condition through analysis of NDVI anomaly (Murali et al., 2008). In this study, the Vegetative drought index was calculated using NDVI Values. The computed NDVI Anomaly monthly values were correlated with SPEI one and three months lag to get the drought years and affected month. NDVI maps of the dry months were classified to show the spatial distribution of Agricultural drought within the study period.

**Table 3:** Agricultural drought risk classification using NDVI anomaly (Gizachew Legesse and Suryabhagavan, K.V.2014).

NDVI anomaly (%)	Drought severity class
Above 0	No drought
0 to - 10	Slight drought
-11 to - 25	Moderate drought
26 to - 50	Severe drought
Below - 50	Very Severe drought

#### 2.4.5 Socio economic data

The socio economic data in this study was maize production in tonnes. It was collected from the ministry of Agriculture, Livestock and Fisheries headquarters. The data was organized at different regional levels. The production was computed to see the yield trend over the last 30 years (1987 to 2016). To quantify the impact of drought on production of maize crops in Kenya, the totals were found and were correlated with annual SPEI, NDVI and NDVI Anomaly to assess the impacts of climate change on crops.

#### 2.5 Data Analysis

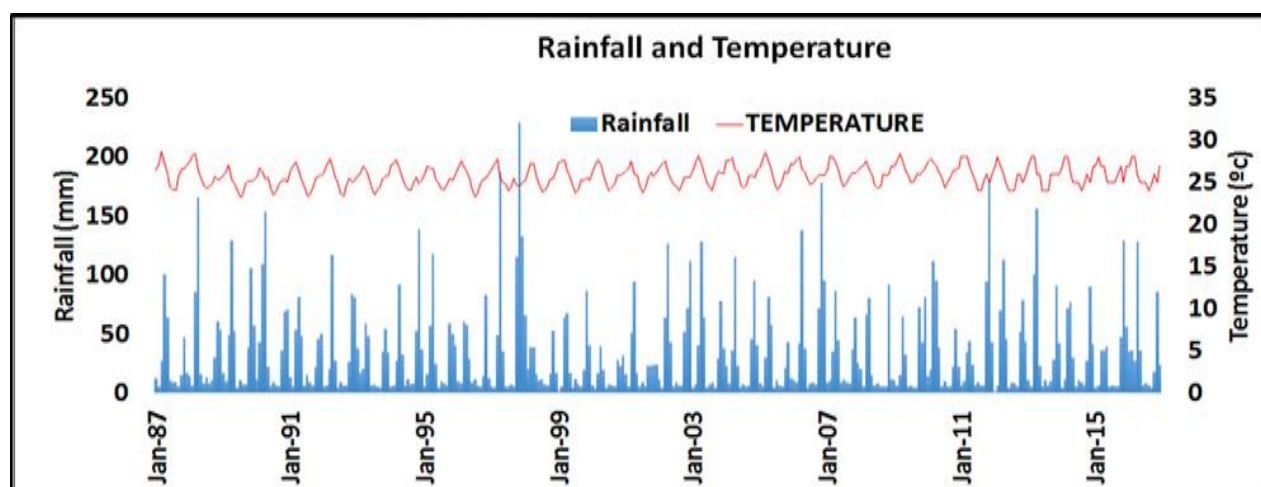
In this study the Standardized Precipitation and Evapotranspiration Index (SPEI) were used to assess the degree of drought in terms of severity, duration and magnitude using observed climate data. In addition, Satellite image based drought indices were used to detect agricultural drought condition and to show its spatial extent. Correlation analysis was done to understand the response of climate and satellite based drought monitoring indices result on crop yield. Harmonization as per Jacob Shadiva Simeon, (2017) consisted of decomposition of data sets so as to graphically determine the relationship between them. In this study, the maize production datasets from 1987 to 2016 were summed up and then followed by dividing of each data set for the respective years by the summation of each data set. This then created new standardized data sets for the years under study. The new decomposed data sets were then used in the analysis through graphical representations. In this case scatter plots were used to show the relationships. SPEI and NDVI data was correlated to find the relationship between them in identifying the drought years and months.

Both the NDVI, NDVI Anomaly (Agricultural) drought values, Meteorological (Climatic) data and socio economic data (crop production) which included maize were correlated to find the relationship between Agricultural, meteorological and socio economic data in relation to drought magnitude

### 3 Results and Discussions

#### 3.1 Temperature and rainfall variability in Kenya (1987 to 2016)

The results in Figure 3 show that both temperature and rainfall have a positive trend, rainfall increases inversely with temperature and most of the months had dry spells with high temperatures.

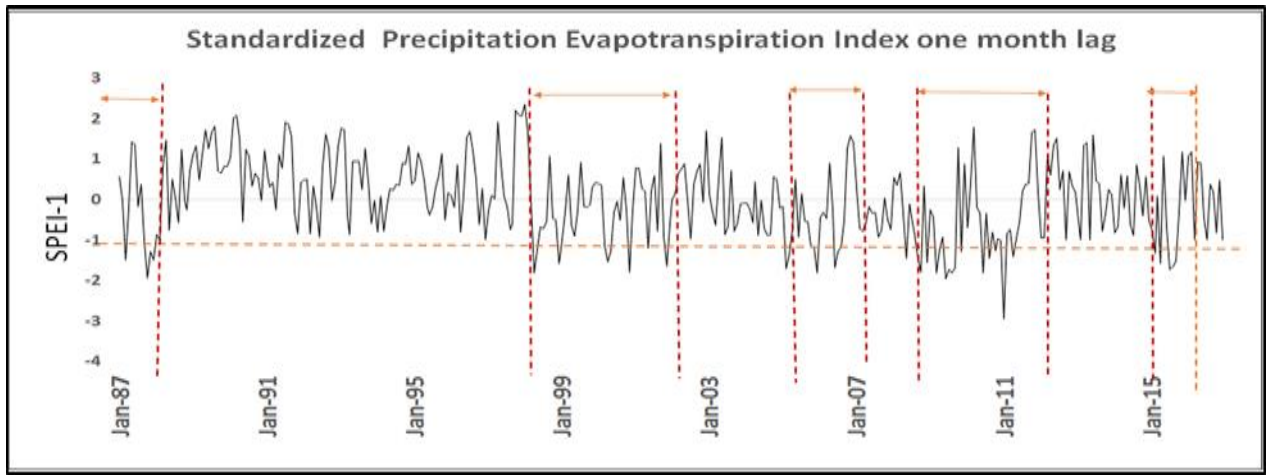


**Figure 3:** Temporal trends of Rainfall and Temperature showing climate variability in Kenya on monthly basis (1987 to 2016)

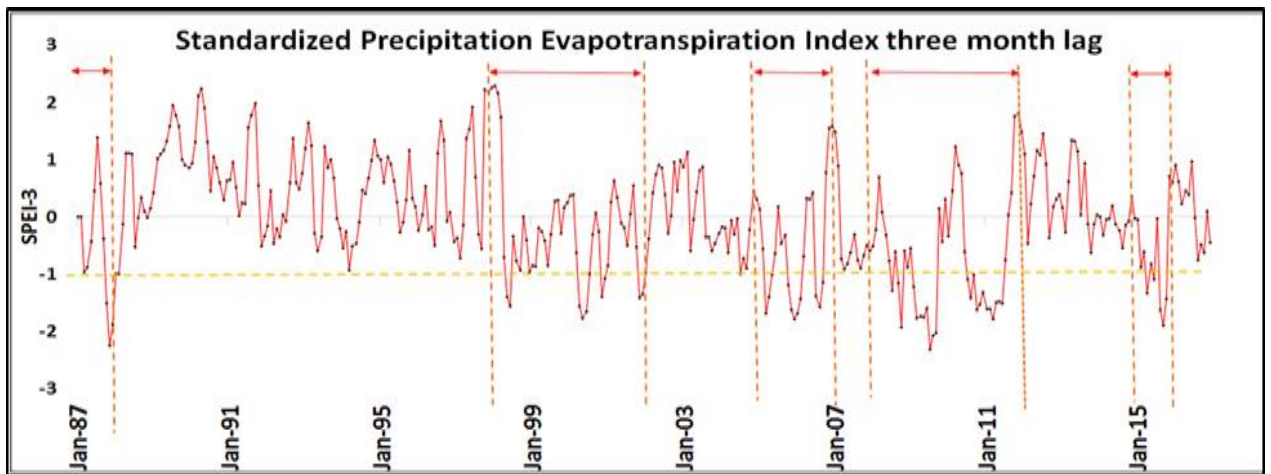
#### 3.2 Standardized Precipitation Evapotranspiration Index in identification of drought years and months.

The Temperature and Rainfall monthly values were used to compute the SPEI values for the whole country from years 1987 to 2016 on monthly basis. The values were then used to plot SPEI trend graphs in which drought years and months were identified as shown in figures 4, 5 and 6 respectively in this study one month and three months scales time series were used in the analysis. The 1 and 3-month SPEI values reflected short- and medium-term moisture conditions and provided a seasonal estimation of precipitation deficiency.

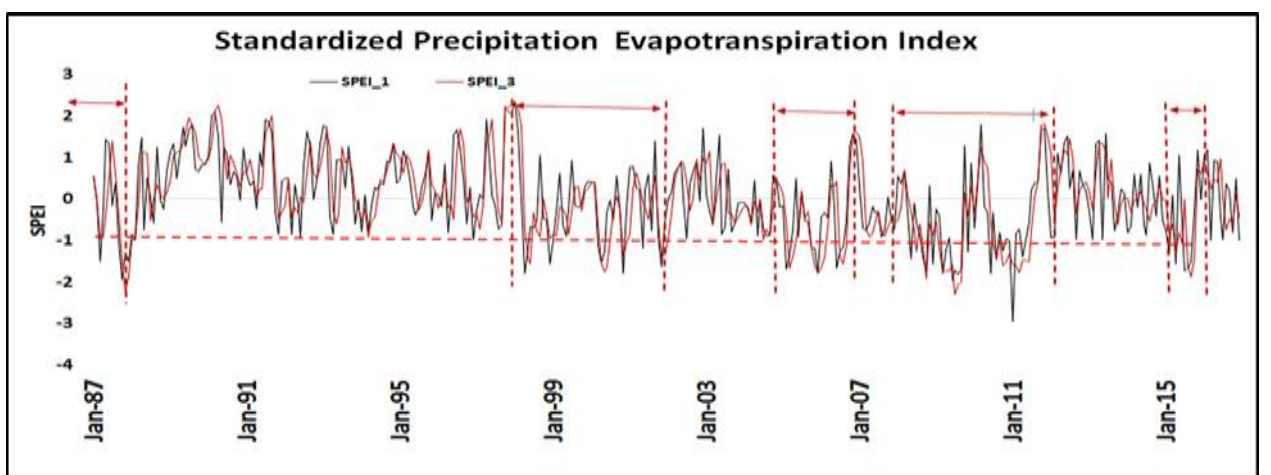
A drought is noted whenever the SPEI value reaches a value -1 and continues until the SPEI become positive again. The drought was categorized as per Vicente-Serrano et al (2010) as shown in table 2. From the results drought years were identified as 1987, 1998, 2000, 2001, 2005, 2006, 2008, 2009, 2010, 2011 and 2015. Categorization of SPEI for drought severity was done using Vicente, (2010) seven drought classes. The drought months were characterized as being Extremely dry ,very dry and moderately dry.



**Figure 4:** Temporal trends of SPEI one month lag (The arrows show the dry years and months, horizontal dotted line show drought commencement and severity while the vertical dotted line show the duration)



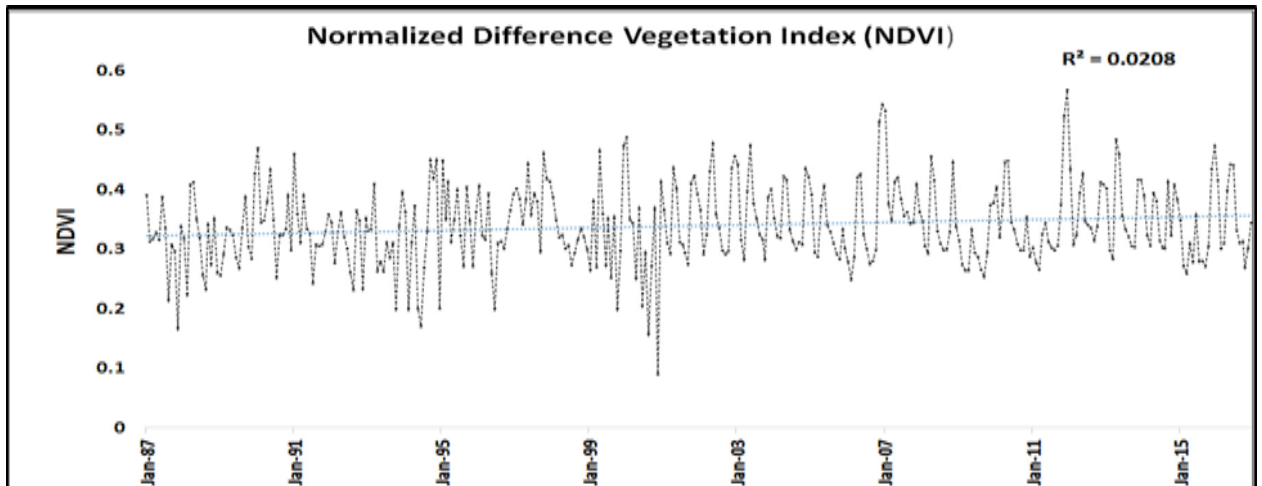
**Figure 5:** Temporal trends of SPEI three months Lag over the study period (The arrow show the dry years and months, horizontal dotted line show drought commencement and severity while the vertical dotted line show the duration)



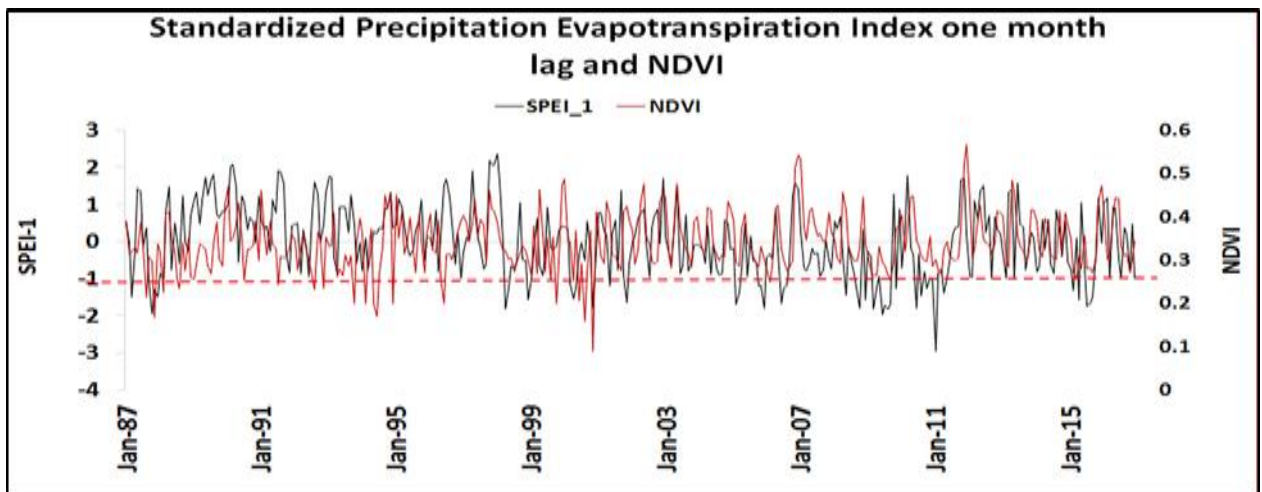
**Figure 6:** Temporal trends of SPEI one and SPEI three months lag over the study period (The arrows show the dry years and months, horizontal dotted line show drought commencement and severity while the vertical dotted line show the duration)

### 3.3 Normalized Difference Vegetation Index (NDVI)

Figure 7 shows that NDVI has a positive trend and the values increase or decrease in association to the vegetation cover. NDVI values lies between -1 to +1 with negative values indicating clouds and water, Positive values near zero indicating bare soil, and higher positive values of NDVI ranging from sparse vegetation (0.1 to 0.5) to dense green vegetation 0.6 and above. The results in Figure 8 indicate that there is about one to three months' time lag between SPEI and NDVI. Since there is a certain time lag between NDVI and SPEI, decrease in NDVI associates with the decreasing amounts of plant cover. The time interval between a precipitation event and the time when precipitated water reaches plants' root and affect plant growth can vary from 1 to 12 weeks depending on vegetation and soil types (Li ,2002). Figure 9 indicates that there is a correlation as the SPEI three months lag decreases, the NDVI values also decreases with some months in the lag.

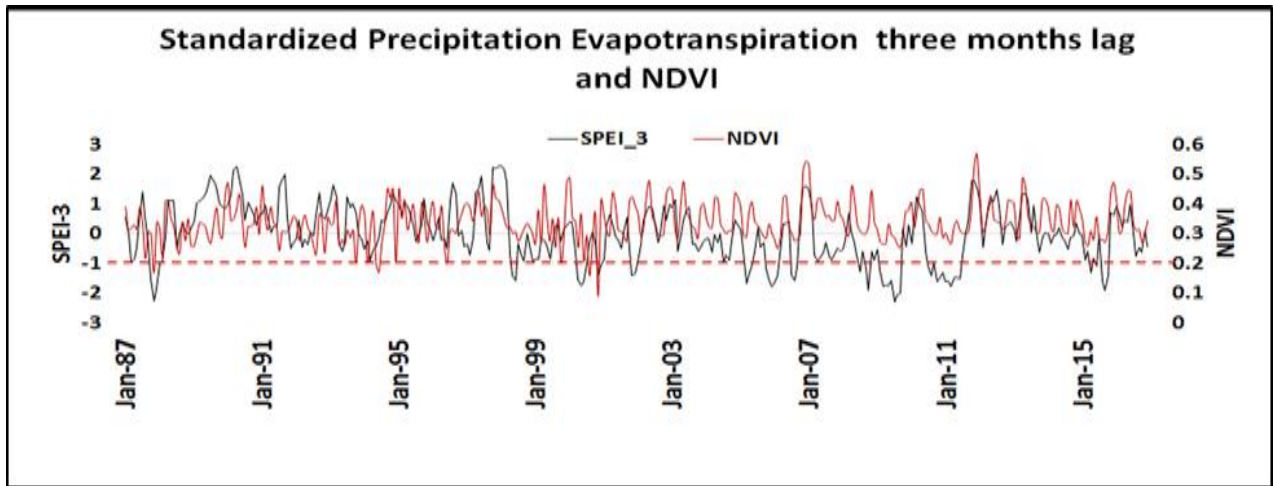


**Figure 7:** Temporal trends of NDVI values over the study period (1987-2016)



**Figure 8:** Temporal trends of SPEI one month lag and NDVI over the study period (1987-2016)

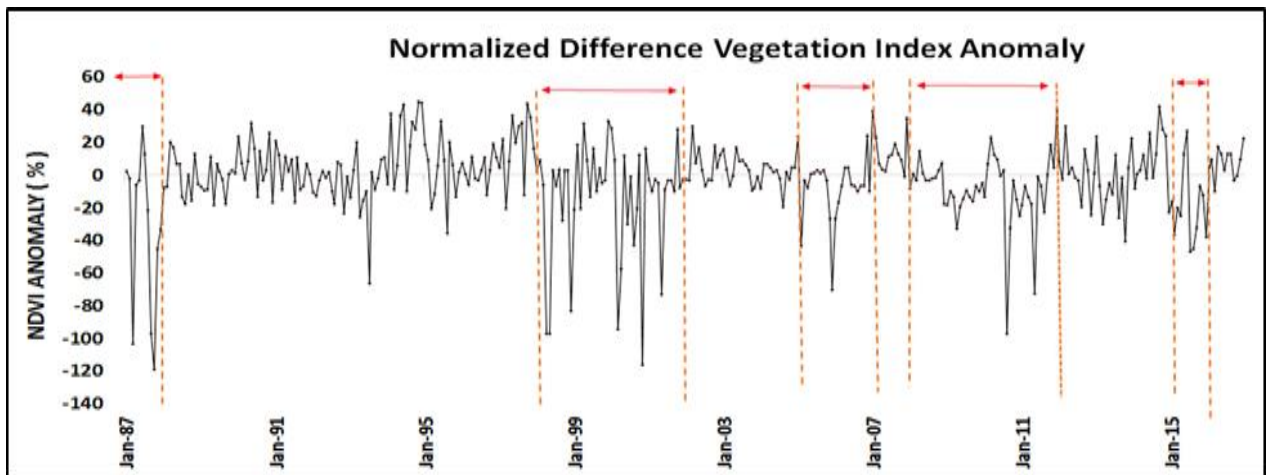




**Figure 9:** Temporal trends of SPEI three months lag and NDVI over the study period (1987-2016)

### 3.4 Normalized Difference Vegetation Index Anomaly in Agricultural Drought Characterization

NDVI Anomaly values were used to characterize agricultural droughts using the drought categories in Table 3. Results in Figure 10 show that the identified drought years were 1987, 1989, 2000, 2001, 2005, 2006, 2008, 2009, 2011 and 2015. Within the figure, the drought years and months are shown by the arrows, the severity is depicted by the horizontal dotted lines using the Agricultural drought risk classification in Table 3, where drought severity commences from 0 and below. While the vertical dotted line, shows the drought duration. The severely affected months are shown in Figure 13.



**Figure 10:** Temporal trends of NDVI anomaly over the study period (The arrows show the dry years and months, horizontal dotted line show drought commencement and severity while the vertical dotted line show the duration)

#### 3.4.1 NDVI Anomaly and Standardized Precipitation Evapotranspiration Index in drought Characterization.

The results in Figure 11 and 12 show the drought years and months identified by correlating NDVI Anomaly with SPEI one and three months lag respectively. The arrows show the drought years and months, the vertical dotted lines show the duration

and the characterization of the event, while the horizontal dotted line show the severity (below it being commencement of drought). The 1987 drought was characterized as short severe drought year for it covered five months with the severely affected month being October.

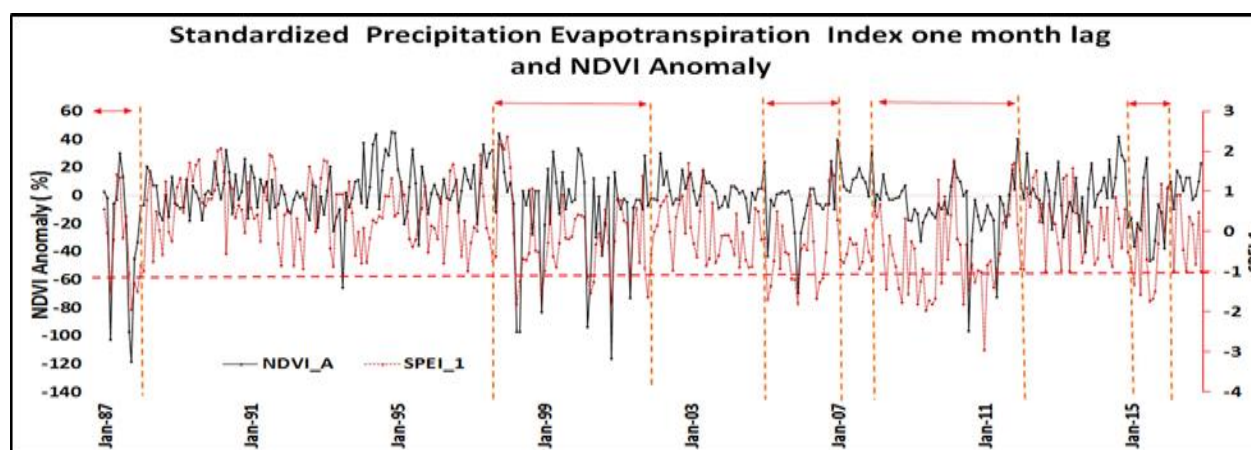
1998 to 2001 was characterized as prolonged moderate drought years, for all the consecutive four years had dry spells. In 1998 three months were affected, the month of April being severely affected and characterized as a very dry month. The year 2000 had four dry months the severely affected month being November and the year 2001 had two months that were affected, the severely affected months being November and characterized as very dry.

2005 and 2006 were characterized as a mild drought duration. 2005 had five drought months with the severely affected months being December characterized as a very dry month. 2006 had two dry months, the severely affected month being June and was characterized as a very dry month.

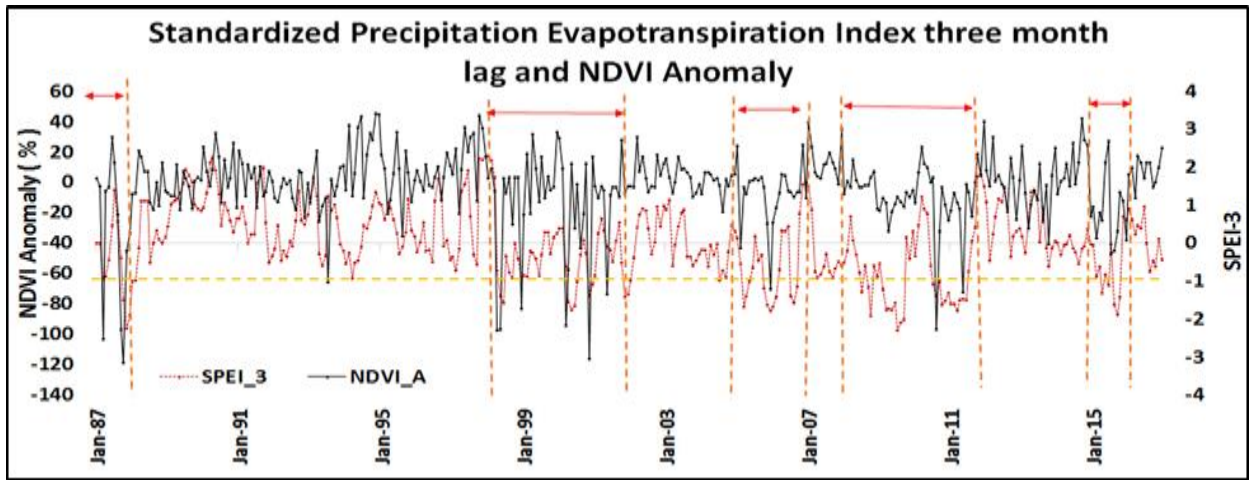
2008 to 2011 were characterized as prolonged severe drought duration. 2008 had four dry months, the severely affected month was October having been characterized as a very dry month. 2009 had 7 dry months, the severely affected month being June (Extremely dry month). 2010 had four dry months, the severely affected month being June (very dry month). 2011 had two dry months, June was the severely affected (extremely dry month).

2015 was a short mild drought year with five dry months. Severely affected month was August. Results show, either short rains or long rains failed or both in the dry years over the study period.

The results are in agreement with some of the results of Osbahr, H. a. (2006) who characterized drought years in his study as 1984, 1992, 1993, 2000, 2001, 2005, 2006 and 2009, Zwaagstra et al.,( 2010) 2008, 2009, 2010 and 2011 and Changwony, C. (2017) as 1987, 1993 and 2004. The years 1984, 1992, 1993 and 2004 and 1998 have discrepancies. This was because the earlier authors did not put into consideration the effects of temperature increase on drought conditions and most of the Studies covered small regions.



**Figure 11:** Temporal trends SPEI one month lag and NDVI anomaly over the study period (The arrows show the dry years and months, horizontal dotted line show drought commencement and severity while the vertical dotted line show the duration)

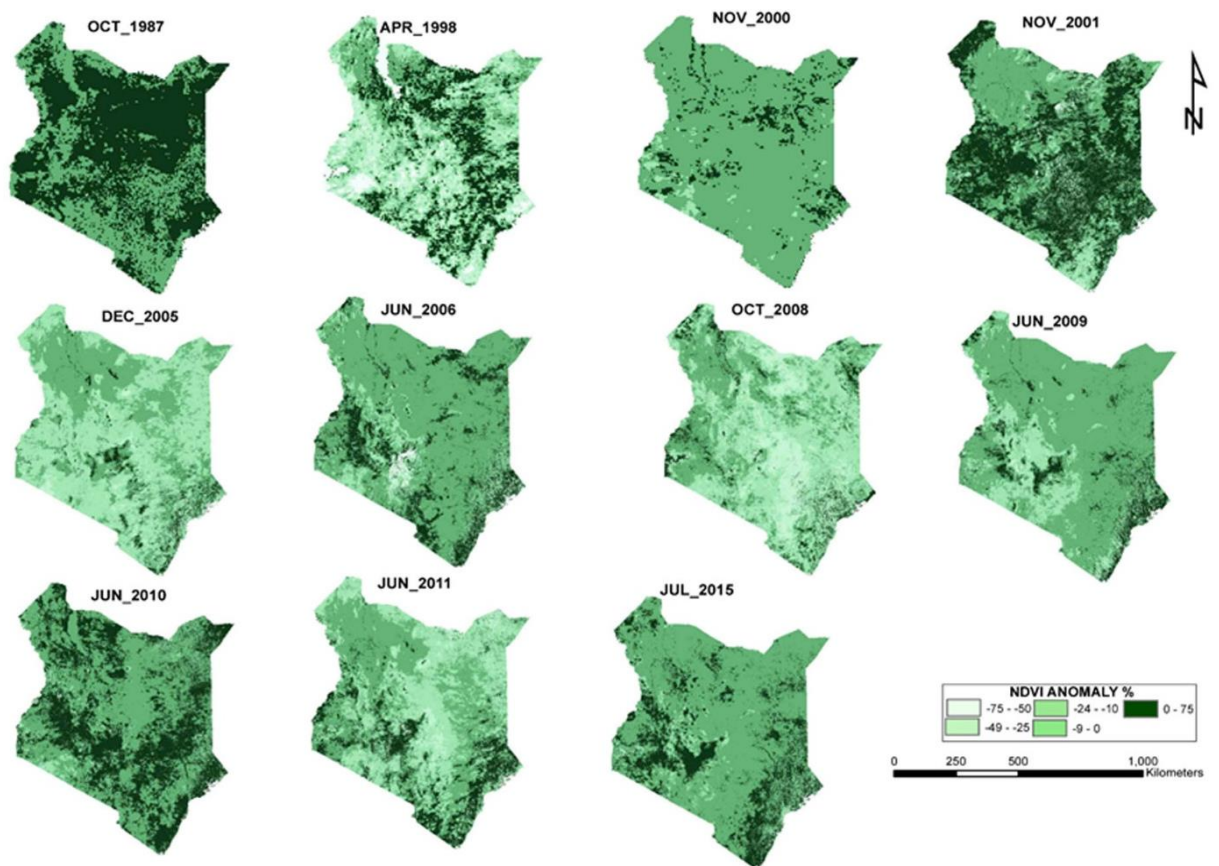


**Figure 12:** Temporal trends of SPEI three month lag and NDVI anomaly over the study period (The arrows show the dry years and months, horizontal dotted line show drought commencement and severity while the vertical dotted line show the duration)

### 3.4.2 Normalized Difference Vegetation Index Anomaly maps for Agricultural Drought.

The results in Figure 13 shows the severe drought months in the drought years. The level of drought severity ranged from slight to very severe in both drought years. The results show non uniformity distribution of drought in the study area during the study period. The maps show that though a month had been classified as being dry, some areas still had some greenness, this is shown in all the maps. In the study period the areas that were most affected were ASAL (Arid and semi-Arid regions) of the country. The periods October 1987, November 2001, June 2010 and July 2015 despite them being dry years and severely affected months, some areas still had some greenness. This may be due to the NDVI time lag. The time interval between a precipitation event and the time when precipitated water reaches plants' root and affect plant growth varies from one to twelve weeks depending on vegetation and soil type for the dry periods (Li , 2002).

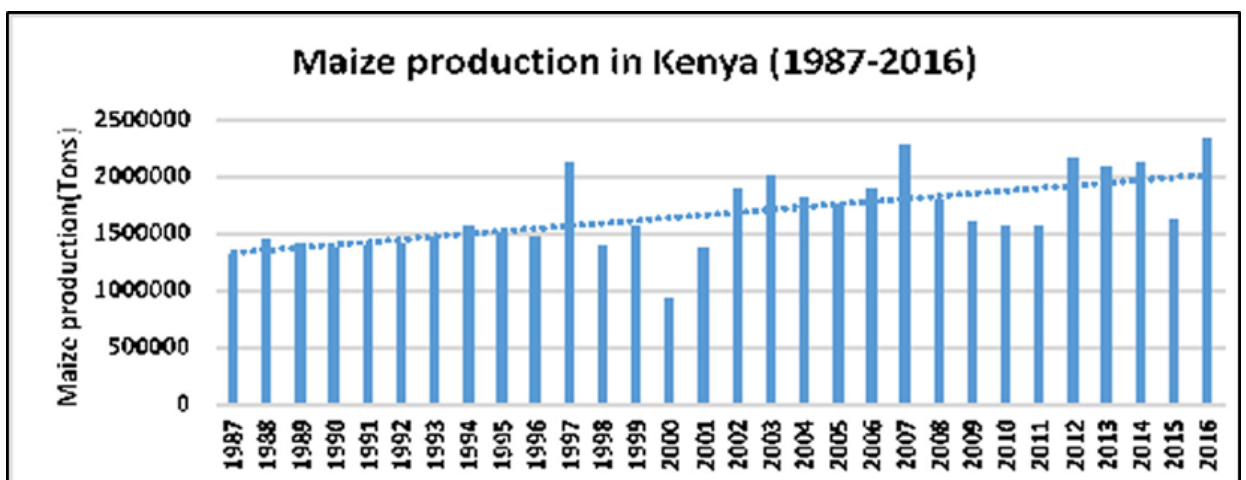




**Figure 13:** Normalized Difference Vegetation Index Anomaly maps showing the spatial distribution of Agricultural drought in the severely affected months within the drought years (1987 to 2016)

### 3.5 Maize production trends nationally in Kenya from 1987 to 2016

Figure 14 shows maize productions in Kenya nationally, between 1987 to 2016. The years 1987, 1998, 2000, 2001, 2005, 2006, 2008, 2009, 2010, 2011 and 2015 had low production. This correlates well with the drought years identified using SPEI and NDVI Anomaly.



**Figure 14:** Maize production in Kenya (1987-2016)

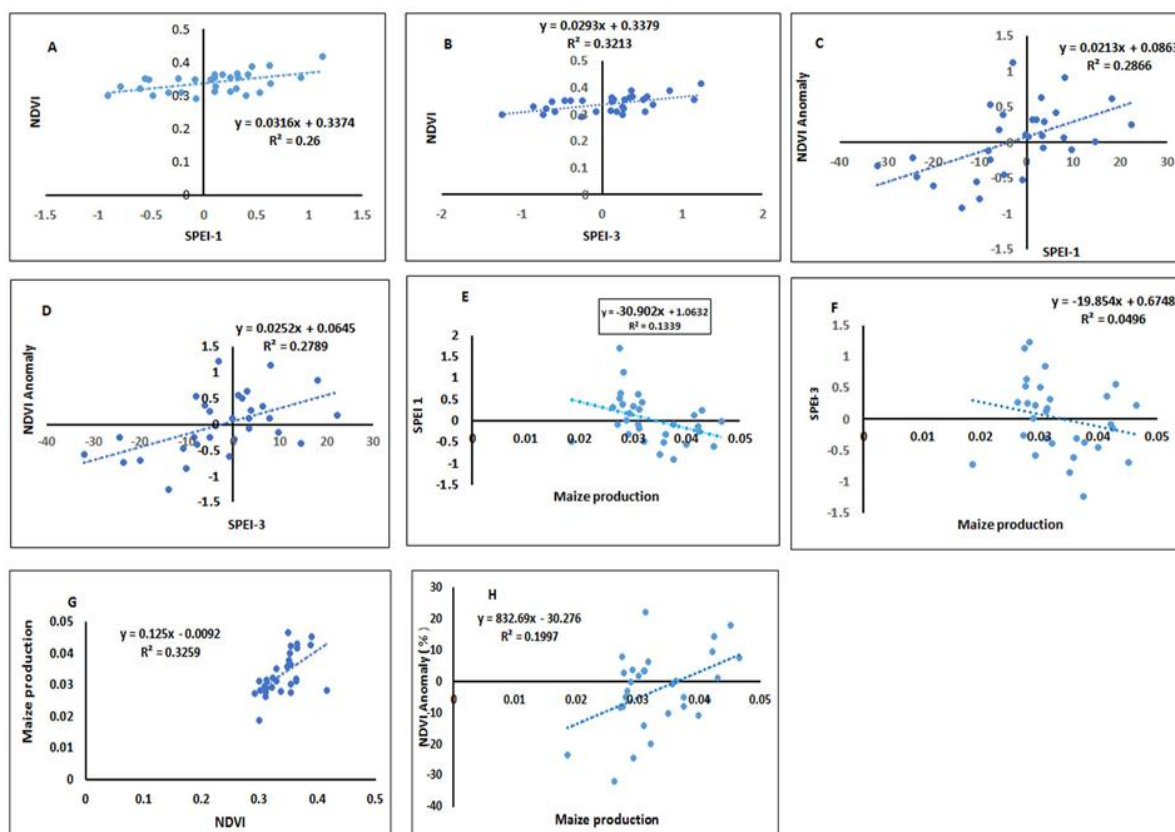
### 3.6 Correlation analysis of results

NDVI and SPEI one month lag relate well as shown in Figure 15A. ( $R^2 = 0.26$ ), where  $R=0.51$ , this implied that within 30 years' data, 51% of SPEI one month lag variable can be explained by NDVI. The relationship between SPEI three months lag and NDVI as shown Figure 15B shows that NDVI correlates with SPEI three month lag. ( $R^2= 0.3213$ ), where  $R=0.566$ . This shows that they also have a better relationship in that within 30 years' data, 57 % of SPEI three month lag variable can be explained by NDVI.

Figure 15C show that NDVI Anomaly and SPEI one month lag has a good relationship in which ( $R^2= 0.2866$ ) where  $R=0.54$ . Therefore 54% Of NDVI Anomaly variable within the study period of 30 years can be used to explain SPEI one month lag. Figure 15D show that NDVI Anomaly and SPEI three month lag has an association in which ( $R^2= 0.2789$ ), where  $R=0.55$ . Therefore 55% Of NDVI Anomaly variable within the study period of 30 years can be used to explain SPEI three month lag. The results in Figure 15A-D revealed that the relationship established between the variables was strong and in line with the findings of Vicente et al., (2010) who reported a strong correlation between the SPEI, NDVI and NDVI Anomaly. Wang et al. (2001) concluded that NDVI Anomaly was more strongly related to climate variables (precipitation and temperature).

The results in Figure 15E show that SPEI one month lag has some relationship with maize yield. ( $R^2 =0.1339$ ) where  $R=0.37$ . In this case, within 30 years' study period, 37% of SPEI one month lag variable can be explained by maize yield of the same time. SPEI three months lag and maize yield were correlated and the results in Figure 15F showed that when SPEI is positive, maize yield increases revealing a good positive correlation ( $R=0.24$ ). The results revealed in Figure 15E-F showed that the relationship between the two variables was positive. SPEI is an index that represents water and temperature deficit or excess. Positive SPEI show that water has been available to plants leading to above normal condition yields, whereas, negative SPEI is reflected through yield reduction. This result is in line with Taotao et al., (2016) who reported a good correlation between yield Anomaly and SPEI.

NDVI has a strong relationship with Maize yield. Figure 15G shows that for the 30 years study period, ( $R^2 =0.3259$ ) where  $R=0.57$ . Therefore 57% of NDVI variable can be explained by maize yield. Figure 15H shows that there is a strong relationship between NDVI Anomaly and maize yields. ( $R^2 =0.19997$ ), where  $R= 0.45$ . Therefore 45% of NDVI Anomaly variable within the 30 years of the study period can be used to explain maize yields. Results in Figure 15G and H show that the strength of the index to explain the existence of agricultural drought through maize yield is relatively good. The result of this study is consistent with the findings of Beyene et al., (2007) who reported a good correlation between NDVI and crop yield.



**Figure 15:** Correlation Analysis: (A) SPEI one month lag vs NDVI, (B) SPEI three month lag vs NDVI, (C) NDVI Anomaly vs SPEI one month lag, (D) NDVI Anomaly vs SPEI three month lag, (E) SPEI one month lag vs maize yield, (F) SPEI three month lag vs maize yield, (G) NDVI vs maize yield, (H) NDVI Anomaly vs maize yield.

## 4 Conclusion and Recommendation

### 4.1 Conclusion

The drought years identified in this study were 1987, 1998, 2000, 2001, 2005, 2006, 2008, 2009, 2010, 2011 and 2015 with months being characterized as being extremely dry, very dry and moderately dry for meteorological drought using SPEI and slight, moderate, severe and very severe for Agricultural drought using NDVI Anomaly. The correlation analysis of SPEI and NDVI demonstrated that SPEI drought detection has one month lag compared to NDVI. The effects of SPEI, lag those of NDVI. SPEI correlates well with NDVI Anomaly. The severely affected years were characterized as: 1987 was a short and severe drought year with a magnitude of -7.2 the months affected were five with the severely affected month being October with -1.9 severity.

1998 to 2001 was characterized as prolonged moderate drought event. It covered three months in 1998 with a magnitude of -3.8, the month of April was characterized as a very dry month with a severity of -1.6. The year 2000 had four months with a magnitude of -5.7, the severely affected month was November with -1.8 and the year 2001 had two months that were affected with a magnitude of -2.8, the severely affected month being November with the severity of -1.6.

2005 and 2006 were characterized as mild drought event. 2005 had five drought months with overall magnitude of -7.3, the severely affected month was December with severity of -1.8 and characterized as a very dry month. 2006 had 2 month of

drought with a magnitude -4.2, the severely affected month was June having severity of -1.7 and was characterized as a very dry month.

2008 to 2011 was characterized as a prolonged severe drought year event. 2008 had four dry months with a magnitude of -6.2, the severely affected month was October with severity of -1.8 (very dry month). 2009 had 7 dry months with magnitude of -11.5, the severely affected month was June with severity of -2.0 (Extremely dry month). 2010 had four dry months with a magnitude of -5.6, the severely affected month was June with a severity of -1.8. 2011 had two dry months with a magnitude of -4.4, January was the severely affected month with a magnitude of -3.0 and characterized as an extremely dry month.

2015 was a short mild dry year event with five dry months with an overall magnitude of -6.3. Severely affected month was August with a severity of -1.7. From the results it can be concluded that either short rains or long rains failed or both.

Drought trends in Kenya do not have a fixed pattern and tend to fluctuate from time to time, this is shown from the rainfall, temperature and SPEI graphs. The rainfall, temperature and NDVI maps of the dry years and months show that there is non uniformity in dryness where some areas along the coast, western, Nyanza and Rift valley tend to be wet whereas the ASAL (Arid and Semi-Arid Lands) that forms about 80% of the total Kenya's land cover are always dry. This has led to effects of non-uniformity in drought detection.

Agricultural drought similarly does not have a fixed trend. This is seen through NDVI and maize production graphs. However maize production fails in different regions due to non-uniform drought occurrence, this is because regions fall under different hydrological basins which experience different climatic conditions at different times.

## **5.2 Recommendation**

The long term historical records of satellite imagery and climatic data have become essential tools in calculating drought severity levels and determine drought risk prone areas. Similarly this study can achieve a great milestone in the Agriculture sector as mitigation measures can be put in place long before the occurrence of drought. This would reduce loss of livestock and human life as a result of loss of water and food.

Due to availability of satellite imageries agriculture has benefited due to constant drought assessment levels. Government agencies and County based Departments can create drought mitigation plans based on drought monitoring data models. Drought modeling using meteorological index (SPEI) was not done in this study due to meteorological drought index lacking spatial extent as many points are required for interpolation to model drought. In this study data used was for the whole country which was only a one point data (Kenya). For future research, it is recommended for further study that would be done using same technology according to water catchment basins and use the same methods to predict future drought in Kenya

## **Acknowledgement**

I express my heartfelt thanks to my supervisors, Dr. Arthur W.Sichangi and Dr. Godfrey O. Makokha for their guidance during the entire project phase, my family for the financial support and all the organizations who provided data for this research

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## **Geo-morphometric analysis of watersheds for flash floods risk management**

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Flash floods form rapidly with little or no warning. Events such as heavy rainfall coupled with the topography, channel characteristics and antecedent conditions of the catchment may lead to the occurrence of flash floods which is characterized by rapid rise of water levels and fast flowing water. Knowledge of the flash flood hazards as well as vulnerabilities is a fundamental prerequisite in designing action plans for reducing flash flood disaster risks. However, many developing regions with observed flooding incidences are also regions of scarce hydrological data. The meteorological and rainfall systems within such developing regions are rarely well developed while the density of river gauging stations is also poor. However, a tentative flash flood hazard assessment may be achieved through Geo-morphometry, the analysis of terrain characteristics, for the factors that contribute to the occurrence of the Flash Floods. Through the study of basin morphometry, we can relate the basin and stream network geometries, shape and relief to the transmission of water and sediment in the basin. Morphometric parameters provide insight into the surface flow, discharge, permeability, infiltration, magnitudes of peak, mean runoff as well as runoff direction and volume. To derive geo-morphometric parameters, the main dataset required is a Digital Elevation Model from which streams and watersheds are delineated. The morphometric parameters are derived from characteristics of the streams and watersheds such as length and number of streams as well as shape, geometry and relief of the catchments. This paper describes a workflow for computing the geo-morphometric parameters from a Digital Elevation Model using QGIS, an open source Geographic Information Systems software. A case study is provided for the Berg and Brigach River catchments in Germany where the computed parameters are normalized and combined in a multi-criteria approach to derive flash flood hazard maps. The paper concludes by discussing the potential role of these parameters in flash floods risk management.

**Keywords:** DEM, Flash Floods, Geo-morphometry, Open Source GIS

# Geothermal Drilling Cost and Rig Availability Optimization Through Maintenance

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## Abstract

Global geothermal power production capacity has been on the rise as developing countries continue to reduce their reliance on non-renewable sources of power which are unreliable and expensive. Kenya being ranked as the highest geothermal power producer in Africa and eighth globally has raised its geothermal energy production and consumption. This is due to its low cost \$/MW-hr. as compared to all the other sources of power. The cost of geothermal power is significantly affected by the production cost, which geothermal well drilling cost is the highest contributor, whereas maintenance, repair and operating (MRO) cost contribute significantly to the drilling cost. It is worth noting that the drilling cost is proportional to the drilling duration, hence to significantly reduce the costs, non-productive time (NPT) should be reduced proportionately which infers the improvement of drilling rig availability, a result of downtime mitigation. To address this challenge, this paper develops a framework using a simulation approach on a case study, modeling the maintenance and repair of the drilling equipment using the availability and maintenance cost as the performance measures. Model parameters are extracted from real maintenance data and optimization of the various aspects such as spares availability and preventive maintenance intervals are performed with a view of improving the availability and reducing the maintenance cost. The results offer important maintenance decision support to both the management and maintenance team of the company and have the potential of further offering insights that eventually reduce the cost of drilling.

**Keywords:** Maintenance, repairs and operations, Non-productive time, Maintenance, Availability.

## 1. INTRODUCTION

### 1.1 Background

Geothermal energy is realized by tapping the underground steam while employing deep drilling rigs. The average depth a drilling rig can drill is 7000m. Drilling is thus a major operation in the geothermal industry. In the geothermal industry, well drilling is achieved mainly by rotation of the drilling string which rotates the cutting tools into the formation. The productivity and output of every company would, therefore, depend on the assets. To be competitive in the market the drilling companies have to consider creative methods and proven ways to enhance the efficiency of their equipment and systems. This would reduce the total production costs (Elevli and Elevli 2010). Moreover, the efficiency of the drilling equipment is measured using parameters like drill availability and utilization. The availability of the rigs is affected to a large extent by maintenance. Good maintenance of a rig involves strict adherence to the instructions of the manufacturers of the equipment. To consider better maintenance, there must be development and enhancement of maintenance activities.



The said parameters for measuring efficiency have a great impact on the results or productivity of a drilling rig. The parameters can be optimized by reducing the downtimes and operational delays termed as the non-productive activities so as to warrant high availability and utilization, and consequently higher productivities and subsequently lower costs (Kansake and Suglo 2015).

## 1.2 The Perfect Well

According to (Tilley et al. 2015), “The Perfect Well”, is a concept about the absolute fastest time that a well could possibly be constructed. This physical limit is the maximum rate of penetration with no flat times. The two factors are identified on a chart with drilling days against the depth. At the flat times, there is no depth penetration. The rate of penetration is the movement in a vertical position for vertical wells and inclined position for the directional wells that show the progress of drilling. The directional wells have both the inclination and the azimuth which are obtained during drilling surveys. The Perfect Well inspires continuous improvement. The concept achieves this by being an objective measure of well construction effectiveness

Limitation of the perfect well are the obstructions when working towards the Perfect Well. They are attributed to general NPTs, unscheduled events and invisible lost time. The time that is spent not constructing the wellbore, is normally unscheduled and unpredictable. It includes rig repairs, waiting on logistics, wait on deliveries like fuel, waits on water and weather, etc. Similarly, there are others unscheduled events such as well control incidents, reaming, lost circulation, lost equipment, or rig breakdown occurs. All these events can be caused by the rig, the crew or nature. Other lost times that is invisible could be due to inefficiencies in operations.

## 1.3 Related literature

Maintenance strategies include reactive maintenance which is done after detection of the defect with an aim to restore normal operating conditions. The second strategy is preventive maintenance that involves periodic inspection, preventive tasks, and overhaul. This strategy is one of the main strategy studied in the paper. On the other hand, risk-based maintenance brings together analysis, measurements and periodic tests to the preventive maintenance. Lastly is the condition based maintenance which incorporates performance monitoring and corrective actions. Most advanced industrial setups adopt an integrated strategy where they utilize the activities of both the planned and unplanned actions. Other companies mostly use, a reactive strategy that entails the process of bringing a faulty component back to a functional condition following planned or unplanned corrective repair activities (Wakiru et al. 2018). Availability of a rig is dependent on several factors. These factors include all the occurrences that take energy away from penetration of rock. If one could minimize the factors, the maximum drill limit could be realized. Comparatively, in the manufacturing sector, maintenance is becoming a crucial aspect towards realizing a good productivity, especially when considering the entire life cycle of equipment. The overall life cycle time which is the time from production to disposal of a piece of equipment determines the productivity, operational costs, and durability, During the usage phase, life cycle time is impacted by the equipment reliability, maintenance, and recovery strategies. To optimize the lifecycle of the equipment, while achieving lower operating costs during this phase, optimizing equipment maintenance and reliability is important. To achieve this, maintenance can be done while having a well-informed maintenance strategy, well trained and committed human labor and structures, appropriate tactics, confined work activities through proper scheduling and planning, maintenance optimization and reformulation of the process (Wakiru et al. 2018).

Cost of drilling geothermal wells is proportional to the number of days spent while drilling. According to (Nyota and Murigu 2016), the cost of a well is directly related to the time it takes to drill a well. The longer it takes to drill a well, the more the well costs. This cost is passed on to the cost of the project. In severe cases, this may lead to surpassing the budget allocation. Also, wells are drilled within a given project time and it is important to ensure that the project is completed on time by minimizing the time it takes in each activity.

#### 1.4 Case background

The pie chart below indicates the share the maintenance downtime has with respect to the uptime and other non-productive time. It is clear that according to (Nyota and Murigu 2016), only 6 % was incurred as NPT for wells drilled in Olkaria. However, for the well under study, 6% was NPT for maintenance alone. This, therefore, shows that there is much room for improvement and that further research in rig maintenance should be undertaken.

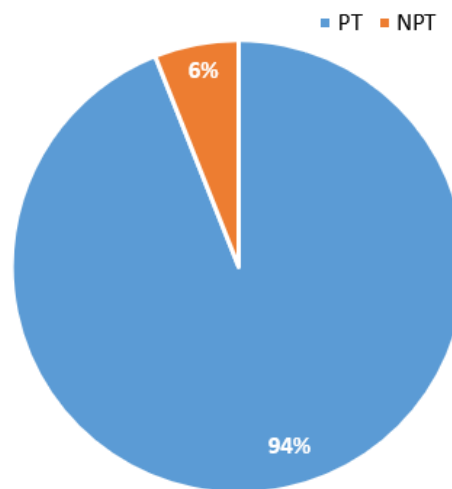


Figure 2: Olkaria Overall PT and NPT chart (Nyota and Murigu 2016)

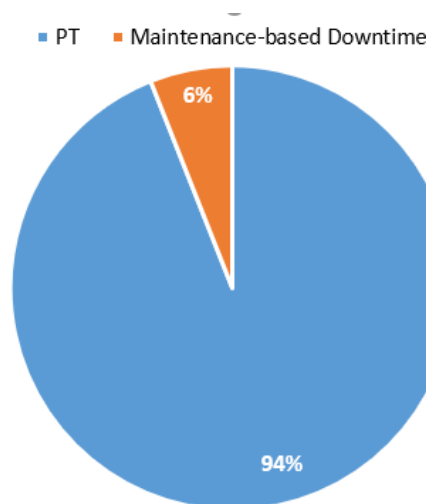


Figure 3: Sample Maintenance NPT

From the graph below, the deviation from the planned drilling days shows that something went wrong. The deviation was majorly caused by non-productive

activities. Among them were sticking, fishing operation, wait on materials, wait on spares and maintenance.

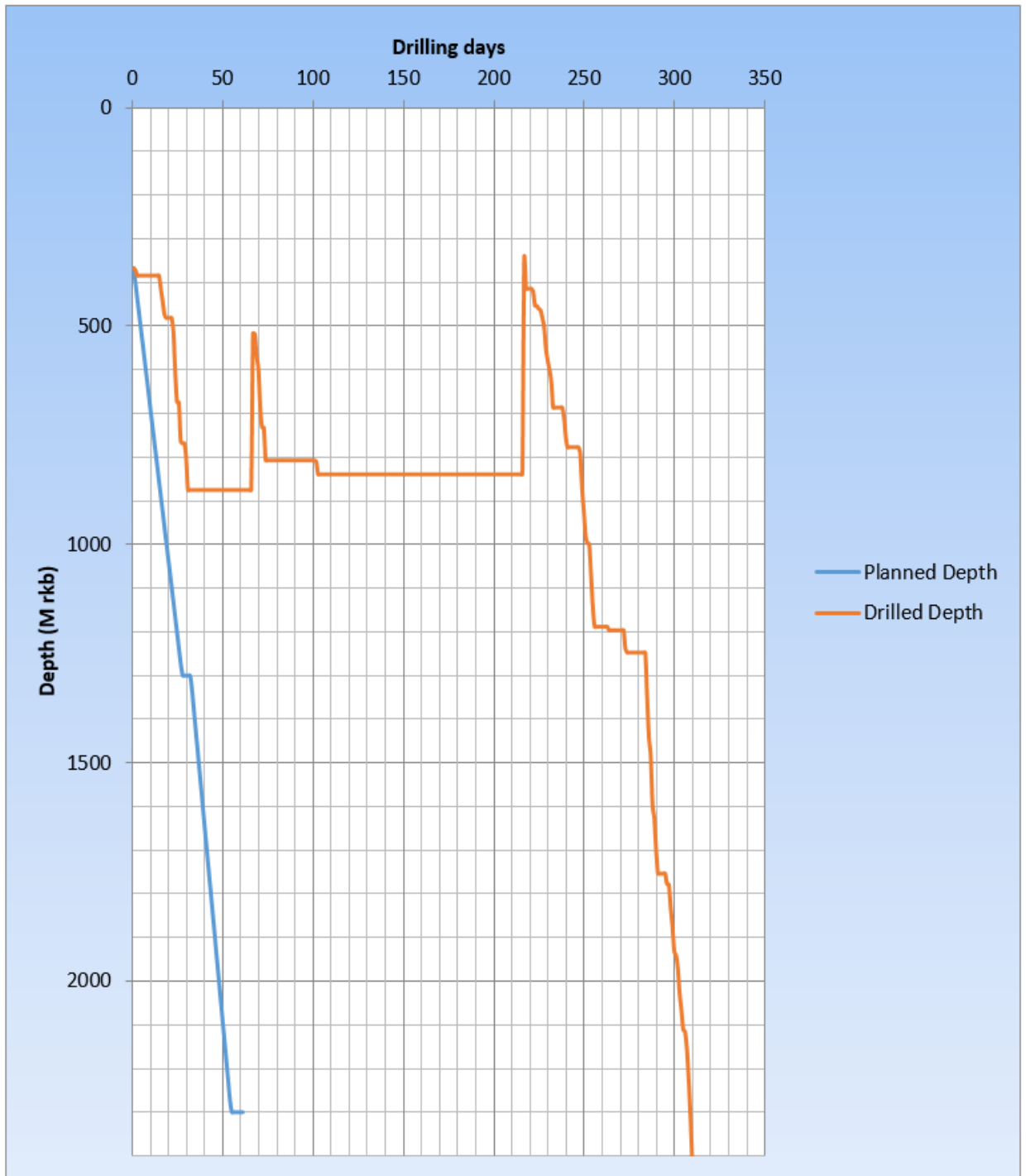


Figure 2: Sample planned drilling days vs actual

### 1.5 Study aim and motivation

From the graph above and the explanation provided, 6% of the lost time was due to maintenance. When the rig components fail, they induce other non-productive time. For instance, when the air drilling system fails, the cuttings fail to be pushed outside and therefore settle on the drilling pipe. Another instance is when the power fails, there will be no rotation and in case the outflow of drilling fluids is not good, then

sticking would be inevitable. Furthermore, when sticking happens, the actions following might be fishing operations. These operations are expensive and would result in the cost of drilling shooting up. This could as well lead to sidetracking which means that the original drilled well profile will have to be abandoned. In extreme cases that have happened is abandoning the well completely. This would result in lost investments.

Optimizing maintenance would, therefore, help in preventing the above from happening and thus check the cost and availability.

When optimizing maintenance it would also be prudent to consider the impact on reliability. A balance must be achieved such that the availability and reliability are high and the maintenance cost is low. By improving the reliability, the failures would reduce and the overall life of the equipment would

## 2. METHODS

### 2.1 Data collection and pre-processing

The data collected was for a well drilled in Kenya, between 2017 and 2018. The total drilling days were 311 against the planned 55 days. This, therefore, makes the well a research interest

Data were extracted from a report in their raw format. The reports included drilling logs, well completion reports, maintenance logs and system stored failure data. The raw data collected was then organized in an excel sheet in an addressable manner for ease of processing and analysis. The data were further categorized according to the subsystems and in order of occurrence. This was the final format which was then ready for modeling.

### 2.2 Data exploration

In this phase, the pre-processed data was explored to retrieve various aspects of the data to inform the modeling. The drilling rig operations can be categorized into nine subsystems as shown in Rig subsystem table

Table 37: Rig subsystems categories

<b>Subsystem</b>	<b>Purpose</b>
Air drilling system	Supply highly compressed air to the drilling string to push the cuttings to the surface. It comprises primary compressors and the secondary compressors.
Hoisting system	Consists of the draw works and other pulley devices used to lift and lower the drilling string into and out of the well.
Power system	Powers all the systems in the rig excluding the air drilling system. It provides power in AC and DC. The system has for main generators and an auxiliary generator.
Well control system	This included the secondary well control systems that help to contain the well during incidences like kicks. It includes the Blow out preventer, the Koomey unit and control boxes.
Well monitoring system	This includes the instrumentation equipment used in monitoring the progress of drilling. It indicates the drilled depth, rate of penetration, weight of the drill string, weight on bit, circulation among others
Mechanical handling system	This is the auxiliary equipment that assists while drilling. It includes shovels, forklifts, power tongs and manual tongs among others

Circulating system	This is used to pump drilling fluid into the wellbore for purposes of cooling the drill bit, carrying the cuttings, stabilizing the well among others
Top Drive system	This is a dynamic rotating system that rotates the drilling system while moving up and down
Rotary table	This is a static rotating system that rotates the drilling string while in a stationary position

### 2.3 Model parameter extraction

For the rig subsystems as indicated in Table 1, various parameters were extracted from the empirical data as will be addressed subsequently.

The **failure frequency** was the rate at which the parts of the systems were failing. This also gives the counts of the failures and thus gives the system with the highest number of failures which could later be a point of interest for further research. The **TNF** also referred to as the time to next failure was derived from the data. This was based on the difference between the current failure of an equipment and or system fail and the preceding failure. The **repair times** for both the preventive and corrective maintenance was extracted from the categorized data. This shows the time spent while doing the repairs be it corrective or preventive. From this, it was also clear that no much has been done on other maintenance policies including predictive maintenance and reliability centered maintenance. The actual **PM intervals** used by the company were also extracted. This was in Hours and was mainly 500 and 4000. The **PM costs and CM costs** were the cost incurred during preventive maintenance and the corrective maintenance. It included the cost of labor and the spares. This was of important since it also forms the pivot of the optimization.

Table 2, illustrates sample model parameters characteristics relating to the different subsystems extracted from the data. This includes the time to initial failure for respective subsystem and the probability distribution for the time to next failure for each subsystem. The TNF was derived by computing the time difference of subsystem failure to the preceding failure on a specific subsystem.

Table 38: Subsystem modeling times

Subsystem	Time to initial failure (Hrs.)	Time to next failure (TNF)
Air drilling system	255	9 + WEIB(240, 0.376)
Hoisting system	679	4 + EXPO(606)
Power system	1963	2 + WEIB(289, 0.339)
Well control system	240	412 + WEIB(121, 0.235)
Well monitoring system	2022	UNIF(122, 2.92e+003)
Circulating system	5116	(-0.001 + EXPO(77.7))
Mechanical handling system	4836	5116
Top Drive system	413	(-0.001 + WEIB(320, 0.339))

While carrying out maintenance on the rig, two main maintenance strategies are explored, which include corrective (CM) and preventive maintenance (PM). Under CM, the different maintenance actions derived from the maintenance data include strategies underlying replacement of failed components with newly manufactured spares, repairing the failed components, adjusting different aspects that cause downtime and finally unclogging the various components such as filters and compressors. While considering PM, the various PM replacement actions

Table 3, indicate the various maintenance strategies with estimated respective mean time to repairs (MTTR) in hours and further will be utilized in the simulation-based model, which is discussed in the following sections.

Table 39: Maintenance actions with respective MTTR

Maintenance action	MTTR (hrs.)
Replace	22.67
Repair	28
Adjust	21.4
Unclog	22
Reset	1
Overhaul -500 hrs	
Overhaul -4000 hrs	

## 2.4 Modelling

Simulation modeling is typically a cost-effective way of substituting physical experimentation. In this case, Arena simulation (Training/ Evaluation/ Student version) was used to model and simulate drilling of a geothermal well. Statistical analysis was used to formulate the data and derive the model parameters which contains all the parameters of actual drilling. The data was represented in a physical model in virtual form then parameters and or conditions were applied. This is the items that were to experiment on a physical model, then simulation modeling followed. This involved leaving the computer to compute/calculate the results of the input conditions on the formulated model. In this way, the actual experimentation was avoided which would have been costly and time-consuming. This enabled the analysis to be cost-effective and efficient.

Figure 2 illustrates the conceptual framework of the model developed for this study. The nine subsystems

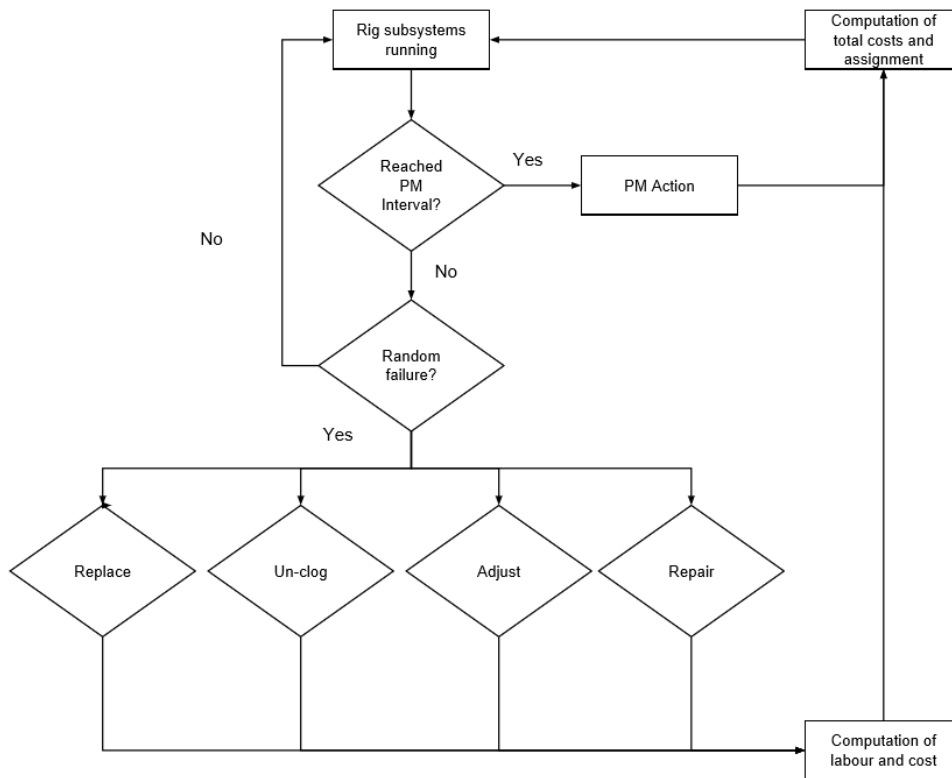


Figure 3: Conceptual framework of the developed simulation model

### 3. RESULTS AND DISCUSSION

In this section, the simulation results are presented followed by a brief discussion on maintenance implications of the results. At the tail end, the summary points at the future research areas proposed to further this study.

The results obtained from the simulation runs were used to thence optimize. The data below was the output from the process analysis in 1000 Euros (K€).

Table 40: Summary of constituent cost elements varying PM Interval

PM Interval (hrs.)	PM Statistics	PM spares (K€)	PM labor (K€)	CM Spares (K€)	CM labor (K€)	Sub-Total Cost		Annual Maintenance cost (K€)	A <sub>0</sub> (K€)
						PM (K€)	CM (K€)		
200	136	136	9.52	61.22	81.997	145.52	143.217	288	63.38
400	83	83	5.81	62.428	78.828	88.81	141.256	230	76.77
500	69.4	66.2	4.618	63.253	78.372	70.818	141.625	212	80.105
600	60	60	4.2	63.116	77.755	64.2	140.871	205	82.98
800	46.9	46.9	3.283	63.215	76.903	50.183	140.118	190	86.515
1000	38.9	38.9	2.723	64.36	75.923	41.623	140.283	182	89.44
1200	33	33	2.31	63.557	75.564	35.31	139.121	175	90.687
1400	28.8	28.8	2.016	62.898	75.382	30.816	138.28	169	91.6

From Table 4, the results depict that an increase in the PM interval generates an increase in the rig availability and a significant decrease in the annual maintenance cost. This is also visualized in Figure 2, which illustrates that the availability starts to plateau at approximately 90%. Similarly, the maintenance costs at the indicated plateau A<sub>0</sub>, is approximately 182K€.

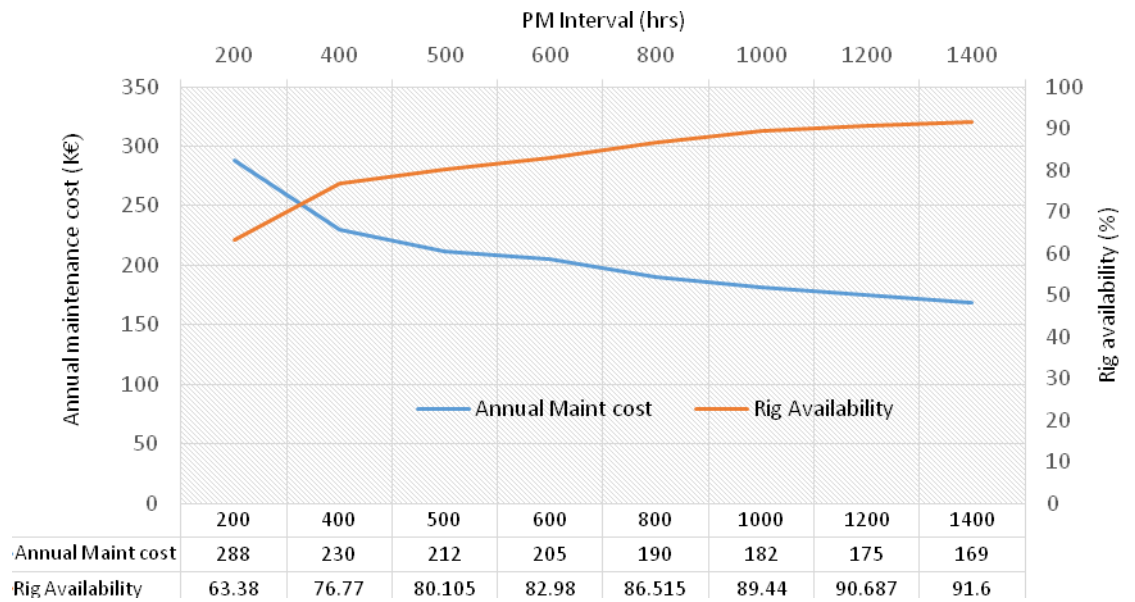


Figure 4: Graph illustrating rig availability and total maintenance cost- varying PM Interval

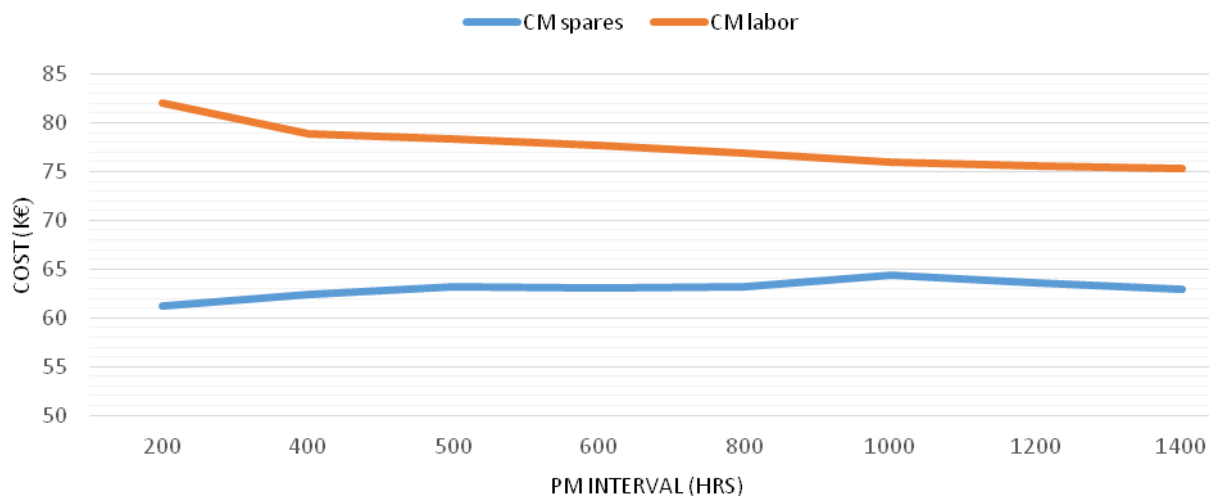


Figure 5: CM spare and labor cost results while varying PM Interval

Concerning the PM cost constituents, that is labor and spares, the percentage decrease of the two costs show a similar trend which indicates a close relationship between the two PM costs.



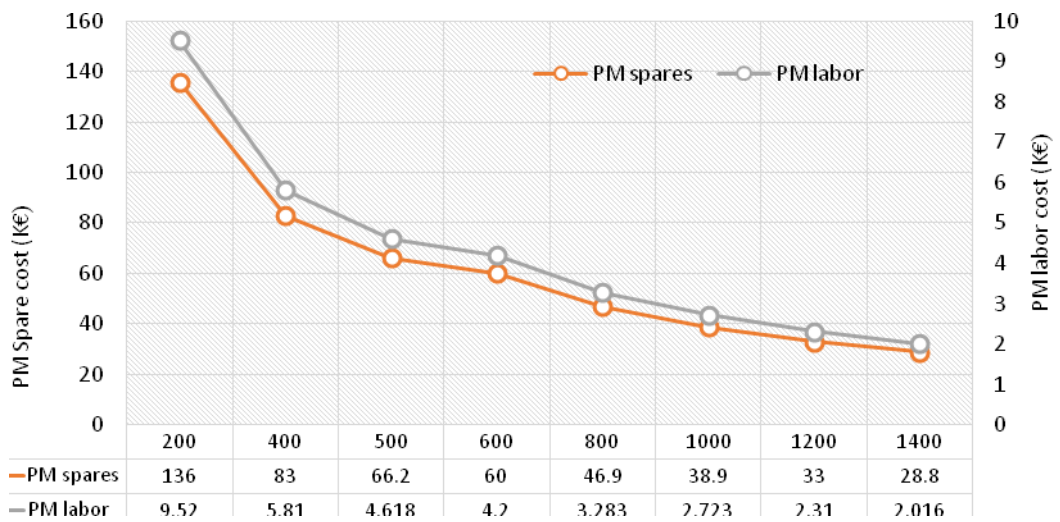


Figure 6: Rig availability and total maintenance cost results while varying PM Interval

Figure 5 shows the trend for the preventive maintenance spare cost and preventative maintenance labor cost with respect to the PM interval. As the PM interval increases, the two costs go down and seem to flatten with an increase in PM interval

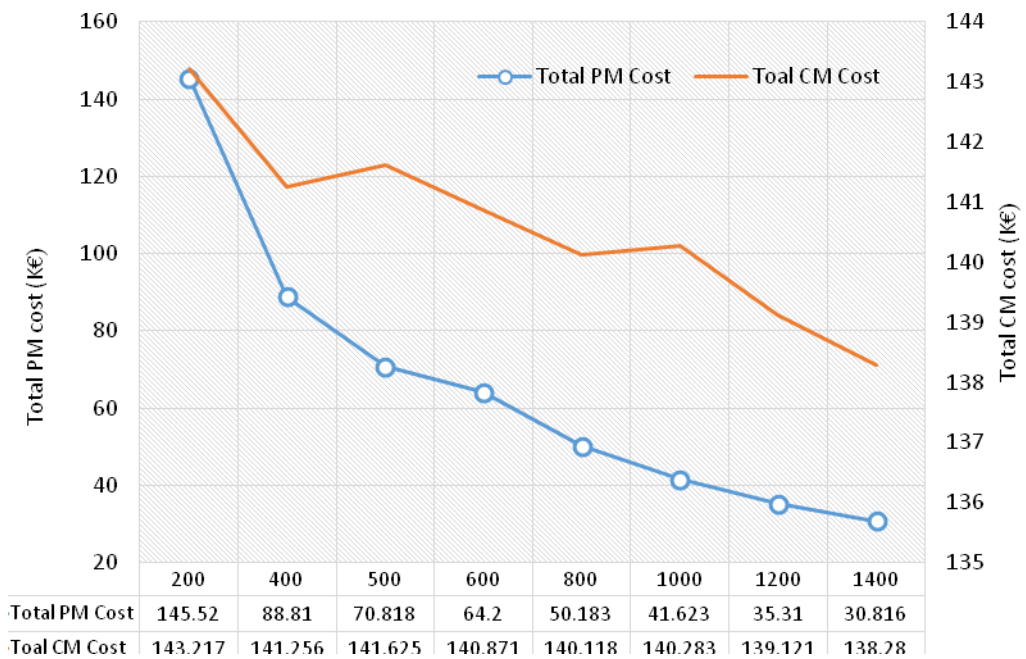


Figure 7: Rig availability and total maintenance cost results while varying PM Interval

This chart is of high importance since the main objective of the paper is to investigate the relationship between the PM interval and the maintenance total costs. It shows that the costs go down as the PM interval increases.

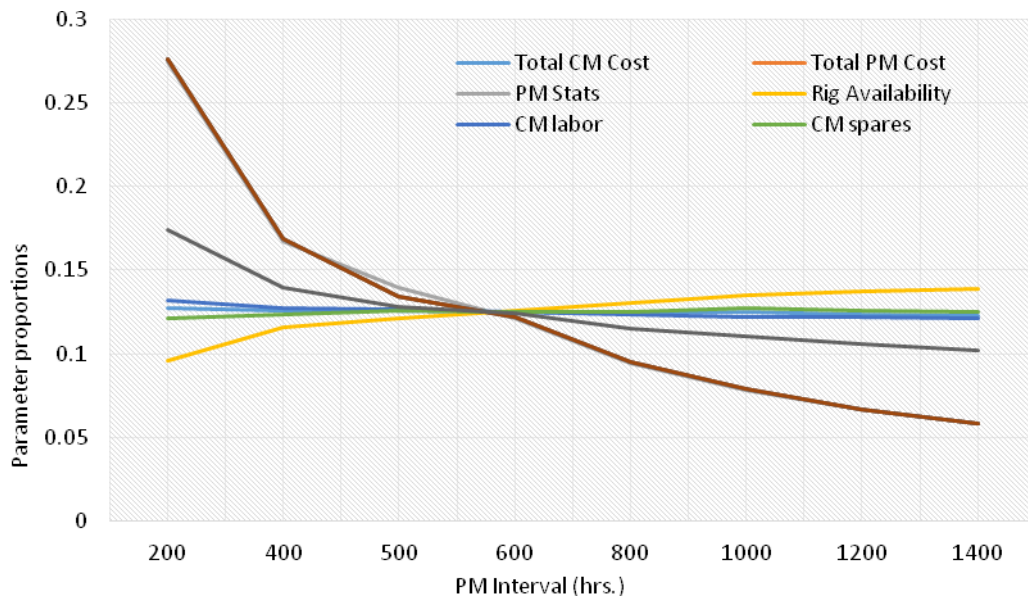


Figure 8: Rig availability and total maintenance cost results while varying PM Interval

Figure 7 carries all the variables under investigation. The values used are a ratio of the respective value to the total value in percentages. This enabled the comparison to be in the same scale and units. All the costs are seen reducing with an increase in the PM interval. The only item increasing with PM interval is the availability. PM spare appears to be the most significantly reducing cost with an increase in PM interval

#### Scenario analysis

As the gap between the various scheduled preventive maintenance increases the availability with respect to delay due to maintenance increases. The cost of maintenance is also observed to go down. The total cost of maintenance is a summation of the preventive labor cost, preventive maintenance spare cost, corrective maintenance labor cost and the corrective maintenance spare cost.

#### 4. CONCLUSION

In this study the objective was to develop a simulation-based model to investigate the various maintenance variables and if the variables impact on the rig availability and the total maintenance cost. The developed model considers corrective maintenance and preventive maintenance of the various subsystem that constitute the rig. In this preliminary study, we have investigated the effect of PM Interval changes on the rig availability and total maintenance cost. The results seem to suggest that the rig availability increases as the PM interval increases. The various maintenance costs are noted to reduce with respect to the increase in PM interval. The reduction of the maintenance cost as the PM interval is increased, is an aspect that should be cautiously be addressed. The developed model has not addressed the subsystem reliability which we view can significantly affect the maintenance cost.

With further, propose to introduce a reliability index of the subsystems into the model to realistically address the aspect of degradation or wear of the subsystems. This being an aspect for our next phase of the research, will realistically mimic the actual operations and maintenance of the system hence address comprehensively the maintenance cost, availability, and reliability. The reliability will take care of the equipment lifecycle to ensure the return on investment is realized before decommissioning of the various equipment or subsystem.

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## **Piloting commercial production of charcoal briquettes from sugarcane bagasse in Homa-Bay County, Kenya**

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### **Abstract**

Homa-Bay County in the sugarbelt of Kenya has only 3% of the land covered by trees. About 75% of households depend on wood from unsustainable forest resources for energy needs. However, in Ndhiwa Sub-County, large volumes (about 3,000 tonnes per year) of sugarcane bagasse generated from two nearby sugar mills remain unutilized. Inappropriate disposal of these residues emits greenhouse gasses (GHGs), responsible for the global climate change. Besides, the communities living next to the mill face a number of challenges that include: poverty, unemployment, food insecurity and lack of access to clean energy. In the framework of Green Economy Partnership (GEP) project implemented by Kenya Forestry Research Institute (KEFRI) and Gum Arabic and Resins Association (GARA) between 2015 and 2017, three community-based bio-enterprise cooperatives have been set-up to produce and distribute carbonized biomass briquettes in Ndhiwa. High quality briquettes have been produced and are replacing wood charcoal and creating opportunities for jobs and poverty reduction. Important lessons have been learnt, critical for scale-up and replication, which include innovative business model of waste-to-energy to scalable business opportunities. Further, the project has provided technology transfer pathway by linking tested technology to the industry, especially the micro-enterprises in the renewable energy value chain. Trials conducted on various aspects of the technology, processes and products are important for improving the production system and logistical processes of feedstock acquisition.

Some key policy recommendations include: formalization of the supply plan with feedstock suppliers and sugar millers; policy revisions to help eliminate identified challenges; optimization and strengthening of the briquette value chain to commercial operations; promotion of standardization of charcoal briquettes for wider market acceptability; promotion of information, research, technology development and transfer; enhancing partnerships and synergies including public-private partnerships for investments and effective management of community-based briquette-fuel enterprises.

**Key words:** Bagasse, Briquettes, Homa-Bay, Ndhiwa, Kenya

## **INTRODUCTION**

In the sugar belt of Ndhiwa Sub-County of Homa-Bay County, with a population of 172,000 (CGH, 2013), at least 85% of households depend on biomass fuel (charcoal and firewood) for their energy needs especially for cooking and heating (GEP, 2015).

Ndhiwa sub-county is amongst the remotest areas in the region, facing a number of socio-economic challenges (GEP, 2015). Poverty among the inhabitants is estimated at 60% as compared to the national average of 47% (KNBS, 2010). The high level of poverty is exacerbated by lack of employment opportunities, food insecurity and degrading environment with forest cover of 3% (FAO, 2017). Yet, apart from semi-processed sugarcane waste from local jaggeries, and cane trash in small farms in the villages, about 100,000 tonnes of surplus bagasse generated by two nearby sugar mills is heaped and left to decay around the mills or burned in open fields under uncontrolled conditions (AFA-SD, 2016). Inappropriate disposal of bagasse emits greenhouse gasses (GHGs) such as methane, a dangerous gas responsible for global climate change (FAO, 2014). While turning bagasse into carbonised briquettes can help address various challenges facing surrounding communities, technical, market, financial and policy barriers must be overcome.

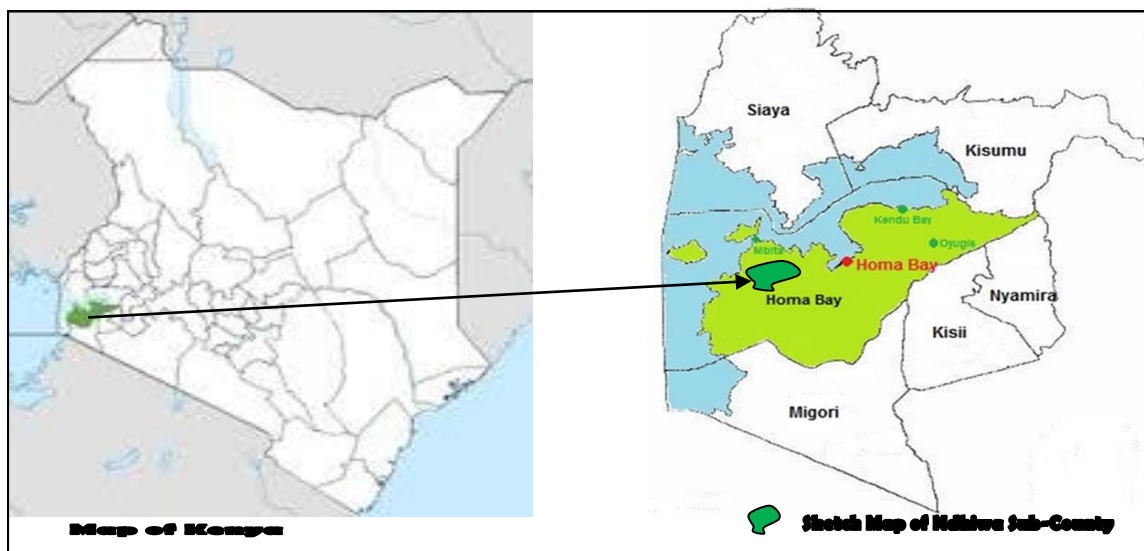
A pilot project “Creating Green Local Economy through Commercial Production of Biomass Briquettes from Agro-Industrial Residues – ‘Green Economy Partnership’ (GEP, 2017) jointly implemented by Royal Norwegian Society for Development (Norges Vel), Kenya Forestry Research Institute (KEFRI) and Gum Arabic and Resins Association (GARA) financed by the Nordic Environment Finance Cooperation (NEFCO) targeted to address some of the challenges facing rural communities in Ndhiwa Sub-County.

The objective of the project was to develop the capacity of local enterprises in sustainable production and supply of carbonized biomass briquettes from sugarcane bagasse. The project aimed to support production of high quality briquettes using efficient carbonization and briquetting methods for thermal applications in households, local enterprises and institutions.

## **METHODS**

### **The project area**

The project was implemented in 5 locations in Ndhiwa Sub-County covering five wards of Kanyadoto, Kanyikela, South Kabuoch, North Kabuoch and Kanyamwa. Ndhiwa is one of the eight sub-counties in the Homa Bay County located along the south west shore of Lake Victoria’s Winam Gulf. Homa-Bay borders five counties of Migori, Kisii, Nyamira, Kericho and Kisumu. The county consists of seven sub-counties namely; Mbita, Homabay Town, Rangwe, Karachuonyo, Kabondo, Kasipul, Suba and Ndhiwa (Figure 1).



**Figure 1: Map of project area**

### **Population and economic activities in the project area**

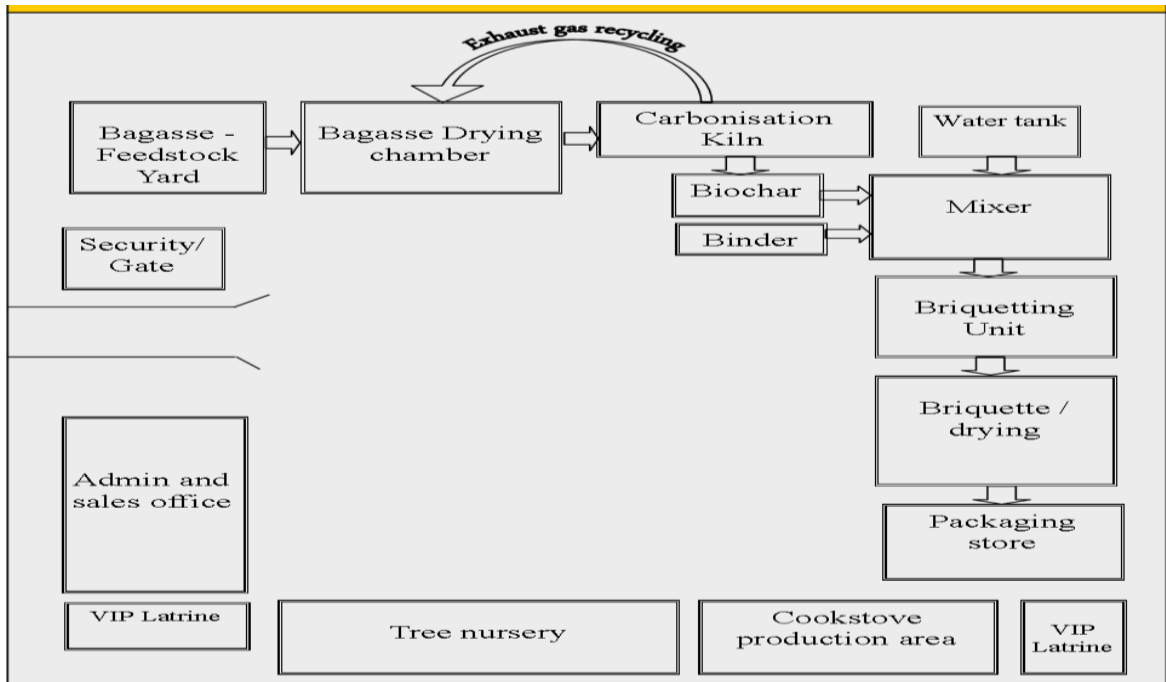
Ndhiwa Sub County has an area of 711.40 Km<sup>2</sup> and a population of 172,212 (KNBS, 2010). The communities in the project area are mainly involved in subsistence agriculture with sugarcane being the main cash crop. Sugarcane grown in the area is crushed at the Sukari Industry, a nearby private sugar company. In addition, there are over 200 local jageries in operation which also provide outlet for the sugarcane crop grown.

### **Methods and processes**

This case study of a pilot project used cooperative business model as an approach to linking tested biomass carbonization and briquetting technology to private sector was implemented through three interlinked key tasks: sustainable briquette production, market analysis and development and advocacy. Sustainable briquette production focused on technology development, setting-up of pilot production enterprises and determination of optimal production parameters. Market analysis and development involved consumer surveys, analysis and business modeling and establishment of distribution outlets. Business advocacy involved organizing farmers into cooperatives, engagement with county government and private sugar millers.

### **Setting-up of community-based briquette micro-factories**

As part of preparatory process, a series of stakeholder consultative meetings were held. After environmental impact assessment and licensing, layouts of 5 production units in five locations were set-up. A complete model of production line was developed (Figure 2).



**Figure 2: Schematic process flow of carbonized briquette production**

### **Design and fabrication of dual-extruder screw briquetting machine**

The project adopted a dual-extruder screw briquetting machine. The design was based on results of an evaluation of existing briquetting machines models in Kenya. The first prototype with 10HP capacity was developed and installed in first production site. This was subsequently modified with improvements to 15HP capacity (Table 1). Fabrication was done at Migori Engineering Facility by trained technicians with technical support from the project team.

**Table 1: Specifications for improvement of briquette machine**

S. No	Item	Description
1.	Motor	15 Hp geared and 3 phase
2.	Production capacity	1 tonne/ day
3.	Finished product size	39 mm diameter
4.	Finished product shape	Cylindrical
5.	Raw material	Carbonized bagasse
6.	Screw length	24 inches
6.	Screw housing	4 inches cylindrical pipe diameter, 1.5 inches thickness
7.	Stand	Height 16 inches made of 2 inch thick angle line metal.
8.	Electrical accessories	3 phase Electrical socket
9.	Pulleys and belt	Diameter of big pulley 375 mm, small pulley 125 mm , V belt with A cross section size B50
10.	Feed hopper	Same as KEFRI model
11.	Screw shaft	Length 32 inches and 1.5 inch diameter

### **Design and fabrication of carbonisation kiln**

The carbonisation kiln was designed with two chambers: fireplace and carbonisation chamber. Fabrication and installation of carbonisation kiln, constructed of steel and insulated with fire bricks involved a series of testing and adjustments during the



project period.

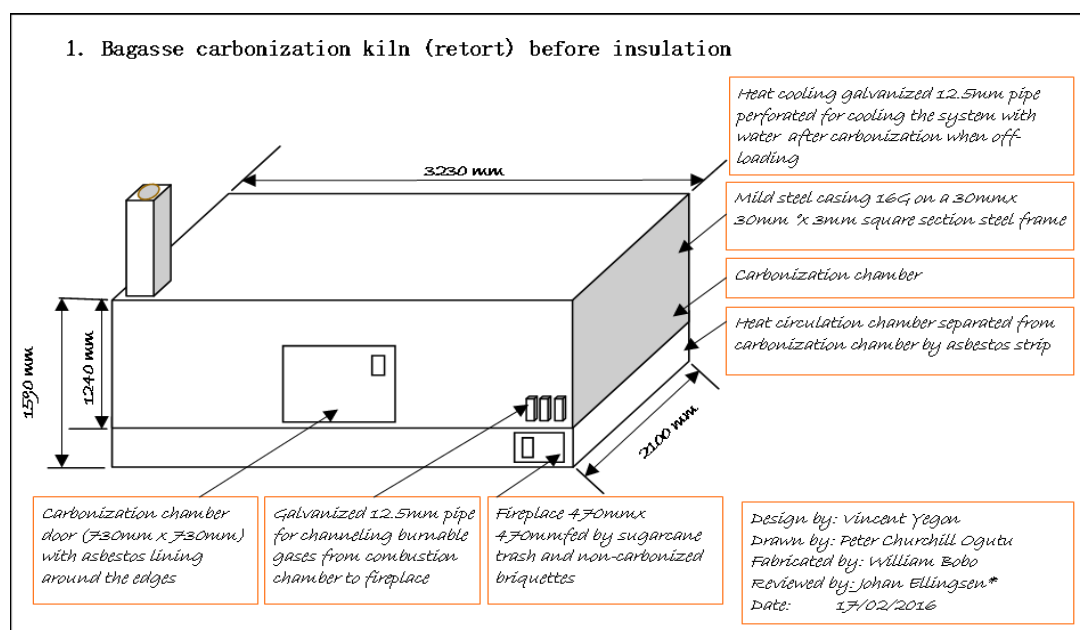


Figure 3: Sketch of bagasse biomass carbonization kiln

### Development of feedstock supply plan

Feedstock survey was conducted among the two existing sugar mills and 50 local jaggeries mills. From cost analysis for gum arabic-based binder, a feedstock supply plan was developed through consultative business planning workshop.

### Technical and economic parameters

The needed data on technical production parameters that would ensure best quality briquettes and determine the profitability of briquette production was collected using two methods. This involved observation and recording of inputs usage during briquette production test runs. Technical data capture forms were developed and used to record data on input (bagasse, binder, labour and power), production (biochar and briquettes) and sales. The daily data were summarized into weekly production reports by trained production clerk. Bagasse briquette production facilities at Awendo and Muhoroni were also visited and informal discussions on drying and sales held with the operators. entered into SPSS template and analyzed.

### Briquette product testing and evaluation

Samples of standard carbonized briquettes of size 32mm in diameter and 63.5mm long were obtained from Ligodho Briquette Factory. Energy properties and emission laboratory tests were undertaken at KEFRI and Kenya Industrial Research Institute (KIRDI) laboratories using indoor emissions analyser and Kenya Ceramic Jiko (KCJ). The tests were conducted in accordance with the WBT 4.2.2 (Guidelines for testing Charcoal Stoves) stove testing protocol and fuel analysis approach measured in an oxygen bomb calorimeter. Tests were meant to gauge the briquettes against known standards (South African), which included calorific values, ash content, volatile matter, fixed carbon content, emissions for CO<sub>2</sub>, CO, and particulate matter.

In order to test acceptance of carbonized bagasse briquettes, a consumer feedback survey was conducted among 199 households in 5 locations in Ndhiwa project area.



Each household was provided with 5 kg of carbonised bagasse briquettes, 5 kgs of charcoal from acacia trees (*Acacia gerrardii*) and KCJ cookstoves. Each household used briquettes and charcoal to cook their normal meals for a period of 2 weeks, each energy product per week. Using follow-up forms, data were collected by enumerators for one week. Data was coded and analysed.



**Picture 1: Briquettes in 45-kg pack bags**

**Picture 2: Briquette testing in KCJ cookstove (Burning time and heat value)**

### **Market analysis and potential for carbonized biomass briquettes**

Study was conducted to analyse and understand biomass energy market situation in the project area, perception of consumers on biomass briquettes and to capture consumer willingness to shift to charcoal briquettes as source of energy. For energy efficiency, a simple guide (tool), determining energy consumption was developed and piloted to 50 households. Questionnaires were administered in 199 households, 10 schools and 10 eateries randomly selected. A total of 4 marketplace events and trade exhibitions were also held in Ligodho Market, Kendu-Bay, Eldoret and Kisumu. Data from consumer analysis, energy efficiency audit and marketplace events were entered into SPSS template and analysed.

### **Business development and policy, legislative and institutional frameworks**

Rapid stakeholder mapping; engagement through consultative meetings with public and private sector actors were held. Formation of cooperatives involved community sensitisation and consultations, and engagement responsible Ministry of Cooperatives. Advocacy efforts involved dialogue and consultative meetings, media engagement, awareness creation events, as well as advocacy training. Technology and knowledge transfer involved technical and skills training for adoption of biomass briquette technology and publications.

## **RESULTS AND DISCUSSIONS**

Key achievements of the pilot project was the establishment of 3 briquette production units in 3 locations, establishment of 5 bio-enterprise cooperative societies and capacity building in technical skills, business aspects and technology and knowledge transfer. The following (Figure 4) are key specific results achieved during the 30-month project period:

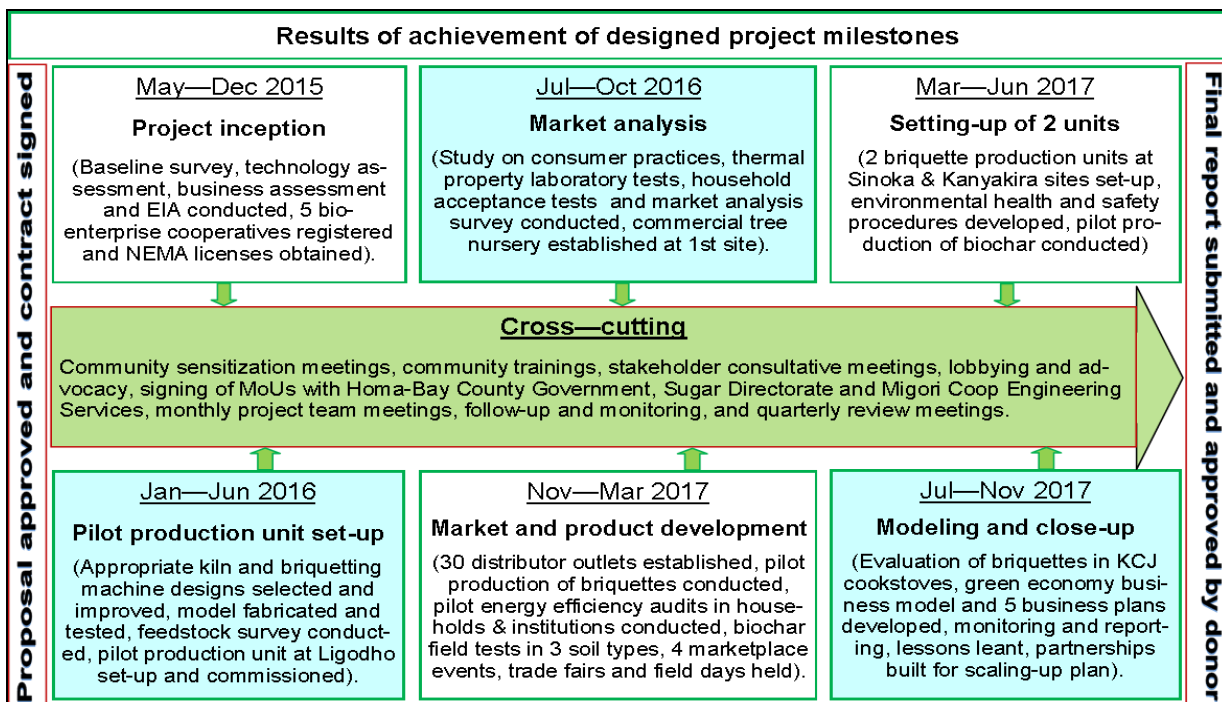


Figure 4: Results of achievement of designed project milestones

### Setting-up of community-based briquette micro-factories

By the end of the project in Nov. 2017, three briquette production units had been set-up in three locations in Ndhiwa. Each unit had a complete production line comprised of carbonisation kiln, briquetting machine, feedstock yard, and a briquette drying area.

#### Biomass carbonization kiln

Four high efficient bagasse carbonisation kilns were installed and commissioned at three briquette production sites (Picture 5). After modifications of the first two models, the final kiln had a capacity of converting 350 kg bagasse of 11-13% moisture content into 75 kg biochar in 4-6 hours at a temperature of 320°C. Kiln operators were trained to ensure the parameters were achieved.



Picture 5: Complete kiln in operation at Sinoka Bioenterprise factory



Picture 6: Former CS Environment Prof. Judy Wakhungu with operators at Briquette factory

#### Dual-extruder screw briquetting machine

Three 15HP-capacity briquette screw extruders were installed, each with a designed production capacity of 1 tonne of briquettes per 8-hour day operation (Picture 6). The

high compaction technology consists of screw press. The biomass is extruded continuously by a screw through a taper die. In the process, briquette quality and production procedure is enhanced, achieving uniform and efficient combustion. Table 2 shows technical optimization parameters of complete production line at Ligodho Micro-factory.

**Table 2: Technical optimization parameters**

<b>Material</b>	<b>Parameter</b>	<b>Value</b>
<b>Production process type</b>	Batch process hour/day	8
<b>Bagasse sourced from Sukari Industries</b>	Moisture content before drying (%)	51
	Moisture content after drying (%)	10-12
	Capacity ( Kgs of dried bagasse/batch)	350
	Temperature ( °C)	320
<b>Carbonization kiln</b>	Carbonization ratio	4:1
	Duration in hours of carbonization – residence period depending on moisture content (hours)	4 - 6
<b>Briquetting machine</b>	Production capacity ( Kgs wet briquettes per hour)	40
	Power rating (HP)	15
	Duration ( Days)	2
<b>Wet briquettes drying</b>	Moisture content before drying (%)	16
	Moisture content after drying (%)	7-10
	1 kg gum arabic binder in 10 litres of water	1:10
<b>Mixing/formulation</b>	4 litres of the gum arabic solution is mixed with 5 kgs of carbonized material	4:5
	1 tonne of carbonized material requires 800 litres of water and 80 kgs of gum arabic.	1:800:80
<b>Number of operators/ personnel</b>	Briquette machine	5
	Carbonization kiln	2
	Drying ( bagasse and briquettes)	2
	Supervisor/Manager	1

### Analysis of feedstock needs for bio-enterprises

The main feedstock materials identified were sugarcane bagasse from nearby sugar mill, semi-processed bagasse from local jaggeries and gum arabic as the binder. Table 3 below provides an analysis of feedstock needs for the three bio-enterprises over three years.



**Picture 3: Sugarcane bagasse from sugar mill**



**Picture 4: Sugarcane waste from jaggery mills**



**Picture 5: Gum arabic – binder material**

**Table 3: Overall analysis of feedstock needs (Kgs)**

Cooperative	Year 1		Year 2		Year 3	
	Gum arabic (Kg)	Bagasse (Kg)	Gum arabic (Kg)	Bagasse (Kg)	Gum arabic (Kg)	Bagasse (Kg)
Likabics	14,584	700,607	17,347	833,377	23,543	1,131,027
Sinoka	3,831	184,052	5,446	180,226	6,840	328,599
Kanyakira	3,889	702,819	9,056	435,074	11,480	551,508
<b>Total</b>	<b>22,304</b>	<b>1,587,478</b>	<b>31,849</b>	<b>1,448,677</b>	<b>41,863</b>	<b>2,011,134</b>

The three cooperatives have a combined total need of gum arabic of 22.30 tons, 31.85 tons and 41.86 tons and bagasse 1,587 tons, 1,449 tons and 2,011 for years 1, 2 and 3 respectively. The results of feedstock needs (Table 3) indicated that the co-operatives are assured of bagasse supply from either the two sugar factories or from the jaggeries. The supply of gum arabic is however highly vulnerable to other possible uses and hence the need to identify other suitable binding materials.

#### Analysis of production and impact on CO<sub>2</sub> emissions reduction

Real production of biochar and briquettes in three enterprises was conducted between June 2016 and Nov. 2017 (Table 4). Reduction of CO<sub>2</sub> emissions achieved was 7.7 tCO<sub>2</sub> from production units in a period of 17 months and a further 3,360 tCO<sub>2</sub> from 28,000 trees planted over a period of 24 months. The overall reduction of 33,709 tCO<sub>2</sub> is projected over 20 years.

**Table 4: Summary of CO<sub>2</sub> effect of bagasse and biochar processed**

Bioenterprise	No of employees	Bagasse received kgs	Biochar produced kgs	CO <sub>2</sub> subst. effect kgs	Biochar on stock kgs	CO <sub>2</sub> subst. effect kgs	Briquettes produced and sold kgs	CO <sub>2</sub> subst. effect kgs	Biochar sold to farmers kgs
Ligodho	7	54,759	8,994	16,189	3,985	7,173	4,259	7,666	750
Sinoka	5	20,040	2,300	4,140	1,800	3,240	0	0	500
Kanyakira	3	3,400	417	751	137	247	0	0	280
<b>Total</b>	<b>15</b>	<b>78,199</b>	<b>11,711</b>	<b>21,080</b>	<b>5,922</b>	<b>10,660</b>	<b>4,259</b>	<b>7,666</b>	<b>1,530</b>
<b>Assumption:</b>	1 ton briquette is estimated to replace 1.2 tons non-sustainable wood (1.5 t CO <sub>2</sub> /ton wood)								

#### Thermal characteristics of carbonized bagasse briquettes

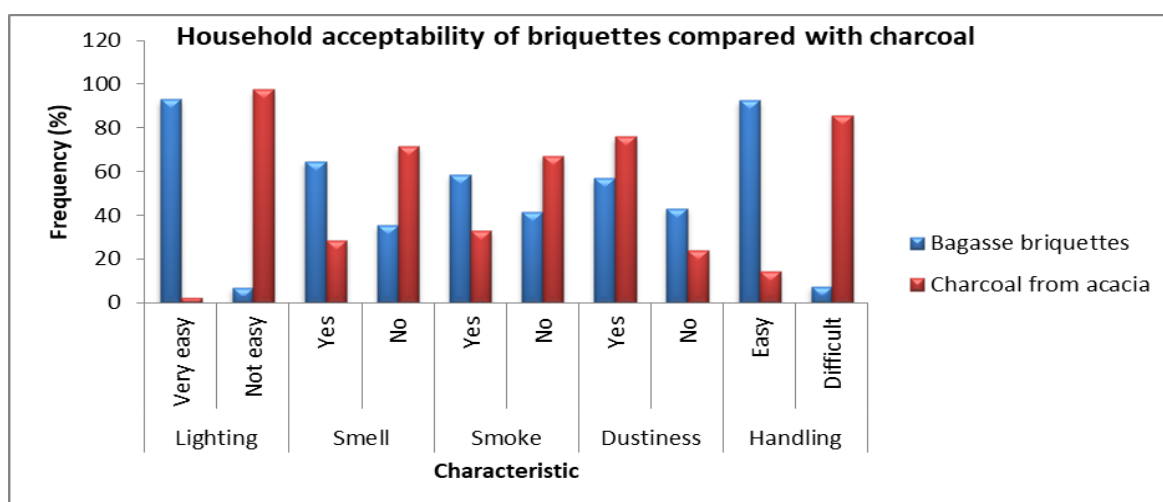
Results from two laboratory tests done at the start of production and after adjustments of production parameters showed that the calorific values of the briquettes gradually improved from 4.5 kcal/g to 5.457 kcal/g (Table 5). The improved calorific value is well within the range of ordinary hard wood charcoal. However the amount of particulate matter was noted to be high especially during the lighting up stage. The high ash content of 20% continued to be challenge. The indoor emissions though high are within limits permitted in Kenya.

**Table 5: Laboratory test results on bagasse briquettes using gum arabic as binder vs charcoal from wood (*acacia gerrardii*)**

Parameter	Charcoal briquettes	Charcoal from acacia gerrardii
Gross calorific value	5.457kcal/g	6.253Kcal/g
Moisture content	5.9%	4.5%
Ignition time	4min	3min
Fixed carbon	41.6%	75.9%
Volatile matter	11.4%	17.9%
Time to boil 5L	34min	23min
Glowing time	164min	154min
Charcoal consumed	424g	424g
Ash remaining	86g	48g
Ash content	20g	8g
Heat value	540 <sup>0</sup> c	760 <sup>0</sup> c

### Consumer acceptability test of carbonized briquettes in households

From results of household acceptability test for applications for cooking, carbonized briquettes and wood charcoal from acacia tree exhibited different characteristics (Figure 6).



**Figure 6: Characteristics of briquettes and charcoal for household use**

Majority of the respondents (93%) found briquettes very easy to light while 55.8% of the respondents rated charcoal as being moderately easy to light. On smell, 64.8% of the respondents said briquettes produced smell against 35.2%. A bout 71.4% of the respondents said charcoal had no smell compared to 28.6% who reported some irritating smell. About 58.3% of respondents said briquettes produced smoke in the lighting stage, whereas 67.3% said charcoal did not. On application, majority of the respondents (92.5%) felt the briquettes were of medium size and easy to handle and (56.8%) found them moderately dusty. However, 85.9% of the respondents felt the charcoal, was of big size and difficult to handle with 75.9% found them very dusty. For the various type of food cooked by households, an average amount of a 2kg tin of briquettes required was 2.0 and that of charcoal was 1.8.

From the results, for consumers, a type of energy source which is faster to light is preferred. However, a smelly, smoky or dusty energy source can be a deterrent to its use and preference by consumers. Smell, smokiness and dustiness can be attributed to use of materials which are not completely carbonized, type of materials and binder used. Consumers prefer use of energy source which is cheaper that would save the



family financial resources.

### Market analysis and potential for carbonized biomass briquettes

Results from market analysis showed the current energy utilization levels in Ndhiwa project area as shown (Figure 4) are households and (Figure 5) restaurants and institutions. For households, firewood (84.8%) was identified as the most common energy source for cooking followed by charcoal (11.2%). Others included paraffin, crop residue and gas.

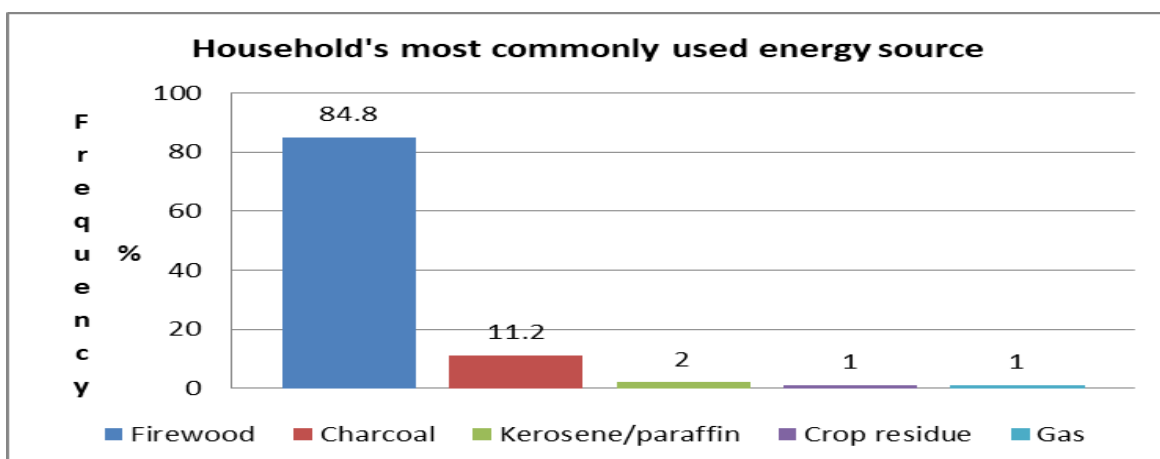


Figure 4: Household's most preferred energy sources

Of 23 restaurants with a daily average of 170 customers interviewed, the most preferred sources of energy (Figure 5) were charcoal (65.2 %), firewood (30.4 %) and gas (4.4%).

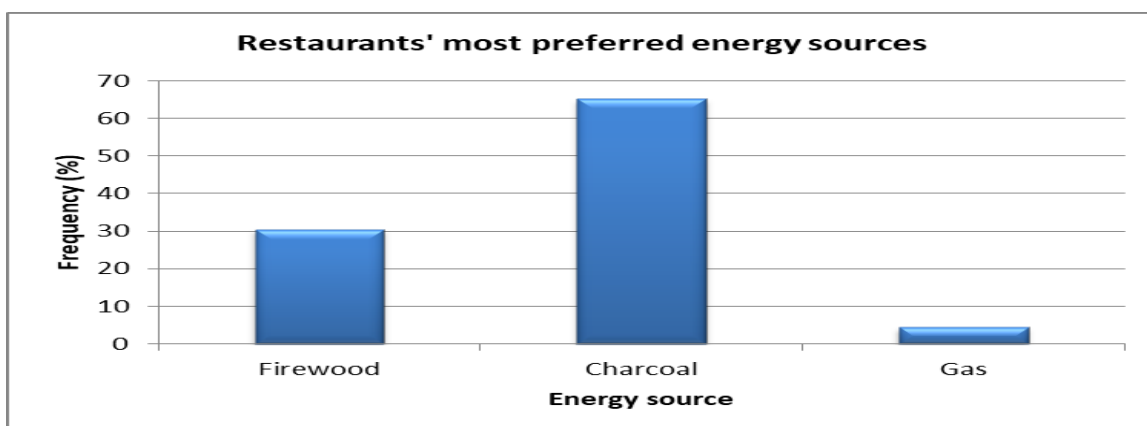


Figure 5: Restaurants most preferred energy sources

Traditional three stones (64%) and KCJ (32%) were most common types of stoves used. Results from focused group discussions revealed worsening accessibility for firewood and charcoal in the next five years and that plantation sugarcane farming practice in the region has led to rapid decline in tree density. On alternative sources of biomass energy, only about 30% of respondents revealed that they have some little information about briquettes. The fact that households and businesses are finding hard to access firewood and charcoal suggests that there is currently unmet energy needs and hence briquettes have potential to bridge the gap.

### Business modeling and economic analysis

Results of financial analysis indicate that within 17 months, a total of 4.3 tonnes of carbonized briquettes, 1.53 tonnes of biochar as soil improver and 18,840 tree seedlings had been sold by first production unit. The total income generated was KES 219,356 with a net profit of KES 78,140 (Table 6). However, the low production was as a result of challenges including modifications and long shut-down times due to frequent power outages. The sales are guaranteed so long as production is able to service order by customers as briquettes and tree seedlings are sold immediately as they are produced.

**Table 6: Financial analysis for Ligodho Bioenterprise (June 2016 to Nov. 2017)**

<b>Product</b>	<b>Price (KES)</b>	<b>Amount sold</b>	<b>Total (KES)</b>
<b>Income</b>			
Briquettes sold in 95 bags @ 45 kgs (KES/bag)	800	95	76,000
Biochar sold to farmers (KES/kg)	20	1,530	30,600
Trees (KES/each)	6	18,840	113,040
<b>Total (KES)</b>			<b>219,640</b>
<b>Production cost</b>			
Cost of production of briquettes/45kg bag (KES 20/kg x 45 kgs)	900	95	85,500
Cost of production/tree seedling	2	28,000	56,000
<b>Total (KES)</b>			<b>141,500</b>
<b>Net profit</b>			<b>78,140</b>
<b>Assumption:</b> 1 piece of briquette block of 63.5 mm (length) by 32 mm (diameter) has the weight of: $1000 \text{ grams} / 35 = 28,7 \text{ grams}$			

### **Policy advocacy and associations**

Through consultations and engagement with Ministry of Cooperatives, 5 cooperative societies were formally registered, trained and linked to manage the briquette production units and participate in market systems and improve livelihood of their members. A total of 30 local traders were trained as briquette distributors, while 9 trained in carbonisation and briquette production. Although the concept generated overwhelming support from community, county and national governments, private sector, and media, key infrastructure like stable electricity supply, all weather road networks, markets and access to feedstock remained main policy challenges to sustainability of production units.

### **CONCLUSION**

#### **Conclusion**

Key achievements of the pilot project was the establishment of 3 briquette production units in 3 locations, establishment of 5 bio-enterprise cooperative societies and capacity building in technical skills, business aspects and technology and knowledge transfer. In regard to climate change mitigation, a total of 7.7 tCO<sub>2</sub> had been reduced from production units and a further 3,360 tCO<sub>2</sub> from trees planted with projected overall reduction of 33,709 tCO<sub>2</sub> over 20 years. Although the project target of establishing 5 production units was not fully realized due to unforeseen challenges,

the concept has demonstrated opportunities for addressing multiple challenges facing smallholder sugarcane farming communities. However, sustainability of the pilot production units is subject to: i) formalisation of agreements for access to sugarcane bagasse or alternative biomass feedstock, ii) stability of power supply in the region and optimisation of production processes to achieve commercial operations and; iii) streamlining of open and ethical biomass energy markets including implementation of charcoal rules (regulations), product standardisation and certification. Potential partnerships with county government, sugar directorate, other non-governmental organisations (NGOs) and private sector provide possibility for scaling up and replication of the business model.

## **Recommendations**

**1:** There is need to review and lobby for improved policy and legislative framework conditions including provision of necessary infrastructure (roads, electricity and markets) for development of sustainable briquette enterprises within the sugar commodity value chains.

**2:** Link community-based briquette enterprises with public and private sugar millers and suppliers and formalize contractual agreements for guaranteed availability of bagasse.

**3:** In order to meet the increasing market demand, there is need to support optimization of production, efficiency and logistical systems of pilot briquette factories to achieve best cost/performance parameters for commercial-scale operations and economic viability.

**4:** To enhance safety, ethical business practices and product quality improvement and marketability in compliance with international standards and based on the demonstrated results, there is need to develop and register standards, protocols and guidelines for production and use of carbonized briquettes from sugarcane bagasse.

**5:** From the results of the project studies, some critical information for scaling-up has been confirmed. However, given the limited scope of these studies, there is a need for reviewing available information on the livelihoods situation and that additional data on the relation between decline in tree cover and demand for fuel wood in the area be established.

## **Lessons learnt**

The innovativeness of this project has been both on the briquette production side and the marketing side. Briquette production focused on turning sugarcane waste (bagasse), into carbonized briquettes to replace charcoal for cooking and heating in the community. Local manufacture of complete briquette line including an efficient carbonization kiln system and briquette production machine has been innovative in regard to technology adaption and development by local engineering enterprises through skills training and mentorship. The project has provided technology transfer pathway by linking tested technology to the industry, especially the micro-and small enterprises in the renewable energy value chain.

The cooperative model has been an innovative market-led approach to creating awareness for carbonized briquettes, a new energy product in the region and in engaging local communities of both genders in product distribution. This has made it



possible for biomass energy consumers to switch to briquettes from wood based energy for their cooking and heating.

The concept of green economy partnership has demonstrated opportunity to solve identified challenges in community, country and global contexts. Even though all the targets were not achieved, the project is an eye-opener on new ways of addressing challenges connected to environmental management and climate change. The project has been implemented with strong human resource, networks and team work, which is a cornerstone for change. The cooperatives established have demonstrated energy and openness with solid support from the communities, county and national governments, critical for scaling-up and replication of the concept.

Trials conducted on various aspects of the technology and processes in briquettes value chain are important for improving the system (kiln and briquetting machine) and logistical processes of feedstock acquisition (biomass raw material and binders) is therefore possible.

Challenges and opportunities emerged are important for further research and development, capacity building and innovations for alternatives and solutions. Although legal confirmation of availability of sugarcane bagasse by a private sugar miller has not been realized, engagement with actors in public and private sector including the Sugar Directorate has confirmed the need for policy intervention in the agro-industry in Kenya. There is also need to map alternative feedstock resources such as local jaggery mills, maize cobs and groundnut shells.

Successful cooperatives are those with a good gender balance or led by women or dominated by women, in the key areas of decision-making processes and in program implementation. The project was implemented with strong gender consideration as an important component in empowering and employment in the transfer of skills and knowledge, decision-making structures and distribution of benefits. The three cooperatives have shown a clear gender balance in the composition.

People need time to change and build networks. It was noted that although the project was well-anchored in Kenya's Vision 2030, the plan was though too optimistic with regard to time lines, volume and value needed to change people's attitude and habits.

## **ACKNOWLEDGEMENT**

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## **Development of a Web-Based Geographic Information System for Mass Land Valuation: A Case Study Of Westlands Constituency, Nairobi County**

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### **Abstract**

Reliance on traditional mass property valuation approaches are inefficient and ineffective in revenue optimization and revenue collection from the rateable properties. County governments continue to lose the much-needed revenues from the land finance-based economies for lack of an up to date mass valuation database. A need for a timely solution is through the establishment of an integrated, transparent, decentralized, affordable and efficient GIS-based mass valuation roll database. The Westlands Constituency, one of the administrative regions of the Nairobi City County was used as the study area because of its rapid real estate development. The development of a web-based Geographic Information System for mass property valuation was the main focus of this research. The research also focused on automation of the mass land valuation roll by creating a centralized database that is accessible by all users on the web-based GIS portal. The web-based Geographic Information System was customized and integrated based on open source QuantumGIS, GeoServer and PostGIS as a relational spatial database. Leaflets and Mapbox APIs were used for the development of an interactive and friendly geographic user interface. Development of a Web-based GIS allows automation of the mass property valuation process by compiling of a centralized GIS-based mass valuation roll database. The developed system also automates revenues management system and data management of the sales comparables for property valuation. The system offers a streamlined flow of property valuation data within the Westlands constituency while ensuring there is well structured process of collecting, storing and disseminating mass land valuation data. The system serves as a platform to integrate data and enable accurate property taxation based on an up to date mass property valuation roll database and quick decision-making. The adoption of the system would optimize revenue collection and property taxation based on a centralized GIS-based mass property valuation roll.

**Keywords:** Open Source, Geographic Information Systems, Property Valuation, Spatial Database

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## 1. INTRODUCTION

Ever rising urbanization offers opportunities for the development of real estate market that calls for an efficient property valuation approach to prepare an up to date mass valuation roll for optimal property taxation (Deshmukh et al., 2016). However, accurate assessment of property values has been difficult for a very long time (Yang et al., 2015). Property assessors relies on access to comprehensive, reliable and timely evidence of recent property transactions in order to make informed predictions of the mass property value (Dimopoulos & Moulas, 2016). Legislative restrictions on data release to the public, confidentiality constraints and conservative attitudes hinder data accessibility within the Nairobi County property market enable efficient and regular property assessment. Availability of a central sales register and confidentiality of land information facilitates property valuation by the county authority for the purposes of property taxation based on their property values. It is also a constitutional requirement in the Kenyan constitution valuation for rating Act Cap- 266 laws of Kenya allows the preparation of the mass valuation roll after every 10 years so as to generate the significant revenue from these properties (Valuation for Rating Act, 2013). However, this has not been the case for Nairobi City County which continues to rely on a mass valuation roll that was last prepared and updated in 1980. This may have been due to lack of resources to prepare an up-to-date mass valuation roll on regular basis. Efficient and effective preparation of the mass valuation roll and subsequent optimal land taxation depends upon the availability of quality and correct land attributes information (Neene, 2017).

Mass property valuation may be assessed using the available traditional valuation methods such as comparative methods, cost methods and interactive analysis method which may be exhaustive, time-consuming, inaccurate and characterized with data inconsistency (Adamuscin, 2017). As such, there is a growing need to develop alternative valuation approaches capable of estimating property values of large numbers in an economical way based on geographical information systems that are able to represent spatial urban dynamics and development (Noor et al., 2015). However, these methods become effective and efficient when integrated into a Geographic Information System that automates data management of property sales transactions in the preparation of the mass valuation roll and hence full automation of mass property valuation (Shehu et al., 2015).

There is a need for a spatially enabled Integrated County Information System (ICIS) database for Nairobi City County into which all information about a property is collected from all sources and compiled into an up-to-date property mass valuation roll. All information about all ratable owner and property should be maintained in a reliable way by designing a mass valuation system in a holistic way. This system should also be centralized, web-based, role-based multi-user system, where all users have their own login and roles to access various components of the web GIS system.

The development of the prototype for a GIS-based mass land valuation roll for Westlands Constituency was achieved by setting out a general objective that was to develop a Web-based GIS for mass land valuation for Westlands Constituency. The research was also guided by specific objectives that aimed;

- To create a centralized spatial database for land parcels in Westlands constituency that identifies the ownership of each piece of real property.
- To establish a web map for owner rateable properties in the mass valuation roll for Westlands constituency.
- To establish an automated web-based GIS mass land valuation roll for property taxation purposes and revenues collection

The developed system can be accessed on the internet browser using various electronic devices like the computers, tablets and smart phones. The system developed can be accessible by multiple users at ago unlike the desktop GIS applications that allow a single user at ago. The system is user friendly and easy to use as compared to desktop GIS application that requires professional training and experience.

The novelty of this research was to develop a web-based geographic information system that integrates property valuation with web mapping technologies. The development of a web-based GIS is a new technology in developing countries like Kenya where property valuation has continued to be done using traditional approaches which are inefficient and ineffective in the preparation of a mass valuation roll for optimal property taxation. Due to rapid urbanization in Africa and over reliance on land finance-based revenues developing countries, call for a need of automated property valuation approaches so as to obtain an optimal revenue collection from these properties.

## 2. METHODS

### 2.1. User Needs Assessment

The anticipated Web-based GIS application users needs assessment was carried out by conducting personal interviews using structured questions. A total of 100 questionnaires were distributed and administered to several staff ranging from the valuation managers, valuation officers, data officers, GIS officers. Out of the 100 questionnaires administered, 80 responses were received back and were used to determine which features they desired to use in the system.

### 2.2. Data Collection and Capture

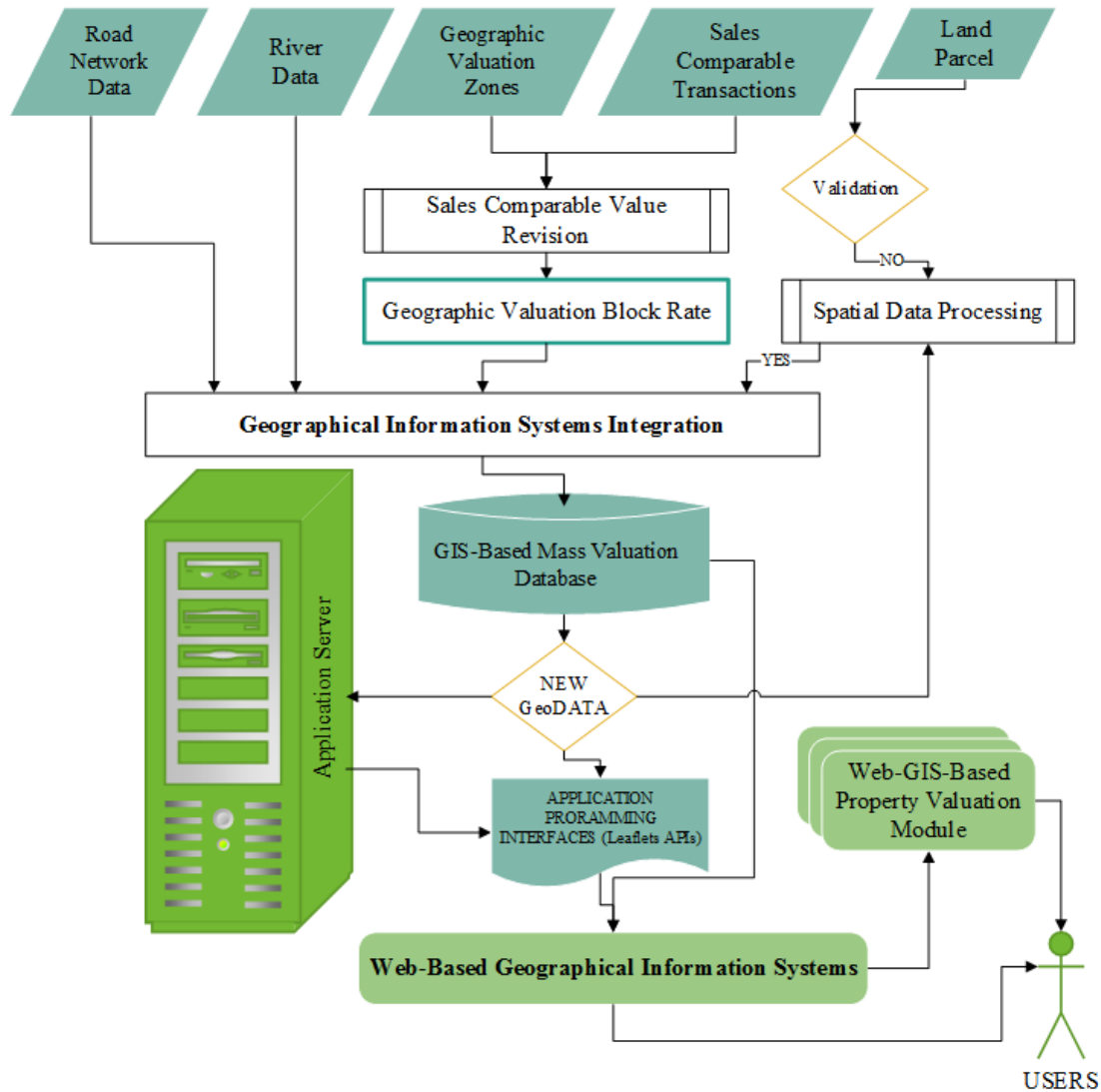
A large format scanner was used to create a raster data from existing paper map. As the scanning took place the scanned image displayed on the computer screen as a raster digital file was saved ready georeferencing. The land parcels datasets were captured through georeferencing cadastral plans and digitization using QGIS. The Geographic Valuation Blocks were also captured through digitization of the hard copy valuation zonal maps designated by the Nairobi City County valuation office. The sales comparable datasets were collected from the National Land commission of Kenya in form of hard copy format. They were then entered into an excel tables for easier integration into a geographic information system environment.

Datasets	Type	Data Format	Source
Land parcel data	primary	Esri shapefile	Nairobi City County valuation office
Building data	primary	Esri shapefile	Ramani Geo-systems
Road data	primary	Esri shapefile	Ramani Geo-systems
River data	primary	Esri shapefile	Geomaps
Estate data	primary	Esri shapefile	Ramani Geo-systems
Sales comparables	primary	Excel	National land commission
Basemaps	online		Open Street maps

Software Application	Function
Quantum GIS 2.14	Spatial data creation and processing
PostgreSQL 9.5/ PostGIS 2.3	Object relational database/Spatial database extension
Geoserver 2.11.1	Data visualization
Leaflets APIs libraries	Development of geographic user interface
Sublime text editor	Programming platform
Xampp server	Creates a local host service

### 2.3 Preparation of the Mass Valuation Roll

An inventory of attributes in the valuation roll were populated by data entry process that included rateable owner personal information like owner names and address of location of the property, serial number, map number, land parcel number and size of the parcel, geographic valuation block code, geographic valuation block rate, market value of the property and the Unimproved Site Value (USV). A GIS-based mass valuation roll was generated from the Microsoft access database by importing it into the QGIS 3.0 where it was then joined with the land parcel shapefile dataset using the spatial join tool available in QGIS 3.0.



## **2.4 Spatial Data Processing and Manipulation**

Installation of Quantum GIS 3.0 software was done by downloading QGIS 3.0 from the internet (QGIS, 2018) and installed in the computer then used to digitize and manipulate data layers for the, property sales comparables, land parcels, roads Geographic Valuation Zones. Hard copy paper maps were scanned using large format scanners and the saved as an image. The scanned image was then georeferenced and digitized into a shapefile format of a land parcels. Quantum GIS was also used to convert tabular data in excel for bulk property valuation roll data figures, property owner information and appurtenances into Esri shapefile format and corresponding attribute data added. Data quality checks were done through data evaluation and validation. A connection to the PostGIS database was configured by inserting the required credentials using a PostGIS plugin available on the QGIS 3.0

## **2.5 Spatial Database Creation**

PostgreSQL 9.5 database was installed in the default program files directory and customizing the new port to 5433 and a database super password was set for use when accessing the database. A new spatial database for mass valuation roll was created in PostgreSQL using a friendly user interface PgAdmin III. PostGIS 2.3 for PostgreSQL 9.5 was installed using the stack builder and a database connection was completed by specifying the login username, password and Port as set while installing PostgreSQL (PostgreSQL, 2018). Various SQL queries were executed to create various tables for the database for the Web GIS for mass land valuation datasets. A connection to the QGIS was also done using the PostGIS plugin on the QGIS.

### **Importing Shapefiles into The Database**

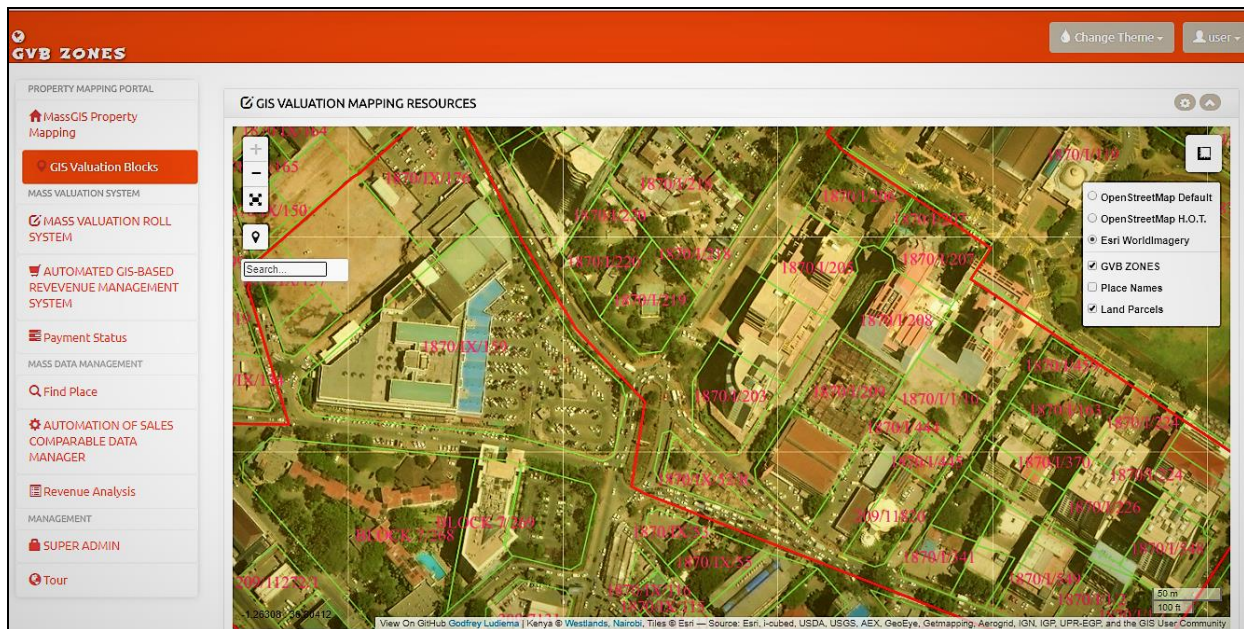
All shapefiles created for the study area were converted to their corresponding relational tables in a PostgreSQL database. This was done to ensure performance of spatial analysis on data of the geographical objects. The conversion of shapefiles to PostgreSQL database tables were achieved by importing the shapefiles using the shapefile import/export manager plugin in PostGIS. The imported tables contain all the attributes of the shapefile including the coordinates and geometry that define each feature in the database. All vector layers for the entire study area were imported into a centralized database. A connection between PostGIS database to QuantumGIS was also done so as to ensure real time updates of the database through a configuration of the PostGIS plugin on QGIS 3.0.

## **2.6 Web Portal Design and Development**

An open source GeoServer was used as a spatial data server for publishing spatial data and interactive mapping applications to the internet (Geoserver, 2018). The GeoServer has excellent performance in terms of functionality and speed on processing large dataset. It runs on top of installed Apache, tomcat and PHP applications. The Hypertext Transfer Markup Language (HTML), PHP, javascript and CSS were used to design the WebGIS application.

## 2.7 Development of the Geographic User friendlier Interface

Leaflets application programming interfaces (APIs) were used to develop a geographic and user friendlier interface for the web GIS platform. The designed interface was made in such a way that the user's interaction is simple and efficient in terms of accomplishing user goals. The interface allows the users to select and search the spatial database for the land parcels in order to view the required data. The user is also able to interact with the universal navigation tools such as zoom in, zoom out, and zoom to full extent to view the map at different scales and identification of different map features. Esri imagery and open street basemaps were also incorporated into the system to enhance spatial context of the study area in terms of data mapping and visualization on the web GIS portal. **Figure 2** demonstrates the running view of developed Web GIS.



**Figure 9:** Running view of developed Web GIS portal

## 2.8 System Testing and Implementation

Each component of the WebGIS framework implemented both in the database and web application levels were tested. All the created relational tables were reloaded into the PostGIS database to test geometries of the vector datasets. In case the geometries are not created then such a table would not be drawn in GeoServer. As such the shapefile would be converted again until the geometries were created. The connection between the created spatial database and QGIS was also tested by making reconnection in QGIS then the chosen data layer in the database loaded into QGIS direct from the database. Edits on the vector data were done and then on saving the changes were directly effected in the relational table which is in turn interconnected to the GeoServer and the web application, hence change are reflected when displaying the data layer in Geoserver



### 3. RESULTS AND DISCUSSION

#### 3.1 Web-based Geographic Information System for Mass Property Valuation

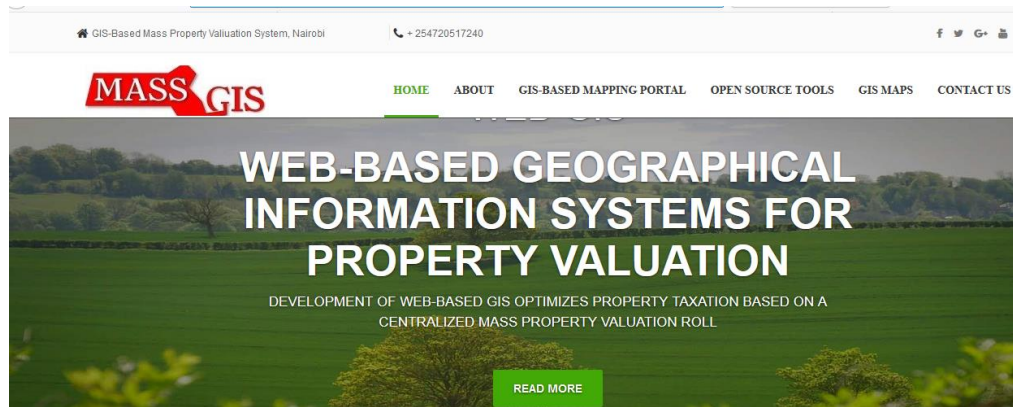
The prototype development is an internet-based Geographical Information System for managing mass land valuation roll for Westlands Constituency in Nairobi City County. It consists of three main tiers. First tier is an application server which is composed of an open source spatial enabled database system that is centralized for use by all users. Secondly, the client tier, a web-based mass GIS valuation system hosted on the main website in Figure 3 comprising of valuation modules for property mapping, geographic valuation blocks, an automated GIS-based revenue management system, payment status and an automated sales data management system.

##### 3.1.1 Open Source Centralized Spatial Database

Establishment of centralized mass property valuation database shown by section of the database in Table 3 improves reliability and update speed of the mass valuation roll. Centralized storage typically employs higher-quality components and redundancy, which makes it significantly more reliable than local storage. This database facilitates virtualization and provides comprehensive data access, if desired, from anywhere in the world by multiple users. Updates carried out on a database run on centralized storage carry through to all end-users, as opposed to local storage, which only applies to that computer which has been the case in Nairobi City County. This database ensures maximized data integrity and minimized data redundancy as the single storing place of all the data also implies that a given set of data only has one primary record. This aids in the maintenance of mass property valuation data as accurate and as consistent as possible and enhances data reliability in the city. The centralized mass valuation roll database also improves data security in managing vast quantities of sensitive county property owner information where data protection is a mission-critical issue. The central database creates and provides fewer challenges than ensuring data security across multiple local storage sites. Data access policies limit the data damage by implementing encrypted virtual private networks, firewalls and rigorous password protection on the mass valuation system. The mass valuation roll database is depended on an open source technology which makes it cheaper for Nairobi City County. The prepared centralized plot to plot inventory determines specific market value of each land parcel and identification the ownership of each piece of real property. The centralized database ensures easier data portability and database administration of land record and it provides a more cost effective approach in mass valuation of property in the city.

**Table 41:** A Section of Mass land valuation roll database

Plotno	Area M2	Street	Mapno	Estate	Owner	GVB Code	GVB Rate	USV
14970/73	1983.2	Kiambu	NMD13L04	Karura	Kwench Ltd	GVB85	19,901.00	39,467,066.17
14970/36	1960.2	Kiambu	NMD13L04	Karura	Stanley Kama	GVB85	19,901.00	39,010,537.23
14970/27	1962.7	Kiambu	NMD13L04	Karura	Daniel Gachari	GVB85	19,901.00	39,060,488.74
14970/28	1960.5	Kiambu	NMD13L04	Karura	Godfrey kabuki	GVB85	19,901.00	39,015,313.47
14970/33	1959.1	Kiambu	NMD13L04	Karura	John Kasuti	GVB85	19,901.00	38,988,248.11
14970/34	1960.1	Kiambu	NMD13L04	Karura	Steve Masala	GVB85	19,901.00	39,007,950.10
14970/35	1959.9	Kiambu	NMD13L04	Karura	Joseph Murage	GVB85	19,901.00	39,004,367.92



**Figure 10:** Web-based Geographic Information System Homepage

### 3.1.2 Application Login of Users to the System

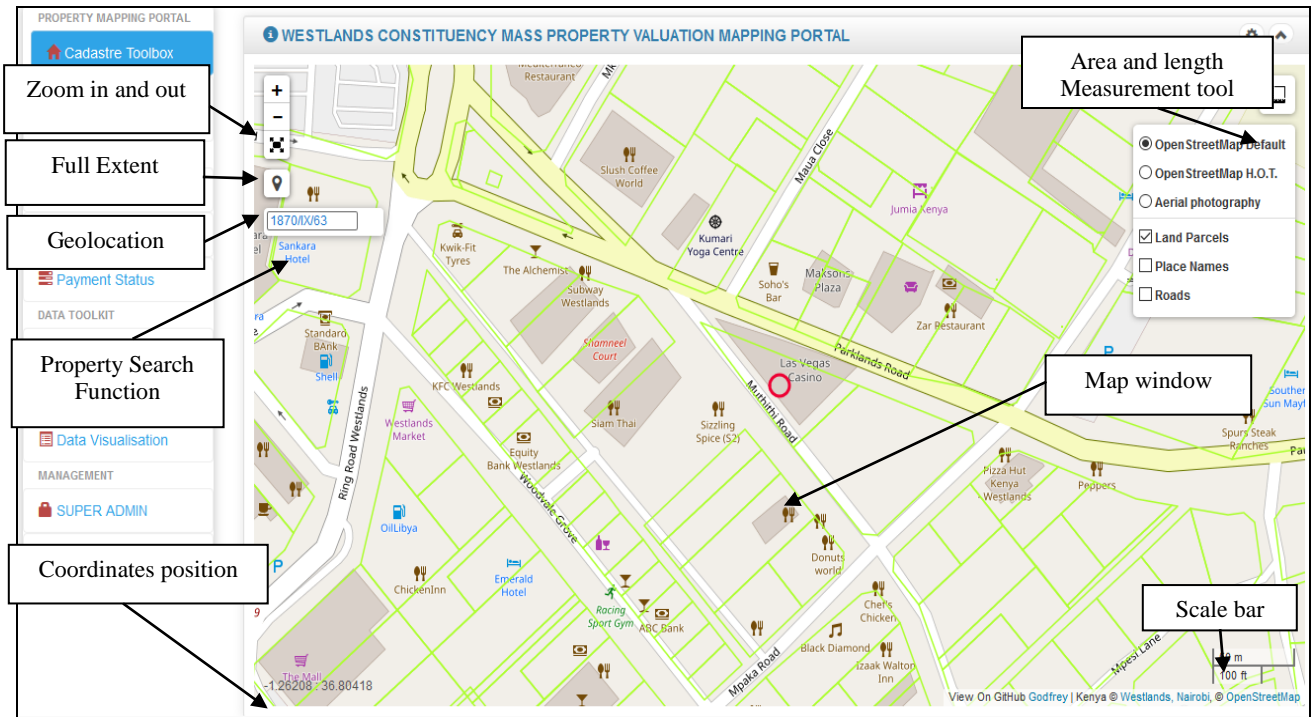
To obtain access rights to the system users have to login using a registered username and password credentials shown in **Figure 4**. In order to have login credentials the system administrator needs to register a new user and provide the access credentials. The web portal has been used for the registration of users and for each login, the username and password credentials are validated to ensure secure login and prevention of unauthorized user access.

**Figure 11:** Login portal o the Web-based Geographic Information Systems

### 3.2 Web GIS Viewer Interaction and Display

The property mapping application in **Figure 5** was designed to give various functional capabilities which are in build in the mapping system using various tools. The map window provides the user with a spatial view of parcel and valuation zones during the preceding valuation year. The map was compiled using a JavaScript map variable that drew on a collection of tiled map services and dynamic map services. Users can pan around the map by click-and-dragging or zoom in and out by using the scroll wheel on their mouse to increase or reduce the scale of the map so as to ease in locating features of interest and zoom to full extent can be used to view the whole map at the default minimum scale. More advanced users can also use the shift-select method to perform a targeted zoom into a specified area. The size of parcel of land on the map was designed to change depending on the scale of the map. One can view additional information for land parcels by single-clicking a feature polygon to create a popup window that displays descriptive information in the mass land valuation roll. The main mapping interface has the layer switcher which consists of various base maps and the valuation data for land parcels, place names and roads data. Within the Geographic Valuation Zones mapping web application, a user could also pan and zoom around a map using their mouse on a computer, or by utilizing a touch screen to pan and using the + and – icons to zoom. A location function is also available on both web applications that utilize the location services available on

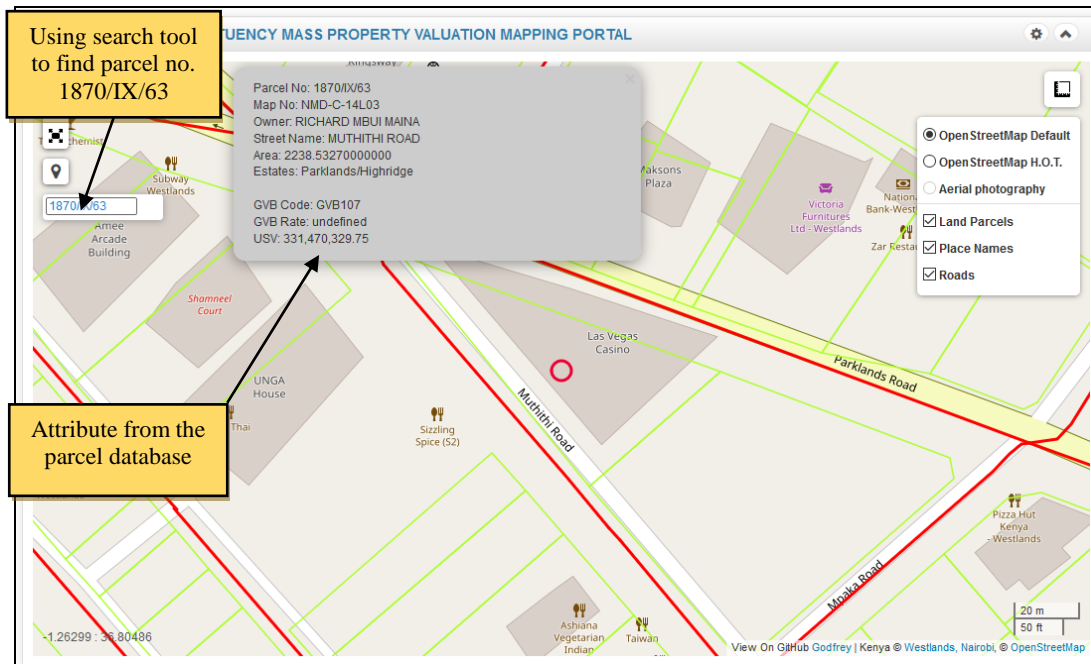
a device to approximate the user's current location.



**Figure 12:** Navigation Tools on the Web-based Geographic Information Systems

### 3.2.1 Automation of Property Searches and Data Retrieval

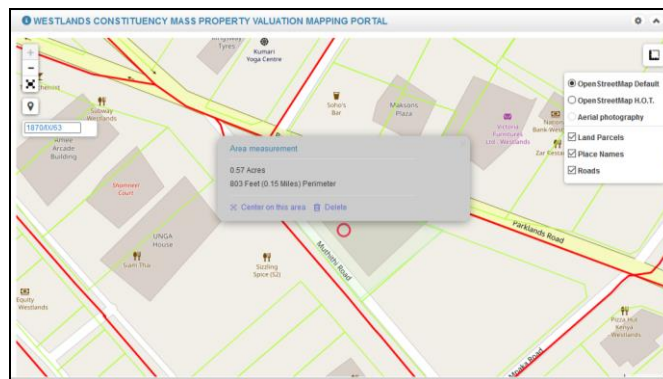
GIS-based automation of property searches on the system enables the user to be able to search for specific property information using the parcel number from the centralized mass valuation roll database. The system user can use the search box to extract specific data related to a given feature and zooms to the specific position of parcel of interest. Data retrieval capability enables the user to obtain the associated land parcel attribute information like parcel number, parcel owner, area, street, estate, land value, geographic valuation code, map number, geographic valuation zonal rates and unimproved site value. This kind of information is very useful for property investors who would want to know all the above mentioned land attributes before making a sound decision on property transactions. **Figure 6** shows the results of property search from the centralized database.



**Figure 13:** Automated property search capability for retrieving specific land parcel information

### 3.2.2 Area and distance measurements on the web GIS

The system enables users to carry out length and area measurement on the map using the length and area measurement tools respectively. The length can be measured in feet while the area measurements being measured in square feet and square miles. Current geographic positions on web map can be measured in terms of longitude and latitude in decimal degrees by clicking at the point of interest on the map. A green marker symbol appears where one has clicked on the map and its coordinates listed in the measure box in the chosen units. In **Figure 7** shows the length and area measurements functions carries on the web map. This enables one to calculate the value of a property of the desired area size within a particular geographic valuation zone by making simple area measurement and the geographic valuation rates of the valuation zone or block. Property investors are able to know the value of a property regardless of the area size against other factors influencing the property value.



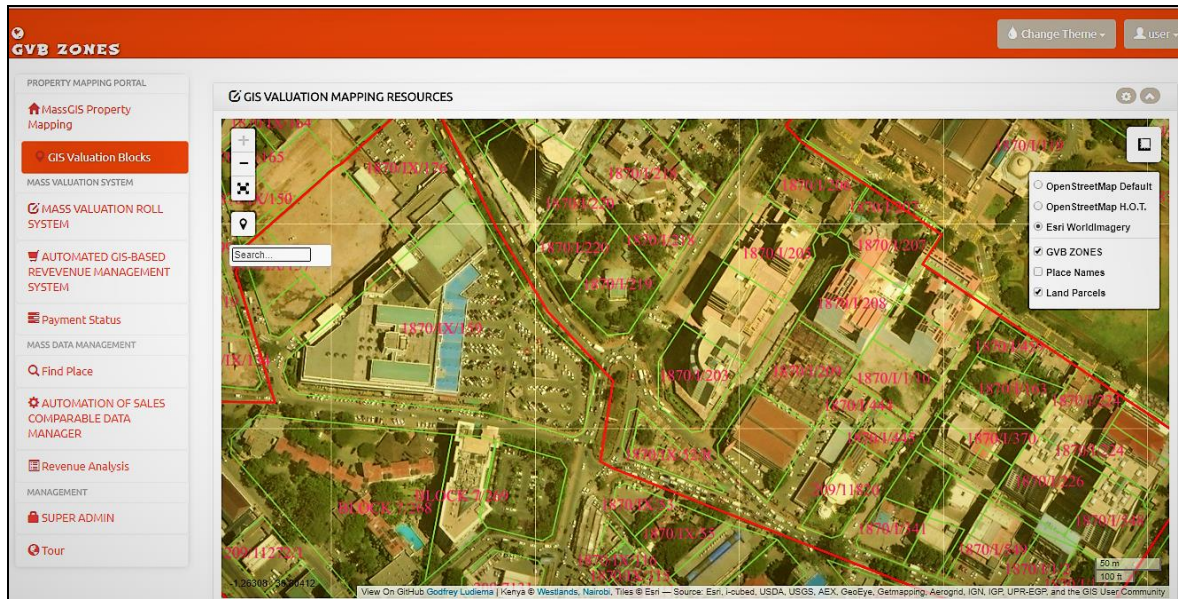
**Figure 14:** Length and Area Measurements Functions on the Web-based GIS

### 3.3 Sub system of web-based Geographic Information System for Property Valuation

The developed web-based Geographic Information System is made up of various sub systems that includes Mass GIS property mapping, GIS valuation block mapping, mass valuation roll system, Automated GIS-



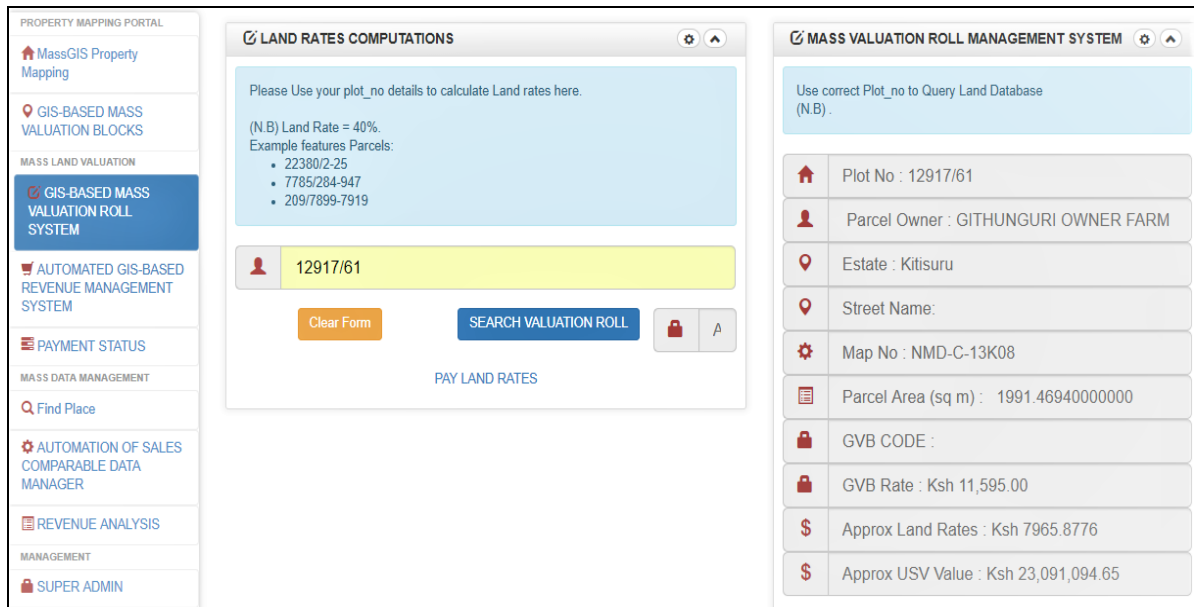
based Revenue Management system, payment status and an automated sales data management system as shown in **Figure 8**. The developed components of the web-based GIS collectively make up a GIS Assisted Mass Appraisal (GAMA) system because of it integrates GIS tools and Computer Assisted Mass Appraisals systems.



**Figure 15:** Components of the Mass Web-based Geographic Information Systems

### 3.3.1 GIS-based Mass Valuation Roll Management System

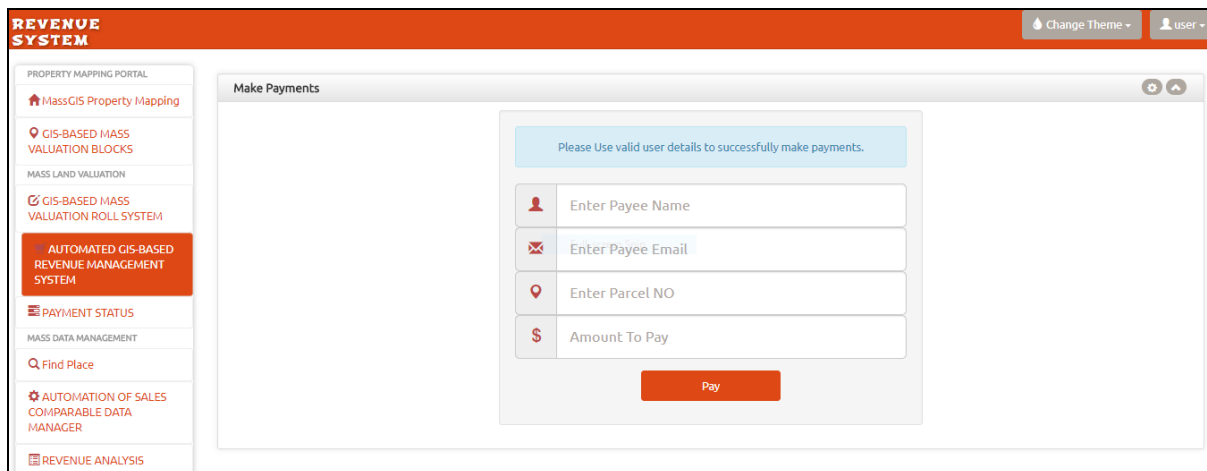
The entire system allows for full automation, continuous and timely updating of the mass valuation roll based on the geographic information system that is very efficient and effective in decision making on the properties valued. An up to date centralized database allows for optimal property taxation. The web-based GIS system allows for data exchanges between land valuation system, the land rates calculation and billing system. This reduces leakage and gives a more robust system for billing, payment, reconciliation and any other purposes as deemed necessary. The user can be able to search the exact information from the valuation roll database using the mass valuation roll management system portal shown in **Figure 9**. The system also allows one to retrieve property taxes due based on the centralized database for mass land valuation. Land rates computations are automatically generated once the parcel number is inserted on the search box.



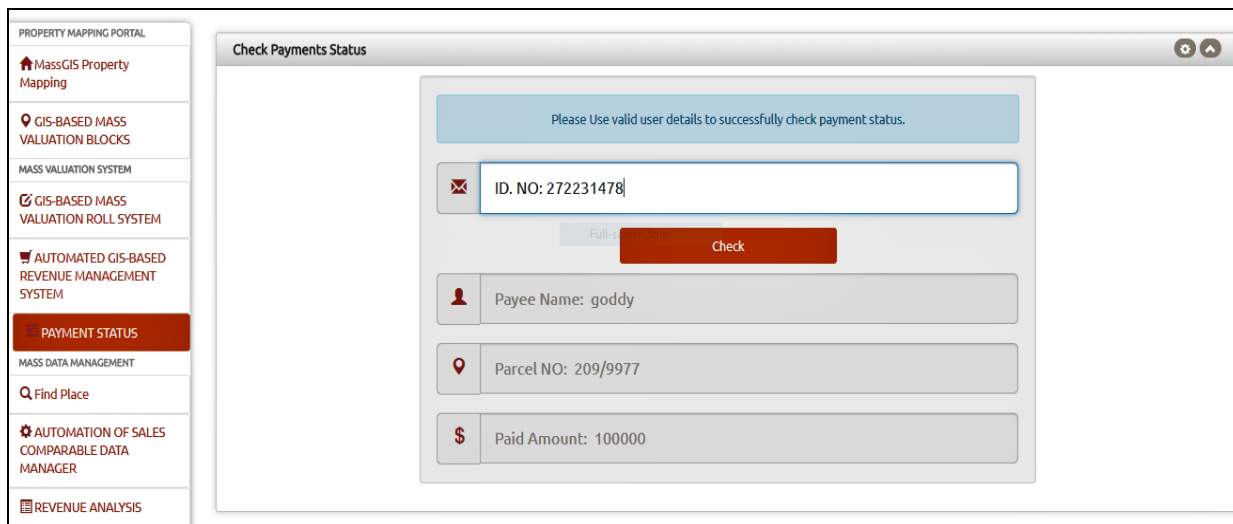
**Figure 16:** GIS-Based Mass Valuation Roll Management System

### 3.3.2 Automated GIS-based Revenue Management System

The development of a GIS assisted mass appraisal system in this research can be used to optimize revenue collection from the property taxes of the valued properties based on an up-to-date centralized mass valuation roll database. The system in **Figure 10** provides a solution by creating an electronic client and centralized property database for easy and reliable management of revenue resources from the property taxes. The property taxes can be monitored with the system on real time basis using a web-based GIS maps. Automation of revenue collection system boosts revenue E-enforcement through real time verification of the property tax payer records shown in **Figure 11**. The collected revenue can be used to provide services and infrastructure thus improving the lives of all the people in the county. This system supervises the timely collection and disposition of property taxes within the mass land valuation authority.



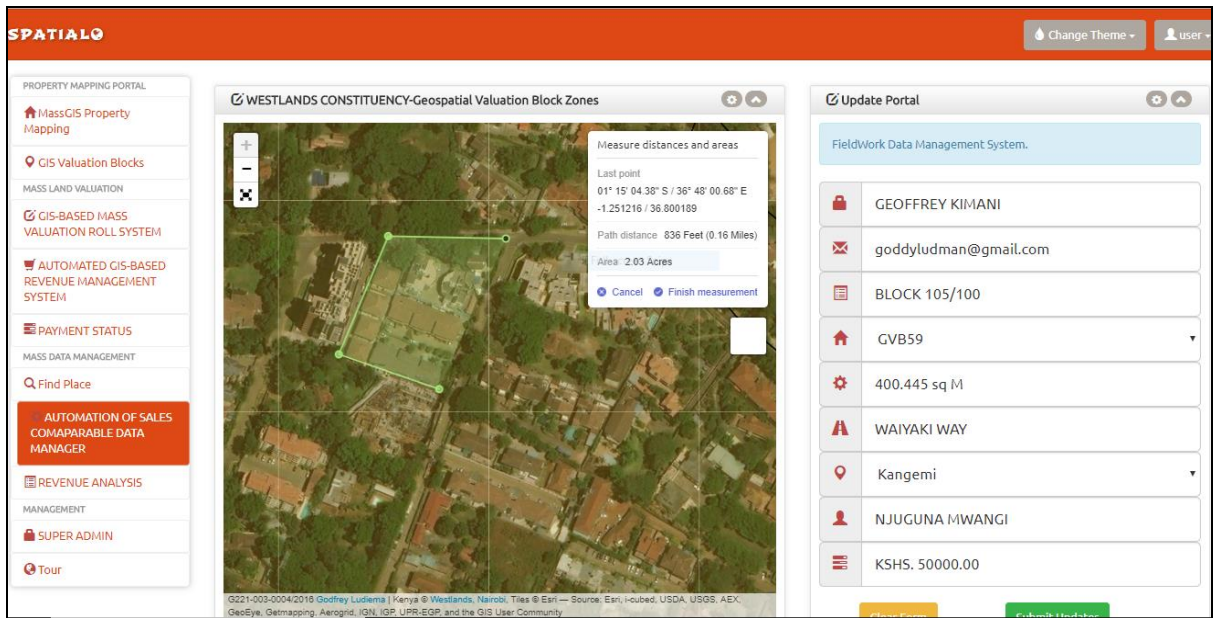
**Figure 17:** GIS-Based Revenue Collection Portal



**Figure 18:** Verification of payment of property taxes paid

### 3.3.3 Automation of Sales Comparable Data Management System

The web GIS system enables valuers to collect data on valued property and sales of similar properties in the same neighborhood and even in different locations, including differences between property prices. It is possible to arrive at reasonably accurate estimates of land values over the whole valuation boundary. The data management system is a basically a field based information system for collecting the geographic valuation zonal values of properties by the valuer from the sales comparable of the recent property transactions. This automates the entire process of collecting sales comparable of properties which are then used to derive a GVB rate values that are applied to the land parcels within the valuation zone. All data on sales property transactions are collected using the web-based portal thus automating the entire system of mass land valuation for any county government or local authority. The parcel ownership information, land parcel number within the valuation authority, the GVB code, area, street, estate and the value for the sales comparable data is captured on the web-based GIS system. With the system the process of preparing mass valuation roll becomes very easy and cost effective, when it falls due, since all the data needed is be readily available in a centralized GIS-based database. **Figure 12** shows the entire sales comparable data management and collection portal.



**Figure 19::**Automation of Sales Comparable Data Management System

### 3.4 User needs evaluation of the web-based GIS application

User feedback regarding the design of the web-based GIS application was collected. The participants in the survey were given an opportunity to interact with the web-based GIS application and there after they were asked a series of short answer and multiple choice questions which used five-tiered likert-item responses. Questions were designed to gauge how the user perceived the web application in terms of usability, web interaction and practicality. 88% of respondents found that the web application had an intuitive user interface and was easy to use as illustrated in the **Figure 13**.

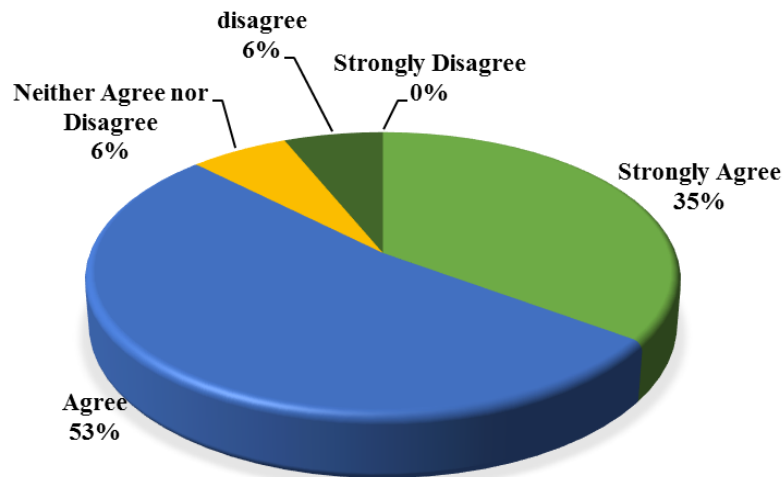


Figure 20: Intuitive User Interface

In **Figure 14** 40 % of respondents found that the inclusion of the zoom in and out tool on the web map was an effective tool for visualizing the land value map and valuation attributes, 27% of respondents were satisfied with the search function as it was effective in locating land parcel of interest on the web map. 13% of the respondents also felt that basemap map control was a very important feature on the web map as it gave the map context of the mapping area for the mass land valuation. This tool gave the map context of the study area from open street maps and aerial photography. 8% of the respondents also found the full



extent map control improved user interaction with the web-based GIS and only 1% of the respondent found geolocation as a vital tool for locating the user.

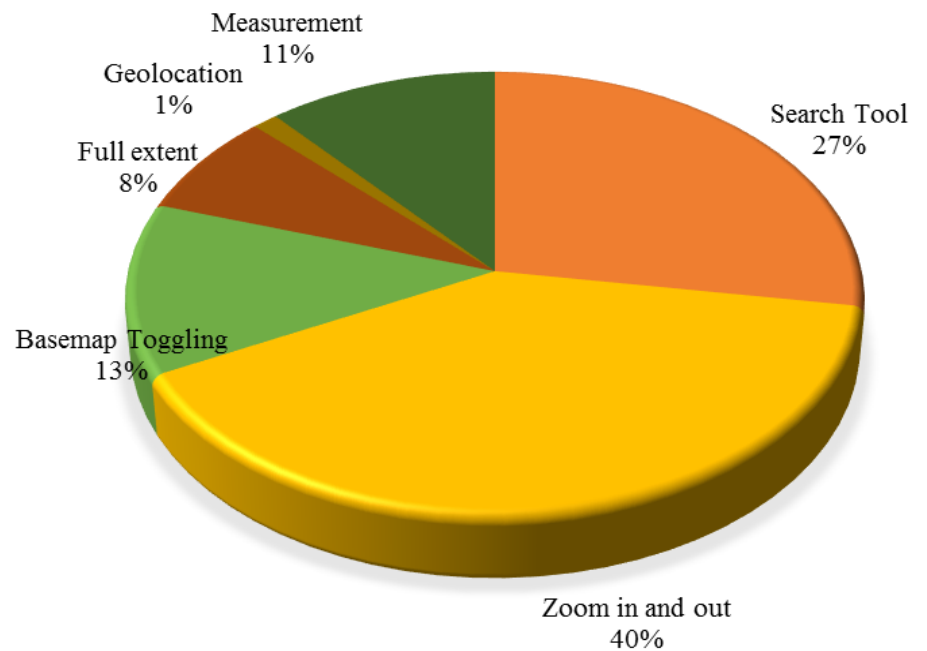


Figure 21: Effectiveness of the web GIS functionality

#### 4. CONCLUSION

The study led to the development of a Web-based Geographical Information system for mass property valuation roll database. The system offered automation and management solutions to the mass property valuation roll, by providing one shared database hence reducing duplication and lowering maintenance cost. The web-based Geographic information system for mass valuation ensures seamless property mapping across the valuation authority. The interactive property mapping component performs land searches, automates mass property valuation roll and updates of the database giving the property valuation authority and property viewers the desired results in a timely effective and efficient way. It enables developers, banks, realtors, businesses, and homeowners to view a seamless property and retrieve property tax information across the study area. The system also offered a mass property mapping interface that ensures Westlands Constituency leverages advancement in GIS technology in its service delivery. The system also offers a streamlined flow of land valuation information by having centralized database system accessible to all hence ensuring there is well structured process of collecting, storing and disseminating property valuation related information. From the study one can draw conclusions that web-based GIS for mass land valuation is a prospective application in the geospatial world and it's an important advancement over the traditional desktop GIS. Its application eliminates duplication and inconsistency and makes location information conveniently and intuitively accessible across organizations, at a lower cost per user. The internet provides a medium for processing spatial information to users at an amount larger than traditional GIS. The study lays the foundation for proper management of a GIS-based mass valuation roll for optimal property taxation purposes. It aids in the realization of the Kenya Vision 2030 in developing an optimal revenue collection for the well-being of the city dweller in terms of service delivery. This research can be extended to create a nationwide GIS-based property valuation system for valuing all the available resources that can provide services for a wide range of users, starting with government institutions and

ending with private individuals. Further improvements to the system could be made to include improved capabilities to carry out analysis using the available data. The system's functionality can also be improved such that it supports all of the procedures that are involved in the land administration like allocation of title deeds.

## ACKNOWLEDGEMENT

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# Differentiation of Some Crops in Leingarten and Moessingen, Baden-Wuerttemberg, Germany Using TerraSAR-X Data

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## Abstract

The aim of this research was to try and differentiate some of the important crop cultures in the Baden-Wuerttemberg area by creating crop signatures from the backscatter values of the different crops from the different identified test sites. At the end it would be established whether the signatures of one crop (e.g. Maize) collected in one of the test sites could be compared or transferred to another test site. This study was done using the TerraSAR-X data, with VV polarization, which was overlaid with crop fields' ground truth data that was collected from the fields. Images covering two test sites at Leingarten and Moessingen for the months of July and August 2010 were used. These test sites were located in different climatic regions that had different sowing times, crop development times and harvesting times as was elaborate in the "Klimaatlas maps". Only radiometric correction was carried out on the images. The speckle noise was not removed or minimized. The crops were classified according to the mean and standard deviation of their backscatter. The results obtained were then compared to results of other researches for checks and accuracies.

Keywords: TerraSAR -X, radar backscatter, Crop signatures, crop differentiation

## 1. Introduction

There have been earlier studies to classify and differentiate the crop cultures in different areas, using both active and passive sensors. The already established methods of classification like the maximum likelihood method have been used for the classification process [Tavakkoli M. et al., 2008 and Löhnertz M. et al., 2006]. This has however been restrictive in the sense that training data had to be collected to create specific signatures for a given area of study. The classes obtained are therefore restricted to that particular area only. There is no transferability with the created signatures. This means that the signatures collected from one area of study in a given year cannot be used to classify or differentiate crop cultures in studies carried out in subsequent years in that same very study area or even to other study areas. The need to establish a way of differentiating crop cultures more by their reflectance characteristics rather than just relying on the collected signatures motivated this study. The radar data was preferred to its optical counterpart as it is independent of weather conditions. It can be able to collect data all year round regardless of the existing weather conditions i.e. it is multitemporal [Tavakkoli S. M. et al., 2008]. The objectives of the study were therefore (i) to establish some of the important crop cultures common in the two test sites, (ii) to differentiate crop cultures using their specific backscatter values (iii) to create classification signatures for the important crop cultures in the area of study independent of the classical classification methods.

## 2. Methods/Methodology

### 2.1 Study Area

The Leingarten test site was located in the district of Heilbronn, in the administrative region of Stuttgart with coordinates 49° 9' 0'' N, 9° 7' 0'' E, with an altitude of 168 meters. The test site had the coordinates:

49.122 N 9.053 E, 49.122 N 9.183 E, 49.17 N 9.183 E and 49.17 N 9.053 E. These coordinates were given from the bottom left corner of the test site in an anticlockwise direction. The average elevation of the test site was 200 meters. The Moessingen test site was located in the district of Tuebingen in the administrative region of Tuebingen, north of the Swabian Alb with coordinates 48° 24' 23'' N, 9° 03' 27'' E, with an altitude of 477 meters. The test site had the coordinates: 48.320 N 9.097 E, 48.327 N 9.125 E, 48.466 N 9.044 E and 48.458 N 9.016 E. These coordinates were given from the bottom left corner of the test site in an anticlockwise direction. The test site extended from North to South with an increase in altitude from an average of 450 meters in the North to an average of 800 meters in the South [Google earth 2011]. The change between these two altitude ranges was not gradual but was rather characterized by a sudden steep slope change. This test site was therefore subdivided into Moessingen upper test site and Moessingen lower test site. The test sites were selected according to the varying range of climatic and phenological aspects that characterize the Baden-Wuerttemberg area and which have a direct influence on the growth and development of the crops at different stages and thus a direct influence on the amount of backscatter reflectance received from the surface [Klimaatlas Baden-Wuerttemberg, (1955)]. For example, considering the seeding time of Oats, the seeds are sown earliest in the Leingarten test site, which is around the 16<sup>th</sup> of March and latest in the Moessingen test site, which is around the 15<sup>th</sup> of April [Klimaatlas Baden-Wuerttemberg, (1971-2000)].



**Figure 1: The two test sites of Leingarten and Moessingen chosen in the Baden- Wuerttemberg area, shown in blue. © Google earth 2011.**

## 2.1. Data

### 2.1.1. Satellite images

The images used were TerraSAR-X images acquired for the months of July and August, 2010 using the Stripmap mode. They were right looking images and were VV-polarized. They covered two strips, Strip\_006 and Strip\_007. The look angle varied from 27°-30° in order to cover the two strips. They were Enhanced Ellipsoid Corrected (EEC) and spatially enhanced (SE). This provided the highest possible square ground resolution. They were acquired in descending direction (D). This is as shown in table 1.

### 2.1.2. Aerial Photographs

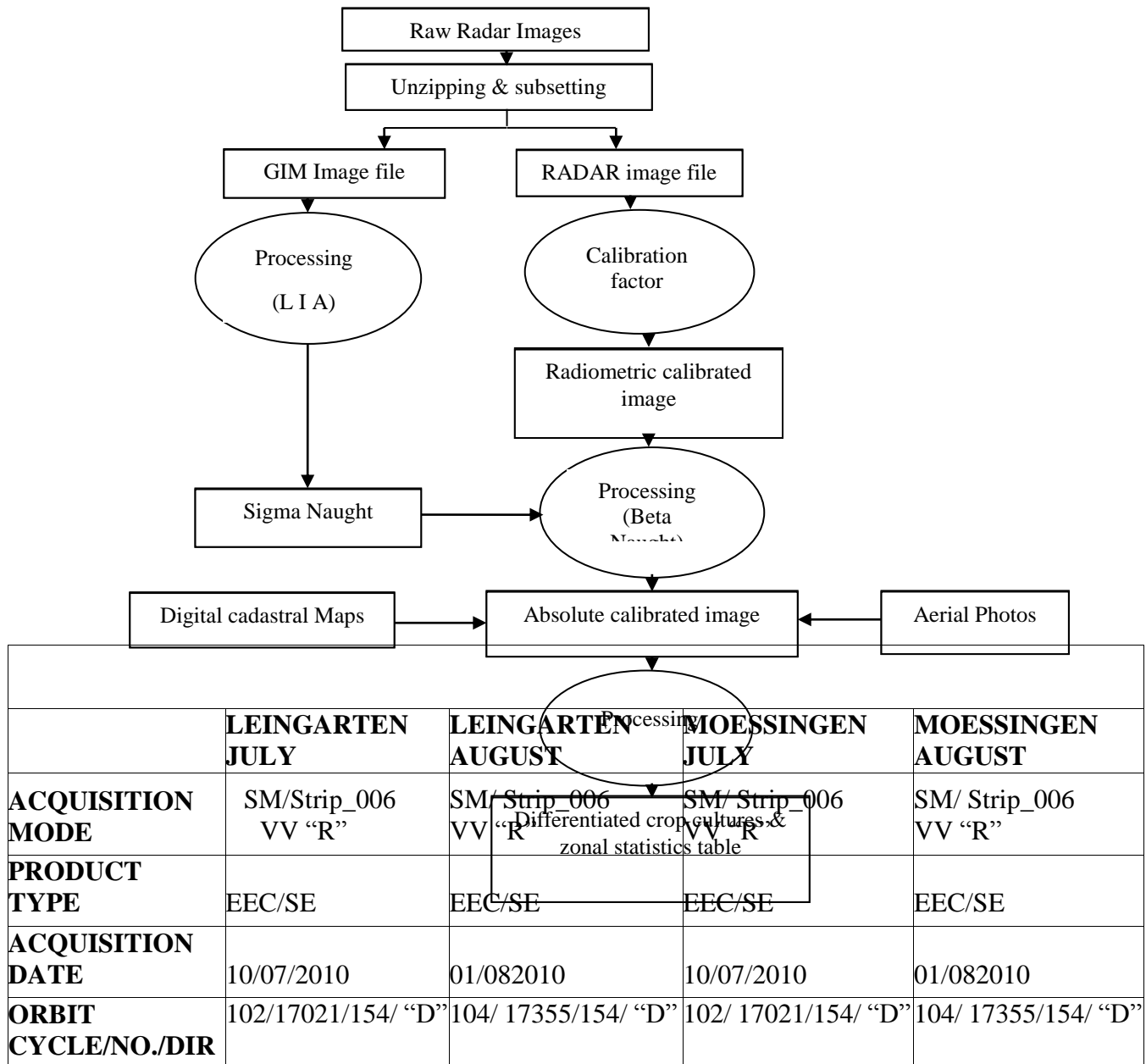
The relevance of the aerial photographs was to show the location of the land parcels in relation to other features like the Forested areas, roads and the buildup areas

### 2.1.3. ALK maps

The Automatisierte Liegenschaftskarte (ALK) or the Digital Cadastral Maps contained records of all the land parcels in the region and the information about where every parcel is located. This information was important especially in the selection of the test site. Test sites had to be selected in areas that were predominantly under agriculture in order to optimize on the results and findings of the research.

**Table 1: Information about the satellite images that were acquired for the study.**  
Data Preparation

This involved the following steps as summarized in the work flow diagram, figure 2:



**Figure 2: Flow diagram showing the work flow**

#### 2.1.4. Unzipping and Subsetting of the Files

The images acquired had been compressed into zip files to reduce their sizes and ease their workability. They had to be unzipped in order to be used. These zip files contained not only the images that were to be used but also extra information about the images. This information, among other things, described the conditions like the local incidence angles that existed when the images were taken, calibration factor and the time when the images were taken. However, information about the existing weather conditions during the image acquisition was not provided, even though this was very necessary for this study. The original image was of type „continuous “and the data type was “unsigned 16-bit” and had one layer. The information about the local incidence angle and on the location of radar shadowing and layover was derived from the Geocoded Incidence Angle Mask (GIM) image. When processing the GIM images, the data type was converted to “float” in order to allow for decimal numbers to be included in the operations [Fritz T. and Eineder M., 2010]. The images were then subset in order to reduce the data size and the amount of time that would be required for processing. In order to ensure the subsetting of the exact same area sizes and locations in the different images, an area of interest (AOI) template was used.

### 2.4. Data Processing

#### 2.4.1. Radiometric and Absolute Calibration

A radiometric calibration process had to be performed on the images before they could be used for any further processing in order to minimize the incompatibility in images taken under different observation conditions like the incidence angles or even the ascending/descending mode by the different radar sensors [Infoterra, 2008]. The calibration factor was obtained from an xml file that came with the image data information. This factor depended on the image polarization.

Absolute calibration allowed taking into account all the contributions in the radiometric values that were not due to the target characteristics. This permitted to minimize the differences in the image radiometry and to make any TerraSAR-X images obtained from different incidence angles, ascending-descending geometries and/or opposite look directions easily comparable and even compatible to acquisitions made by other radar sensors [Infoterra, 2008]. This was done by the computation of Beta Naught and Sigma Naught [Infoterra, 2008].

The radar brightness or Beta Naught  $\beta^0$  which represents the radar reflectivity per unit area in slant range, was obtained by multiplying the calibration factor with the power of the digital numbers (integer pixel values) using equation 1. This was then converted into decibel (dB) values using the equation 2 [Fritz T., 2007].

$$\beta^0 = k_s * |DN|^2 \quad \dots\dots\dots \text{Equation 1}$$

$$\beta_{dB}^0 = 10 * \log_{10} (\beta^0) \quad \dots\dots\dots \text{Equation 2}$$

Where:

$\beta^0$  = Beta Naught or radar brightness representing the radar reflectivity per unit area in slant range.

$\beta_{dB}^0$  = Beta Naught in decibels

$DN$  = Digital numbers or image pixel values

$k_s$  = Calibration factor

For the Sigma Naught  $\sigma^0$  (radar reflectivity per unit area in ground range), the local incidence angle (angle between the radar beam and the normal to the illuminated surface) was necessary since the backscatter from the crop culture surfaces was not only influenced by the relative orientation of the illuminated cell and the sensor, but also on the distance in range between them [Fritz T., 2007].

Information about the local incidence angle for each pixel of the geocoded SAR scene and about the presence of layover and shadow areas was provided by the Geocoded Incidence Angle Mask (GIM) which was also delivered as a file in the image data delivery information [Infoterra, 2008]. Incidence angles were given as 16bit integer values in tenths of degrees, e.g.  $10.1^\circ$  corresponds to an integer value of 1010. The last digit of this integer number is used to indicate shadow and/or layover areas as follows:

- 1..... indicates layover (ex. 1011)
- 2..... indicates shadow (ex. 1012)
- 3..... indicates layover and shadow (ex. 1013)

Layover and Shadow (LS) information was extracted by applying the formula:

$$LS = GIM \text{ mod } 10 \text{ [Infoterra, 2008].}$$

The incidence angle was derived from the Geocoded Incidence Angle Mask (GIM) using the equation 3 and the sigma naught computed using the equations 4-7 [Uprety P. and Yamazaki F., 2010].

$$\theta_{ioc} = \frac{(GIM - (GIM \text{ mod } 10))}{100} \quad \dots\dots\dots \text{Equation 3}$$

$$\sigma^o = (k_s * |DN|^2 - NEBN) * \sin \theta_{ioc} \quad \dots\dots\dots \text{Equation 4}$$

$$\sigma^o = \beta^o * \sin \theta_{ioc} - NESZ \quad \dots\dots\dots \text{Equation 5}$$

$$\sigma^o = \beta^o * \sin \theta_{ioc} \quad \dots\dots\dots \text{Equation 6}$$

$$\sigma^o = \beta_{dB}^o + 10 * \log_{10}(\sin \theta_{ioc}) \quad \dots\dots\dots \text{Equation 7}$$

Where:

$\sigma^0$  = Sigma Naught

$\theta_{ioc}$  = local incidence angle

$NEBN$  = Noise Equivalent Beta Naught



$NESZ = \text{Noise Equivalent Sigma Zero}$

$$NESZ = NEBN * \sin \theta_{loc}$$

The values for NESZ were specified between -19 dB and -26 dB and therefore its influence in this study was neglected as it was very minimal [Fritz T., 2007].

#### 2.4.2. G.I.S Data Processing

Information about the crop fields was collected and stored in a GIS dataset. The attribute data that was collected included information about the land parcels and the crops in them. This included: the use of the parcel; the crop culture in the land parcel; the BBCH-code; the height of the crops; the distance between the rows of the crops; the cultivation (winter crop or summer crop); the date of the field visit; any notable remarks; the parcel number; the shape length and area of the land parcels. A test site was chosen and on this test site one crop culture selected using an attribute query. A buffer of 4 meters was then created from the edge of each field to keep each crop field as homogeneous as possible and to eliminate mixed or unreliable pixels in the statistics. The different layers of the test sites data plus the calibrated satellite images and the aerial photos were added as layers and models were created that combined the radar images and the land parcels data.

The “zonal statistics as table” tool was used to output the end results as a table showing the statistical information of the crops in every field. This is as shown in table 2 below. The mean and standard deviations for each field were calculated in decibels (dB). The mean-mean and the mean standard deviations were also calculated in decibels (dB). These gave an average value of one crop culture in the crop fields within a test site. For example, in the Leingarten test site, all Maize fields were selected and the mean and standard deviation values calculated. These values of the mean and standard deviations were then averaged to give the mean-mean and mean standard deviation values respectively.

Attributes of ZonalSt_TG_LGTM_august_lower_mais_buffer									
OBJECTID *	VALUE_	COUNT_	AREA	MIN_	MAX_	RANGE	MEAN	STD	SUM_
1	997	4552	7112.5	-25.053944	2.341859	27.395802	-8.705017	4.379142	-39625.238
2	1366	308	481.25	-22.81398	-1.490676	21.323303	-9.2106	3.755008	-2836.8647
3	1368	12888	20137.5	-35.597271	1.922626	37.519897	-9.301498	4.235312	-119877.72
4	1372	1339	2092.1875	-26.04134	-0.839913	25.201427	-10.762121	4.37819	-14410.48
5	1373	423	660.9375	-29.278999	-2.87409	26.404909	-12.358243	4.222351	-5227.5366
6	1375	1935	3023.4375	-28.416834	1.251346	29.66818	-9.846208	4.638504	-19052.412
7	1422	12633	19739.063	-35.445221	2.890366	38.335587	-9.454227	4.36948	-119435.25
8	1443	1626	2540.625	-28.406128	2.910829	31.316957	-8.56489	4.339567	-13926.511
9	2570	761	1189.0625	-25.9028	-0.745014	25.157785	-9.927362	4.52657	-7554.7227
10	2572	128	200	-24.047718	-2.082833	21.964886	-10.269938	4.312688	-1314.552
11	2573	1167	1823.4375	-26.626488	1.332313	27.958799	-10.669389	4.752126	-12451.177
12	2576	1229	1920.3125	-27.552719	-0.857966	26.694754	-10.627723	4.604264	-13061.472
13	2577	685	1070.3125	-26.478634	-0.949397	25.529238	-10.987731	4.408999	-7526.5957
14	2581	3062	4784.375	-34.285385	1.204954	35.490341	-9.705909	4.323368	-29719.492
15	3628	12619	19717.188	-29.783073	2.870744	32.653816	-9.215509	4.388228	-116290.49
16	3629	315	492.1875	-30.915609	-0.424925	30.490685	-10.631854	4.752624	-3349.0342
17	7520	759	1185.9375	-35.993538	2.021352	38.014889	-10.124439	5.458703	-7684.4492
18	13590	3157	4932.8125	-30.72871	2.594256	33.322968	-10.028106	4.819969	-31658.73
19	16088	16569	25889.063	-32.658169	1.240397	33.898567	-9.712559	4.335337	-160927.39
20	16089	11383	17785.938	-29.13938	3.066774	32.206154	-9.171688	4.407368	-104401.32
21	24656	2263	3535.9375	-25.423613	1.957475	27.381088	-9.325326	4.421725	-21103.211

**Table 2: Results of the zonal statistics as table after processing carried out on the Leingarten test site.**



### 3. Results And Analysis

#### 3.1. General Results

The crop cultures that majorly cut across the six test sites were:

1. Winter Barley (Gerste)
2. Rape (Raps)
3. Summer Barley
4. Winter Wheat (Weizen)
5. Oats (Hafer)
6. Summer Wheat
7. Maize (Mais)
8. Potatoes (Kartoffel)

The results displayed in the table 3 below show the mean reflectance back scatter values (in decibels, dB) and their corresponding mean standard deviation values (in decibels, dB) of six different crop cultures that were common in all the six test sites in Leingarten and Moessingen.

<b>CROSS MEAN BACKSCATTER VALUES FOR THE MONTHS OF JULY AND AUGUST (dB)</b>								
Test site	Month		Barley	Oats	Maize	Rape	Wheat	Potatoes
Leingarten	July	m/mean	-11.5	-10.5	-9.7	-10.1	-10.7	-7.5
		m/stdev	4.3	4.2	4.4	4.5	4.4	4.3
	August	m/mean	-15.8	-16.1	-11.2	-10.6	-16	-7.4
		m/stdev	4.4	4.5	4.4	4.4	4.5	4.3
Moessingen upper	July	m/mean	-10.8	-12.8	-9.4	-9.5	-12.0	-10.7
		m/stdev	4.3	4.5	4.5	4.3	4.3	4.7
	August	m/mean	-13.1	-12.3	-10.3	-10.4	-14.3	-9.9
		m/stdev	4.4	4.4	4.5	4.4	4.3	4.7
Moessingen lower	July	m/mean	-14.2		-9.0	-12.4	-14.2	-8.0
		m/stdev	4.5		4.5	4.5	4.5	5.0
	August	m/mean	-16.6		-11.0	-11.0	-14.7	-10.2

		m/stdev	4.6		4.4	4.4	4.5	4.6
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**Table 3: Table showing the various crop cultures in the different test sites, their mean backscatter values (m/mean) and their mean standard deviations (m/stdev).**

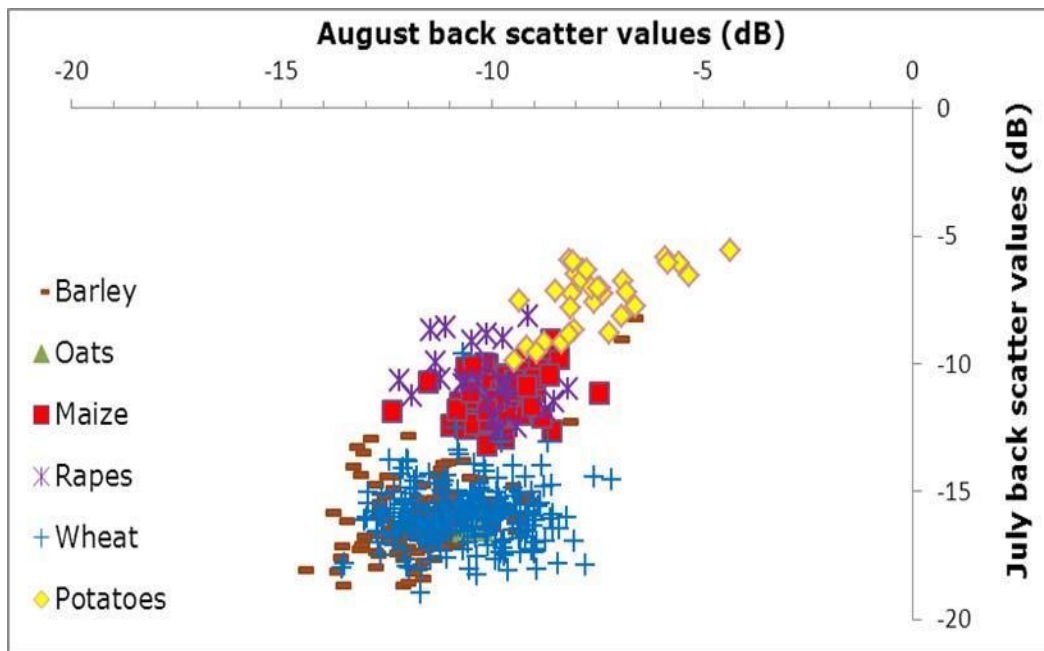
### 3.2. Test Site Analysis

#### 3.2.1. Leingarten Test Site

This is shown in figure 5. In July, Potatoes could be uniquely identified. Rape could not be identified from Maize while Barley could not also be differentiated from Wheat and Oats. Three (3) distinct groups of crop cultures could therefore be differentiated: Potatoes; Rape and Maize; Barley, Wheat and Oats.

For August, Potatoes could be uniquely identified. Rape again could not be differentiated from Maize while Barley could not also be differentiated from Wheat and Oats. Again, three (3) distinct groups of crop cultures could be identified: Potatoes; Rape and Maize; Barley, Wheat and Oats.

There was a general increase from July to August. The greatest increase was in Barley, Oats and Wheat with an increase in mean-mean backscatter values of more than 4 dB. Maize, Rapes and Potatoes had an increase of less than 1.5 dB. There was an increase in mean standard deviation for Rape, a decrease for Barley, Oats and Wheat, and no change for Maize and Potatoes (Table 3).



**Figure 5: Mean back scatter values display of crop cultures in Leingarten test site.**

#### 3.2.2. Moessingen Upper Test Site

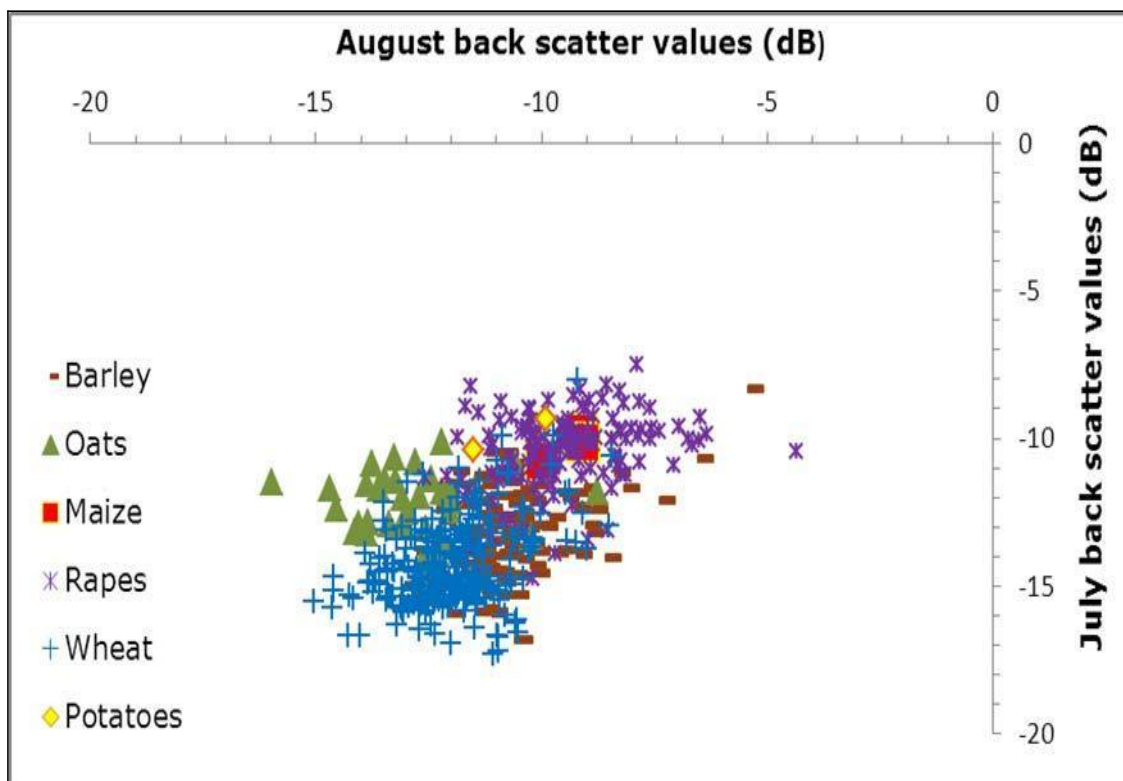
This is shown in figure 6. In July, the Oats, Barley and Wheat cultures could be differentiated from one another but it was difficult to differentiate for the Potatoes, Maize and Rape cultures. This means that four (4) distinct groups could be formulated: Potatoes, Maize and Rapes; Oats; Barley; Wheat.

For August the Oats and Wheat cultures could be well differentiated but it is difficult to differentiate the Potatoes from the Barley and the Maize from the Rape. The cultures could therefore be grouped into four

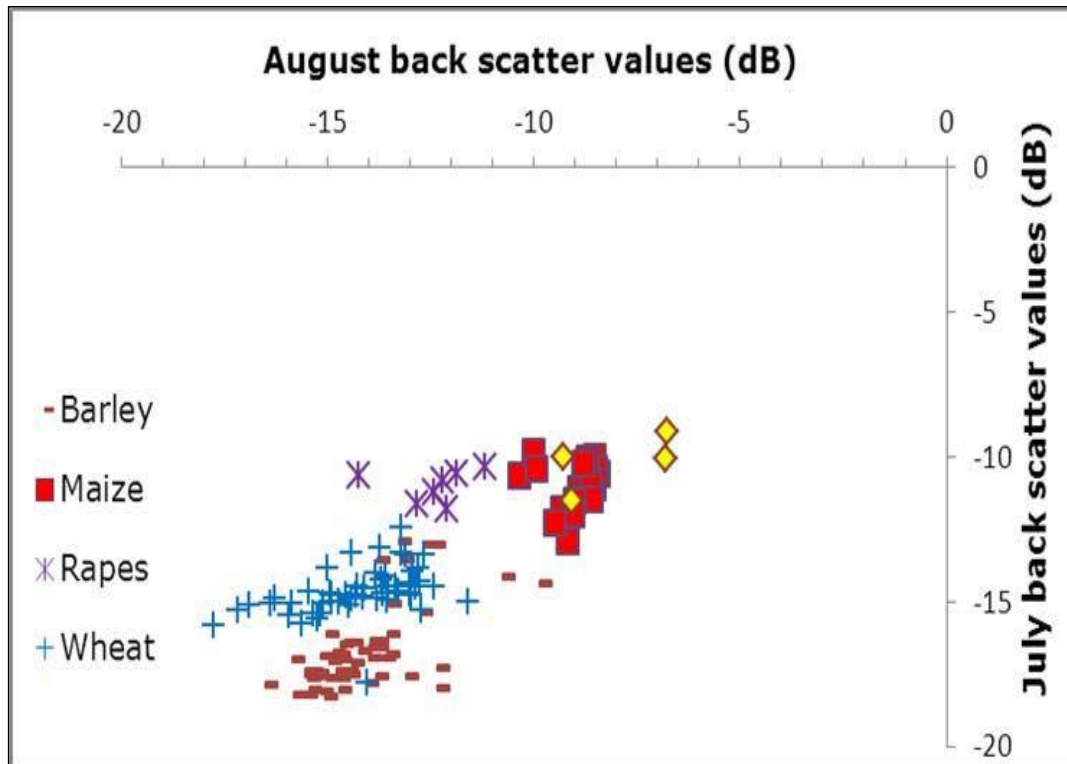
(4): Maize and Rape; Potatoes and Barley; Oats; Wheat. That means that for the two months only the Maize and Rape cultures could not be differentiated. There was also a general increase in mean-mean backscatter values from July to August except for Oats and Potatoes which showed a decrease (Table 3).

### 3.2.3. Moessingen Lower Test Site

This is as seen in figure 7. There were no fields containing Oats. All cultures could be differentiated apart from Maize and Rape for July. The occurring crop cultures could therefore be grouped into four (4) as: Maize and Rape; Potatoes; Wheat; Barley. For the month of August, Barley and Wheat could not be differentiated while all the other crop cultures could be differentiated. The four (4) distinct groups that could be identified were: Barley and Wheat; Potatoes; Maize; Rape. This means that in the two months all cultures within the test site could be differentiated from each other. General increase of mean-mean from July to August except for Rape where there was a decrease of 1.4 dB. The greatest change was in Barley, Maize and Potatoes with an increase of over 2.0 dB with an increase of 0.5 dB in Wheat. The July mean standard deviation was 4.4 dB for Maize and Rape, 4.5 dB for Wheat and 4.6 dB for Barley and Potatoes. The August mean standard deviation was 4.5 dB for Barley, Maize, Rape and Wheat and 5.0 dB for Potatoes. There was an increase in mean standard deviation for Maize, Rape and Potatoes, a decrease for Barley and no change for Wheat (Table 3).



**Figure 6: Mean backscatter values display of crop cultures in Moessingen upper test site.**



**Figure 7: Mean backscatter values display of crop cultures in Moessingen lower test site.**

4. Conclusion

The achieved results were also compared with results from previous studies that had been carried out using similar procedures as an accuracy check. From the summary of the groupings of the different crop cultures in the different test sites that had been generated in the table 4, it could be observed that most of the crop cultures had unique backscatter characteristics in the various test sites. In some test sites, it was observed that some crops might have been harvested earlier than in others. An example is Barley in the Leingarten test site or Oats in the Moessingen upper test site.

<b>TEST SITE</b>	<b>JULY</b>	<b>AUGUST</b>
<b>LEINGARTEN</b>	Potatoes	Potatos
	Rapes, Maize	Rapes, Maize
	Barley, Wheat, Oats	Barley, Wheat, Oats
<b>MOESSINGEN UPPER</b>	Potatoes, Maize, Rapes	Maize, Rapes
	Oats	Potatoes, Barley
	Barley	Oats
	Wheat	Wheat
<b>MOESSINGEN LOWER</b>	Maize, Rapes	Barley, Wheat
	Potatoes	Potatoes
	Wheat	Maize
	Barley	Rapes

**Table 4: Summary of the groupings of the different crop cultures according to their mean backscatter values, which were realized from this study.**

Comparison Of July Mean Backscatter Values With Reference Mean Backscatter Values							
		Barley	Oats	Maize	Rape	Wheat	Potatoes
Leingarten Test Site	<b>August</b>	<b>-11.5</b>	<b>-10.5</b>	<b>-9.7</b>	<b>-10.1</b>	<b>-10.7</b>	<b>-7.5</b>
	July	-15.9	-16.1	-11.2	-10.6	-16	-7.4
Moessingen Upper Test Site	<b>August</b>	<b>-10.8</b>	<b>-12.8</b>	<b>-9.4</b>	<b>-9.5</b>	<b>-11.9</b>	<b>-10.7</b>
	July	-13.1	-12.3	-10.3	-10.4	-14.3	-9.9
Moessingen Lower Test Site	<b>August</b>	<b>-14.2</b>		<b>-9.0</b>	<b>-12.4</b>	<b>-14.2</b>	<b>-8.0</b>
	July	-16.6		-11.0	-11.0	-14.7	-10.2
Reference Values	<b>July</b>	<b>-12</b>	<b>-12</b>	<b>-8</b>	<b>-10</b>	<b>-14</b>	<b>-8</b>

**Table 5: Comparison of the realized mean backscatter values from the study with those of a previous study (reference values) carried out in the Fuhrberg area, North East of Hannover, Germany. The shaded cells are the values for July which had been deemed unreliable [Bargiel D. et al., 2010].**

As a check for the accuracies of the study results, the mean backscatter values were compared with results of a study that had been carried out by earlier in Fuhrberg area, North East of Hannover, Germany by Bargiel [Bargiel D. et al., 2010]. He used the backscatter values also to differentiate the different crop cultures. The only differences were that he employed the use of a filter (multitemporal DeGrandi filter) and that he recorded the cultivation practices of the farmers. The average values he acquired are shown in table 5 at the bottom row, in orange. These values were compared with the unshaded values in the table, which represent the reliable values that had been realized from the various test sites, while the shaded values represent the values for the month of August and the values for the month of July which had been deemed unreliable. The best accuracies were achieved in the classification of the Oats, Rapes, Wheat and Potatoes. The mean backscatter values for the Barley and Maize showed a bigger deviation from the reference values. This can be due to the fact that both Maize and Barley are cultivated for various purposes and the purpose for which the crops are intended dictates the method of cultivation. The fact that a filter was applied in the data processing could also probably explain the slight differences that existed in the mean backscatter values.

In order to improve the values of the backscatter values, records of other parameters like: Soil characteristic values during image acquisition like the wetness, soil type or whether the soil was cultivated or not, the moisture present on the surface of the leaves during the time of acquisition, the local weather condition during the time of acquisition, for example the humidity and the cultivation practices undertaken by the farmer e.g. tillage method, weeding method, purposes for which the crop is been grown should be taken into account.

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## TWH

### **A review of literature on local community participation towards sustainable tourism development in East Africa**

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#### **Abstract**

Tourism is a major contributor to global economic growth, hence it has been earmarked for the achievement of the aspirations of the 2030 Agenda for Sustainable Development. As a result, UNWTO has partnered with governments, private partners, international and regional finance institutions and other organizations to realize sustainable Development Goals (SDGs). One of the SDG goals is to promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all by 2030 by devising and implementing policies to promote sustainable tourism. Impliedly, inclusivity of local communities is critical to the achievement of the aspirations. Ironically, literature contends that local communities lack participation opportunities in decision-making relating to tourism and experience inadequate financial, social and vocational benefits from projects that commercially exploit their resources. Therefore, this study reviewed the extent to which local communities participate in sustainable tourism development. This study adopted a qualitative approach by reviewing and analyzing existent literature on the topic under study. Based on the literature, the findings of these studies reveal that local communities participation in tourism is coercive, a low form of participation which denies the local community more opportunities to participate in key policy and decision making process. This study concludes that local community participation towards sustainable tourism development is more coercive and induced than spontaneous. Besides much participation is associated with socio-economic pillar of sustainability at the expense of the ecologic pillar. In addition, several personal and environmental factors influence local community participation. Consequently, this study proposed an integrated framework of factors which influence local community participation that can be used in East African countries. However, a quantitative study is recommended to investigate the reliability and the extent to which the framework can be applied in the Kenyan tourism destinations.

**Key words:** community participation; Local community; Sustainable tourism development; tourism

## INTRODUCTION

Tourism has been earmarked for the achievement of the aspirations of the 2030 agenda for sustainable development, hence UNWTO has partnered with governments, private partners, international and regional finance institutions and international organizations to realize the sustainable development goals, one of which is to promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all by 2030 by devising and implementing policies to promote sustainable tourism development (UNWTO 2014).

The World Tourism Organization (WTO) (1998: 19) defines sustainable tourism development as “tourism which meets the needs of present tourists and host regions while protecting and enhancing opportunity for the future. It is envisaged as leading to management of all resources in such a way that economic, social, and aesthetic needs can be fulfilled while maintaining cultural integrity, essential ecological processes, biological diversity, and life support system.” (ETE/ UNESCO 2009).

In other words, sustainable tourism development is ecologically sustainable, economically viable as well as ethically and socially equitable. More specifically, sustainable tourism development is summarized under the following four main principles: communities’ wellbeing; protection of the natural and cultural environment; quality tourism product development and tourist satisfaction and adaptive management and monitoring. More precisely, sustainable tourism development supports and ensures the economic, social and cultural well-being of the communities in which tourism takes place. Secondly, sustainable tourism allows the use of natural and cultural resources for gaining economic profit while at the same time guaranteeing that such resources, both natural and cultural are protected and the maintained. Thirdly, sustainable tourism development is anchored on the quality of tourism products offered by a region and is characterized by material criteria like the quality of transport, accommodation and food, but also by non-material criteria like hospitality and experiences. Lastly, sustainable tourism development depends on the application of adaptive management and monitoring of tourism activities to ensure that tourism is developed in a way which is ecological, economic and socially sustainable (ETE/ UNESCO 2009).

On the other hand, local community participation in tourism is defined as the involvement of all local people and other stakeholders in the formation of programmes or policies that would assist to change their communities (Phiri 2009). Studies (Arnstein 1969; Pretty 1995; Tosun 2006) posit that local community participation in tourism projects is key to the achievement of sustainable development agenda both at the international and national fronts. According to Mugizi, Ayorekire & Obua, (2017) some of the positive socio-economic contributions of tourism towards sustainable development agenda can be realized through tourism revenue earnings, creation of employment opportunities, employment quality, balance of payment, local prosperity by reducing leakages, community wellbeing, social equity, biological diversity and resource efficiency.

However, according to Murphy (2013) one important factor to consider in order to sustain the socio-economic contributions for sustainable tourism development is the need to involve local community participation in the development process. In as much as local community participation contributes to ecologically sustainable, economically

viable and socially equitable tourism development, studies (Nsabimana 2010; Muthuri 2012; Muganda, Sirima, & Marwa, 2013; Mugizi *et al.*, 2017) assert that there is little local community participation in tourism planning and development.

Besides, most studies focus on importance and the extent of local community participation rather than the factors that influence such participation (Tosun 2006). For instance, Nsabimana (2010) study focused on the extent to which communities are involved in sustainable tourism development and conservation activities in Rwanda while Muthuri (2012) focused on factors hindering local community participation in tourism development in Kenya. Muganda *et al.*, (2013) study extensively focused on the role of local community participation in tourism development in Tanzania.

From the studies reviewed, it's evident that several factors influence local community participation towards sustainable tourism development. Muganda *et al.*, (2013) reckons that the local community perceptions towards their participation in tourism projects is imposed on them. Consequently, a knowledge gap exists between what local community thinks of their roles in sustainable tourism development is as opposed to their imposed roles.

Besides in most developing countries, interferences from authorities in local community tourism projects and little consultation between the government and local community in key decision making seem to be rampant. For instance, in Kenya the findings of a study carried out in Kimana Community Wildlife Sanctuary around Amboseli National Park, point out interference from the government in bid to control the sanctuary (Ondicho 2012).

More often, the decision and policy making process is top down and mostly dominated by the government, private sector and /or NGOs (Scherl & Edwards 2007). Deriving from the Doxey's Irritation Index model (1975), little consultation between the government and local community may cause local communities to demonstrate misgivings about tourism when they are less involved in key decisions. This may eventually develop into irritation expressed either verbally or physically against tourists. Nsabimana (2010) and Muthuri (2012) underscore that little consultation between the government and local community leads to resistance to tourism which may results into illegal activities by the local communities against tourism.

Mugizi *et al.*, (2017) notes that a heterogeneous nature of the communities presents unequal opportunities and different expectations in the participatory approach to tourism planning and development. Mugizi *et al.*, (2017) expounds that while some local community members may have little information about tourism, others may lack the resources to benefit from tourism activities hence, they may be prone to manipulation and exploitation from the privileged. For instance, there are cases in Kenya where communal pieces of land of local communities around tourism protected areas are managed by foreigners, which has caused resource use conflicts (Okello 2011).

Based on the literature reviewed, there seems to be a myriad of factors which influence local community participation in sustainable tourism development. Therefore, the purpose of this study was to examine Therefore, this study reviewed the extent to which local communities participate in sustainable tourism development. The study was guided by the following research objectives

## **Research objectives**

- i. To identify the level of local community participation towards sustainable tourism development in East Africa
- ii. To identify factors that influence local communities' participation towards sustainable tourism development in East Africa
- iii. To propose a framework for local community participation towards sustainable tourism development in East Africa.

## **Literature Review**

According to UNEP & UNWTO (2005) sustainable tourism development requires the informed participation of all relevant stakeholders, as well as strong political leadership to ensure wide participation and consensus building. Achieving sustainable tourism is a continuous process and it requires constant monitoring of impacts, introducing the necessary preventive and/or corrective measures whenever necessary. The main focus of sustainable tourism development is firstly, to make optimal use of environmental resources that constitute a key element in sustainable tourism development, maintaining essential ecological processes and helping to conserve natural resources and biodiversity. Secondly, sustainable tourism development aims at enhancing respect to the socio-cultural authenticity of host communities, conserve their built and living cultural heritage and traditional values, and contribute to inter-cultural understanding and tolerance. Lastly, it ensures viable, long-term economic operations, providing socio-economic benefits to all stakeholders that are fairly distributed, including stable employment and income-earning opportunities and social services to host communities, and contributing to poverty alleviation (UNEP & UNWTO 2005).

For this study, sustainable tourism development was conceptualized as economic, social, and ecological sustainability of the tourism resources (ETE/ UNESCO 2009). More specifically, the social dimension was measured by community wellbeing and social equity, while economic dimension was measured by employment quality, reduction of leakages and economic viability. In addition, ecological dimension was measured by biological diversity and resource efficiency (UNEP & UNWTO 2005).

On the other hand, there has been a lot of literature on local community participation in sustainable tourism development activities. As a concept local participation is regarded as a bottom -up process that empowers marginalized groups thus providing them with opportunity to have a say and greater control over decisions and activities that affect their lives and well-being (Scheyvens, 2007).

In order to conceptualize local community participation in sustainable tourism development, community participation model propounded by Tosun (1999a). Later on in 2006, the model was reviewed in relation to other models from other disciplines such as developmental studies hence, a more comprehensive model was developed. Since then, Tosun (2006) model has widely been in tourism studies.

Tosun (2006) model is a combination of Arnstein (1969) and Pretty (1995) models of community participation which focused on participatory development approaches in development studies. According to Arnstein (1969) citizen participation is the redistribution of power that enables the have-not Citizens to be deliberately included in the future. It is the means by which they can induce significant social reform, which enables them to share in the benefits of the affluent society. Arnstein (1969) approach was in terms of a ladder or typology of citizen participation including eight

levels, which are classified in turn among three categories relative to authentic citizen participation. While the lowest category represents manipulative participation, the highest category refers to degrees of citizen power. The middle category indicates degrees of citizen tokenism. On the other hand, according to Pretty's (1995) typology of participation, local participation is a critical factor to the success of development projects. As such, development projects and programmes implemented by Non-governmental Organizations (NGOs) and governments need to incorporate a strong aspect of local community participation. Each level of participation allows for differing degrees of external involvement and local control, and reflects the power relationships between them. Self-mobilization is the most crucial of all the seven categories because without it the local communities would not have a platform to make meaningful contributions to decisions that are made to guide the implementation of development programmes that benefit them. Clearly, the benefits received by local communities from tourism and related activities will depend on the extent to which they have been involved and the equitable manner in which the benefits have been shared.

Tosun (2006) model takes a participatory approach to tourism to facilitate implementation of principles of sustainable tourism development by creating better opportunities for local people to gain larger and more balanced benefits from sustainable tourism development taking place within their localities. This results into more positive attitudes to tourism activities and conservation of local resources, and increases the local communities' tolerance to tourism. These could ensure both visitor satisfaction and ongoing benefits for the residents of destinations areas. More specifically, there are 3 typologies of community participation in tourism. The typologies are classified as spontaneous, induced and coercive (Tosun 2006). Firstly, spontaneous participation refers to an ideal mode of local community participation which provides full managerial responsibility and authority to local community (Tosun 1999a). Spontaneous level of participation represents situations when the local community has full control and authority (Sakhile & Tembi 2017).

Secondly, induced community participation in tourism is perceived to be the best type of participation as the local community is allowed to hear and be heard. They have a voice in the sustainable tourism development process, but they do not have power to ensure that their views will be taken into account by other powerful interest groups such as government bodies, multinational companies, international tour operators, etc. Therefore, it seems to denote level of tokenism. This type is the most common mode to be found in developing countries where a local community only endorse decisions regarding tourism development issues made for them rather than by them (Tosun 1999a).

Induced community participation is top-down, passive and indirect in the sense that local communities may participate in implementation and sharing benefits of tourism, but not in the decision making process. This level of participation implies that the local community has no autonomy to influence decision-making. This is often referred to as top-down approach. Lastly, coercive participation is realized when some of the decisions are made to appease the local community by meeting a few basic needs, so as to avoid socio-political risks for sustainable tourism development (Sakhile & Tembi 2017).

Lastly, coercive participation is manipulated and contrived as a substitute for genuine participation. The real objective is not to enable people to participate in sustainable

tourism development process, but to enable power holders to educate or cure host communities to turn away potential and actual threats to future of sustainable tourism development. Some decisions may be taken to meet basic needs of host-communities by consulting local leaders so as to reduce socio-political risks for tourists and sustainable tourism development. Although it seems that sustainable tourism development is to take place based upon host communities' priorities, it is heavily skewed towards the fostering and development of tourism, and would primarily be concerned with meeting the needs and desires of decision makers, tourism's operators and tourists.

Figure 2.0 illustrates the typologies of community participation as modified by Tosun (2006)

7. Self-mobilization	←	8. Citizen control	Degrees of Citizen Power	→	<u>Spontaneous Participation</u> Bottom-up; active par.; direct participation; par. in decision making, authentic participation; self planning;
6. Interactive participation		7. Delegated power			
		6. Partnership			
5. Functional participation	←	5. Placation	Degrees of Citizen Tokenism	→	<u>Induced Participation</u> Top-down; passive; formal; mostly indirect; degree of tokenism, manipulation; pseudo-participation; participation in implementation and sharing benefits; choice between proposed alternatives and feedback.
4. Participation for material incentives		4. Consultation			
3. Participation by consultation		3. Informing			
2. Passive participation	←	2. Therapy	Non-participation	→	<u>Coercive Participation</u> Top-down, passive; mostly indirect, formal; participation in implementation, but not necessarily sharing benefits; choice between proposed limited alternatives or no choice; paternalism, non-participation, high degree of tokenism and manipulation.
1. Manipulative participation		1. Manipulation			
Pretty's (1995) typology of community participation		Arnstein's (1971) typology of community participation			Tosun's (1999a) typology of community participation

Keys: Corresponding categories in each typology      →      ←

**Figure 2.0:** Community Participation

Tosun (2006).

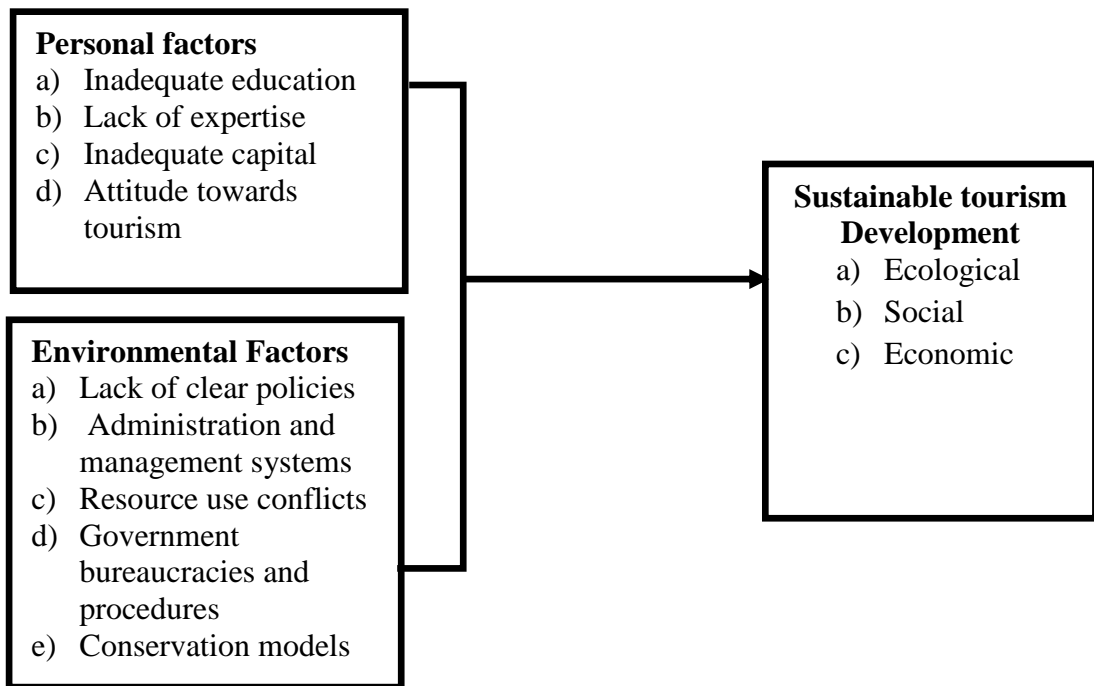
In as much as Tosun model (2006) is widely used in studies of local community participation in tourism, it has some limitations which relate to centralization of tourism administration, attitudes of professionals towards tourism, lack of human and financial resources as well as dominance of the elite in tourism activities, hence creating an impression that tourism programmes often benefit those with the capacity to participate in the planning, development and management of tourism which is not often the case. The capacity is what has been referred to as self-mobilization because it empowers the local community to make and execute decisions (Tosun 2000).

Besides, the model falls short of the explanations on why and how the different levels of participation exist. It is significant to examine understand factors which may result into the typologies in order to enhance local community participation in sustainable tourism development. However, there are various factors that can lead to spontaneous, induced and coercive participation. Such factors may result from individual personal issues to more complex systematic and structural issues. The individual personal issues may be within the local communities' ability to influence them while the systematic and structural issues may be resultant from the environment in which they operate in.

This study proposed a model of such factors as shown in figure 2.1

### Proposed model for the study





**Figure 2.1:** Factors influencing Local Community Participation

Modified from Nsabimana (2010); Muthuri (2012); Muganda, *et al.*, (2013) and Mugizi *et al.*, 2017).

#### **METHODOLOGY**

The study adopted content analysis research design. It took a qualitative approach by reviewing previous studies on local community participation towards sustainable tourism development.

**Table 2: Summary of reviewed studies**

	<b>Title &amp; Authors</b>	<b>Findings of previous studies</b>	<b>Methodology</b>
1	<p>The role of local communities in tourism development: Grassroots perspective from Tanzania</p> <p>Muganda,, Sirima, &amp; Marwa, (2013)</p>	<p>a) Local people views on their role indicated that they think that they should be involved in policy formulation and decision making the process; financially supported and be made ‘watchdogs’ in development issues.</p> <p>b) Illiteracy, limited capacity due to lack of education, lack of knowledge and skills were cited as some of the factors affecting involvement in tourism activities</p> <p>c) Decision making and policy formulation is still top-down and passive, not only in Barabarani area, but Tanzania in general.</p>	<p>i. Mixed method approach</p> <p>ii. Data collected between June-august 2008</p> <p>iii. Questionnaire, survey and observation tools used</p> <p>iv. Sample size: 139 households from a population of 2480</p>
2	<p>Factors that influence local community participation in Tourism in Murchison falls conservation area in Uganda</p> <p>Mugizi, Ayorekire &amp; Obua, (2017)</p>	<p>a) Majorly, participation is at coercive level, attributed to the nature of tourism employment opportunities such as security guards, trail maintenance, casual labourers, waiters, tour guiding and attendants in craft shops and restaurants.</p> <p>b) Highest level of participation is functional, which involves activities such as advising community tourism groups, representing communities on discussion platforms for conservation issues and providing leadership in Community Based Tourism Enterprises.</p> <p>c) None of the participation is at self-mobilization level due to limited education, lack of capital to support independent initiatives or inadequate support from donor agencies.</p>	<p>i. Sample size: 335 households randomly selected</p> <p>ii. Data collected by use of questionnaires and interviews.</p>
3	<p>The extent of community involvement in Tourism Development and conservation activities in Eastern Rwanda</p> <p>Nsabimana, (2010)</p>	<p>a) There is little participation in economic activities such as employment (though in low numbers for menial jobs)</p> <p>b) Local community operate small scale businesses such as curio shops,</p> <p>c) Hardly involved in process of decision making and policy formulation.</p> <p>d) Policies regard local residents as dormant participants who need to only be informed and economically assisted, (less valued as partners in decision making processes).</p>	<p>i. Data collected by use of questionnaire and interviews</p> <p>ii. Research Design: exploratory</p>

4.	Factors hindering Kawiru Community participation in tourism development in Meru National Park, Meru County Muthuri, (2012)	<ul style="list-style-type: none"> <li>a) Lack of Community-Based Organization</li> <li>b) Locals not effectively involved in the management of parks.</li> <li>c) Poor knowledge on tourism, high illiteracy levels, financial constraint and negative attitudes affect participation</li> <li>d) No clear policies which engage locals and challenge illiteracy</li> </ul>	<ul style="list-style-type: none"> <li>i. Cross sectional descriptive design</li> <li>ii. T/Popln. 19,679, sample frame: 1,800 and sample size 126.</li> <li>iii. Questionnaires, observation interviews</li> </ul>
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## RESULTS AND DISCUSSION

Based on the analysis of the previous studies it is apparent that communities have not been involved adequately in sustainable tourism development in spite the fact that they form an integral part of sustainable tourism development agenda. Studies (Nsabimana 2010; Muthuri 2012; Muganda *et al.*, 2013; Mugizi *et al.*, 2017) have indicated several factors which influence their participation in sustainable tourism development. The factors are both personal and environmental.

Personal factors such as inadequate education, lack of expertise, inadequate capital to operate and negative attitude towards tourism may affect the level of participation. The findings coincide with Ondicho (2012) and Okello (2011) studies which underscored that that most often, local communities education is inadequate and hence the reason why most locals are left to do seasonal unskilled jobs. This eventually degenerates into local community intolerances to tourism conservation. In addition, lack of expertise creates room for interferences from the government, private non local investors and the local elites who take advantage of the locals and control some of the local community based initiatives. Negative attitude towards tourism is occurs when there is delayed compensation for destruction and death of the locals caused by human wildlife conflict and the failure to benefit from tourism.

On the other hand, lack of clear policies on how to engage the local communities in sustainable tourism development, less effective administration and management systems where most decisions are centralized and resource use conflicts are major factors which affect local community participation in sustainable tourism development. In addition, competing interests between other stakeholders and the local communities, government bureaucracies and procedures (which cause delays in compensation of reported human wildlife cases) also affect local community participation. The other factor noted to have an influence on local community participation in sustainable tourism development is the conservation models adopted by parks.

These findings coincide with Okello (2005) which asserted that management systems adopted by the central government in decision making process is often top down, marred with bureaucratic and cumbersome procedures especially when it comes to compensation for human wildlife conflicts. Besides, the conservation models adopted for instance, by the International Union for Conservation of Nature Category II Park model which has been criticized for displacing people, outlawing human settlement

and designating resources as ‘protected’ have worked against local community participatory approach to sustainable tourism development. Other findings (Scherl & Edwards 2007) also emphasizes that the decision and policy making process is classically top-down and is dominated by the government, private sector and/or NGOs.

Furthermore, Okello (2005) pointed out that resource use conflict, especially in cases where there is conflict of interests for instance between the government (e.g. through Kenya Wildlife Service, (KWS) and the local community in a project can influence participation. For instance, most often KWS interest in a community based tourism project is creation of space for wildlife dispersal, the private investors’ interest is profit maximization, while the local elite’s main interest is reported to be mainly as being swindling of funds from the projects for personal gains (Okello 2005). This scenario leaves the local community in a situation of little benefit from what is supposed to be their resource.

## **CONCLUSION**

Apparently from the reviewed literature, local community participation towards sustainable tourism development is more focused on the coercive and induced form than spontaneous. Besides much attention of participation is associated with socio-economic pillar of sustainability at the expense of the ecologic pillar. There seems to be more subtle initiatives and policies which encourage local community conservation practices. Moreover, due to the low form of participation, the local community are more prone to negatively interfere with conservation activities, which threatens ecological sustainability. In addition, personal and environmental factors influence the participation of local community in sustainable tourism development. These factors if well addressed by stakeholders can positively influence local community participation at all levels. However, for generalization of the findings of this study, there is need for further research using more quantitative methods of analysis.

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# **Role of Local Food in Tourism Promotion in Kenya**

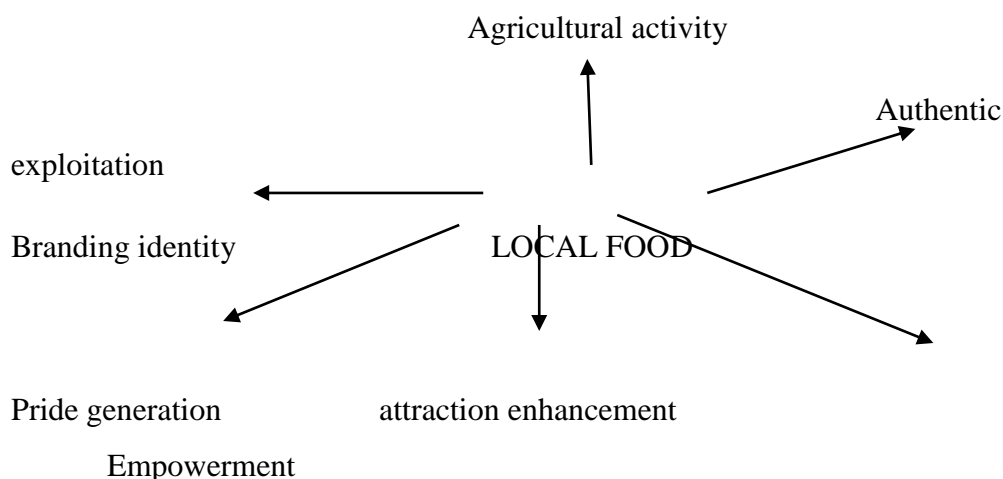
**Peninah Chege**

## **1.0 Introduction**

Tourism has become a major income earner and one of the international recognized trade categories ranking high along with fuels, chemicals and automotive products. In Kenya, tourists mainly come for the customary wildlife safari and beach tourism attractions which on their own may not offer sustainable tourism in the long run. The tourism industry needs to diversify their products and integrate more cultural tourism based components of which food and drink is a key component. According to (UNESCO, 2001), culture encompasses several aspects such as food, rituals, dances, festivals, sculpture, building designs, religion, dressing and other practices. Culture is based on the mosaic of places, foods, traditions, art, rituals and experience of people.(Nasaa Arts, 2004). From the two descriptions of culture, it can be believed that food is a key aspect of culture. Kenya being a multi-ethnic nation with more than forty ethnic communities has highly diverse mix of cultures which should be packaged and vended as one of Kenya's tourism products.

Food is a fundamental part of the tourist experience. Increasingly, local food is used in tourism as an integral part of the visitor attraction to enrich tourist experiences. Local food acts as a differentiating feature for destinations and can play an important role in increasing visitor yield, stimulating growth in other economic sectors and promoting sustainable occupations. The close relationship between local food and culture enables the promotion of cultural heritage through promotion of local foods. Thus, linking local food and tourism has the potential to create more sustainable tourism practices and outcomes. Local food, as part of the tourism experience, involves a number of benefits that reflect the principles of sustainable development.

**Figure 1.1: The contribution of local food to sustainable development**



Source: du Rand et al., (2003)

The relationship between food and tourism has progressed from traditional hospitality, cuisine and gastronomy” to the development of the innovative concept of “food tourism (Jones & Jenkins, 2002). Approximately 30% of tourists’ total expenditure is spent on accommodation, food and drink in hotels, and an additional 11.3% is spent on food and drink away from the hotel (Tohamy & Swinscoe, 2000) and that 40% of tourists’ expenditure is spent on food alone (Boyne & Hall, 2004).

Joint marketing strategies that link food with tourism have been successfully implemented by Australia and New Zealand (Hall & Mitchell, 2002a). Initiatives to promote Spain’s culinary heritage as part of the region’s cultural products have enabled Spain to be re-branded as a destination with a valuable cultural heritage alongside its primary attractions of sun, sand and sea (Ravenscroft & Westering, 2002).

In Kenya, the promotion of local food as a component of its destination attractiveness is still in its embryonic stage (Okech, 2014). On the background of the above facts, this research paper was done to find out the role of local food in tourism promotion in Kenya. The prime objective of the paper was to identify the extent to which local foods are used in Kenya’s tourism print and e-marketing materials.



## **2.0 Literature review**

There are many forms of tourism in Kenya, some of which are fully developed while others are yet to be developed to their full potential. Culinary and food tourism are some of underdeveloped niche tourism sub-sectors in Kenya. Culinary tourism is a sub-set of agro-tourism which focuses on the search for, and enjoyment of, prepared food and drink. Food tourism on the other hand encompasses the travel to experience a particular type of food or the produce of a specific region (CM Hall, 2003). Food tourism can be an important driver for regional development by strengthening local production through backward linkages in supply tourism chain partnerships (Renko, 2010) and is regarded as an important vehicle in delivering sustainable tourism (Everett, 2013). Both agri-tourism and food tourism can foster economic and community development and new intercultural insights.

Culinary tourism looks at the aspects of exploratory eating or participating in foreign food ways as a way of encountering and consuming other places and cultures (Long, 2004). Food attractions may include special events such as food festivals or cooking holidays (Di Domenico, 2012) or the promotion of local food through farmer's markets, enhanced local menu items and the inclusion of locally grown food produce in the hospitality supply chain (Torres, 2002). Local cuisines represent a core manifestation of a destination's intangible heritage and through its consumption tourism can gain a truly authentic cultural experience. (Renko, 2010). Studies have shown that for effective food tourism development, pre-existing tourism infrastructure is a prerequisite. It has also been argued that proximity to urban areas is important in developing local food tourism. (Dougherty, 2013).

Local foods have much potential to enhance sustainability of the tourism industry. The potential of culinary as a theme to sharpen a destination image should not be underestimated. Culinary can give destination uniqueness where specific local foods can be presented as an iconic feature for particular destinations. Kenya being a culturally diverse nation, local foods can provide it with a unique brand.

## List of cultural attributes unique to Kenya

Local people

Local language

Tales and legends

Dressing

Cultural architecture

Wood carvings

Soap stones

Beads and jewellery

Weavings

Music and dance

Food and drinks

Religion

Source: Adapted from Okech (2014, p. 4)

From the list it can be argued that food and drinks is an important aspect of culture which should be incorporated in promoting and marketing heritage tourism in Kenya.

### **3.0 Methodology**

This paper employed content analysis research approach focussing on relevant print and e-marketing material from Kenya Tourism Board (KTB) and Kenya Tourism Federation (KTF). The two institutions were selected since they are legally mandated to promote and market tourism in Kenya. The aim of the study was to find out the role of local foods in tourism promotion in Kenya. The study analysed information from magazines, brochures, reports and newsletters from the two institutions both in hard copy and soft copy. Websites of the two institutions were also analysed keenly particularly with respect to information relevant to the themes that had been established. Additionally, policy documents relevant to tourism were also analysed to establish the extent to which policy guidelines have emphasised diversification of tourism products and in particular the promotion of local foods as component of Kenya's attractiveness.

Additionally to increase objectivity of the study, secondary data was obtained from websites of five star hotels in Nairobi County. The pictorial and textual content of tourist brochures and websites were analyzed. The results from this analysis were then validated by a discourse analysis conducted on the same printed materials and websites. Content analysis according to Wood & Kroger (2002), are used to texts, pictures obtained from the website and print materials and also to get the hidden meaning of images where a set of themes have been established. Discourse analysis was used to understand the background and identify the embodied meanings from the images (Fairclough 2003).

To enhance objectivity in analysis of the information, the researcher was guided by the following questions, which to a large extent formed the major and minor themes for content analysis.

1. What are the forms of tourism promoted in Kenya?
2. What tourism products are promoted in Kenya?
3. What specific cultural/ heritage tourism products are marketed in Kenya?
4. What aspects of food tourism are promoted in Kenya?

#### **4.0 Results and discussion on KTB and KTF**

It is important to note that even though the study combined both print and e-marketing materials, there was heavy reliance on website information. Most of the materials and information contained on the websites were not up-to-date. Further, e-brochures and newsletters were not accessible even though the websites had indicated that they are available. To cure this challenge, hard copies were used, though very few were available.

#### **4.1 Tourism forms, attractions and products promoted in Kenya.**

The study found out that wildlife safari and beach tourism were the main forms of tourism marketed by Kenya Tourism Board and the Kenya Tourism Federation. Kenya has been promoted as the ideal safari destination. Some of the attractions and products featured included the vast plains with abundant wildlife and unique cultures, the tropical coastline of warm waters, coral reefs and powdery palm-fringed beaches. Unique attractions such as the annual wildebeest migration among others were also regarded highly in making Kenya the ideal wildlife safari destination. Specific safaris promoted included: Masai Mara balloon safari, walking safaris, camel safari, dhow safari, helicopter safari, snake safari and birding safari.

Sports tourism was the second most featured tourism type. Specific emphasis was put on water sports with the main sporting activities being diving, kite surfing, big game fishing and white water rafting among others. Playing golf was the other sporting activity promoted across all the available marketing materials that were accessed by the researcher. Wonderful photos of different golf courses were featured to offer magnetic visual appeal to golf lovers.

Cultural and heritage tourism was promoted across all the marketing materials examined. Emphasis was however mainly on urban culture and village visits. Under the umbrella of village visits, focus was placed on traditional ceremonies and handicrafts particularly from the Masai in Amboseli and Masai Mara and the Samburu communities in the northern rangelands.

Other tourism forms promoted included active travel involving activities such as mountain biking, hiking and trekking and skydiving. Special interest travellers were

also targeted through promotion of Kenya as a destination offering opportunities for filming, photography, archaeological tours, agro-tourism and business travel. Events and festivals were also promoted through Maralal camel derby, Lamu cultural festival and the rhino charge.

### **Other forms of marketing used to promote tourism in Kenya**

The study found out that recognitions and awards have been used to a great extent by KTB to market Kenya as an authentic, world leading safari destination. Some of the awards and recognitions highlighted included:

- a. Kenya's award of the World's Leading Safari Destination at the 20th World Travel Awards (WTA) grand finale in Doha, Qatar.
- b. Kenya Airways recognition and award as Africa's Leading Airline
- c. Masai Mara national reserve recognition as Africa's Leading national park Brand.

Hotel recognitions highlighted included:

- a. Africa's leading Meetings, Incentives, Conferences and Exhibitions (MICE) Hotel which was awarded to Safari Park Hotels & Casino
- b. Africa's leading Eco-Hotel awarded to Amboseli Serena Safari Lodge
- c. Africa's leading Eco-Lodge awarded to Il Ngwesi lodge
- d. Africa's Leading green hotel awarded to Aberdare Country Club
- e. Africa's Leading new hotel awarded to Villa Rosa Kempinski Nairobi
- f. Africa's Leading resort awarded to Alfajiri Villas.

These awards and recognitions present Kenya as the ideal place for holiday makers, eco-travellers and conference planners.

### **Review of the Why I love Kenya Magazine (WILK)**

WILK is the official magazine of the ministry of tourism and wildlife and the Kenya Tourism board. The magazine is primarily used for marketing by the ministry of tourism and wildlife and KTB. The study found out that like all other marketing materials this magazine has also fallen short of the need to diversify tourism products since it focused on the wildlife safari and beach tourism. Though, to a small extent the magazine highlighted culture and heritage as some of the attractions, it did not market local food explicitly as a product to be enjoyed by tourists while in Kenya.

# Why I Love Kenya

By David Lekuta Rudisha

## Meet Kenya's 'King David'

*In this issue we meet Kenya's legendary middle-distance runner, David Lekuta Rudisha. Known in Kenya as 'King David' he is the 2012 and 2016 Olympic Champion, World Champion and World Record Holder in the 800 metres. He is also the first and only person to run the event in under 1h.41m. Winner of a record three consecutive 'Track and Field Athlete of the Year' awards, David won the IAAF World 'Athlete of the Year' award in 2010 and the 'Association of National Olympic Committees' award for 'Best Male Athlete' of London 2012. A proud Maasai, David was also awarded the Moran of the Burning Spear award from the Government of Kenya.*



### Tell us why you love Kenya?

Kenya is a great country, and so diverse – I just love it. If you travel from north to south you'll find everything you need to see in the world. There are deserts, beautiful rivers, mountains and highlands. And there's the Great Rift Valley – which means home to me. There's also a unique richness of culture and wildlife. My favourite area is Maasailand – it's so peaceful and natural – and I love nature.

### What about the people?

I love the Kenyan people; they have such spirit. They smile even when times are hard. I'm Maasai – and the Maasai have a unique character.

### How does it feel to represent Kenya on the world stage?

To represent a country like Kenya is very special. The most exciting part is when they play the Kenyan national anthem. I always feel very emotional then – like I am carrying 40 million people with me.

### Tell us about your background

I grew up in Kilgoris, bordering the Masai Mara. My dad, Daniel Rudisha, loved sport. He represented Kenya in the 1966 Commonwealth Games (400 meters) and in the 1967 World Championships. He took home a silver medal in the 1968 Mexico Olympics. That medal really sparked my passion. My Dad trained me for my early school competitions – every evening – up and down the hill.

### What is your favourite animal?

The lion: without a doubt. It plays a great part in our Maasai culture. In the past we had to perform the ritual killing of a lion with a spear – to show we had courage. Today I am the patron of a programme run by the Big Life Foundation in Amboseli that has reduced lion killing to zero. Since 2012 we've demonstrated our courage by our sporting achievements in the bi-annual Maasai Olympics. It not only mobilizes awareness for wildlife conservation but it also helps to resolve animal vs. human conflict.

### What does the future hold?

I might retire from running after the 2020 Olympics in Tokyo. I want to concentrate on other things. I'd like to write a book about my father's legacy and pursue my work with the Maasai Olympics. I'd also like to raise awareness about how everyone should have the right to emergency medical care: it's something I feel strongly about. But I'll always be connected to athletics. When I watch an 800 meter race on TV, my heart pounds, I want to be there – pushing my countrymen along – I feel such a connection.

Photo: Yutaka/Aflo Sport / Alamy Live News

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## Excerpt from WILK magazine

This excerpt shows that very few people if not none, recognise local foods as one of the unique products that should be marketed. As a result local foods are not mentioned when Kenyan celebrities are asked to explain why they love Kenya.

## Meetings, Incentives, Conference and Events (MICE) sector

It is common knowledge that this tourism niche will be marketed through displays of good food and facilities to capture the attention of meeting and event planners. The study has shown that although food has been used to some extent to market hotels and lodges as ideal venues for MICE, most of it is non-local. Much emphasis was placed on the hotels uniqueness and exclusiveness based on their geographical location and facilities as opposed to offering local food cuisines.



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Excerpt from the WILK magazine

### **Review of the Kenya tourism strategy 2013 – 2018**

The strategy was developed to help identify key tourism products that can be marketed to bolster tourism arrivals in Kenya. A review of the products identified by the strategy showed no explicit mention of local foods as one of the products that should be marketed.

#### ***Tourism Products identified by the strategy***

*The SSA has a number of tourism products on offer: Wildlife Tourism, Scenic Tourism, Birding Tourism, Hiking, Resort and Beach tourism, Water sporting, Cultural and heritage tourism, Business and Convention tourism. Safari tourism is a key product for East Africa and Southern Africa. The main East Africa safari destinations are Kenya and Tanzania. Resort tourism is also a key product in East Africa. The main East Africa resort destinations are Mauritius, Seychelles, and Mozambique. West Africa has small pockets of resort tourism in Cape Verde, Senegal, and The Gambia but mainly attracts business tourists. In Central Africa there is almost no resort or safari tourism, but business tourism is growing. Angola, Cameroon, Chad, and Republic of Congo are business destinations. Cultural tourism is perhaps the most underdeveloped key product. Every country has some cultural heritage attractions, indigenous culture, and/or craft products. Cultural tourism*

*has the most potential in the Sahel countries of West and East Africa. Where SSA appears to have a distinct competitive advantage, is in the delivery of combination products. Combo holidays which combine and extend traditional products with experience-based add-ons, are SSA's emerging —trump card||. Combo-holidays offer multiple experiences, and appeal to the growing segment of the market that is well-travelled, active, and interested in holidays that combine relaxation with adventure, culture, nature, or business.*

Excerpt from the strategy 2013 -2018: Source: Government of Kenya, (2013)



## Discussion for discourse and content analysis for promotion of local cuisine by Five Star hotels in Nairobi County

All ten (10) five star hotels in Nairobi County formed the sample for website analysis. The sources for the samples of printed materials and websites are listed in table 3.1.

SL	Business Type	Website	Printed Material
1	Five (5) star hotels in Nairobi (TRA)	√	–
2		√	–
3		√	–
4		√	–
5		√	–
6		√	–
7		√	–
8		√	–
9		√	–
10		√	–
11	KTB	√	√
12	KTF	√	√

Out of 455 images from 10 five star hotel websites only 43 had food either local or international or both. Discourse analysis on the website texts revealed that only 2 out of 10 hotels was specific on local foods while 7 hotels had international cuisines mentioned.

**Table 3.2: Hotels with text or images specifically on local food**

Five star hotels in Nairobi	Website text		Website images	
	Local food	International food	Total number	About food
Villa rosa kempinski	No	Yes	6	1
hemingways	No	Yes	36	4
Sankara	No	Yes	45	6
Norfolk	No	No	105	3
Tribe	Yes	Yes	39	4
Sarova Stanley	No	Yes	44	7
Radisson blu	No	No	45	3
DusitD2	Yes	Yes	45	2
intercontinental	No	No	45	3
The boma	No	yes	45	10
<b>Total</b>			<b>455</b>	<b>43</b>

Through content analysis the words and images depicting food and food related activities was put in different themes and the frequency of occurrence of textual content and images were recorded. In order to portray the extent that food was used in tourism marketing materials, the most frequently used themes from the texts and images were identified and their frequency of occurrence recorded.

Table 3.3: Frequency of website images about food on various themes

Themes	Frequency
Imported /locally grown food as attraction	16
Food display with local food	5
Indigenous food	2
International foods	6
Restaurant/bar as facility	5
Dining experience	1
Total	35

One of the most frequently portrayed images of food in the marketing materials is fruits.

It was also the most common image of local food. However, these images were mostly

used as displays and decoration. Only two images out of 35 had local foods namely *mukimo* and *mutura*. Restaurants and bars were also a frequently featured image. Sometimes, minor attention was given to food and dining by limiting the information provided to only the name of the restaurant and the opening hours of the restaurant while some did not have any information or link to food or dining and generally lacked detailed information on food.

Most of the marketing materials did not place much emphasis on portraying food as an important part of the tourist experience. Moreover, in all the marketing materials the scarceness of information about local food and local food related activities was evident.

## 5.0 Conclusion and recommendations

This paper attempted to establish the extent to which local foods are used in tourism promotion with specific focus on tourism print and e-marketing materials in Kenya.

Kenya is a culturally diverse country with a plethora of unique traditional foods that can be promoted to diversify tourism since food tourism plays a pivotal role in the development of cultural heritage tourism.

Kenya is yet to realize the impact of local foods in marketing tourism since almost none of the tourism marketing materials analysed had tapped into the potential of tourism marketing through local foods. It can therefore be concluded that the extent to which local foods have been used in tourism print and e-marketing is almost zero.

The study has further revealed that too much emphasis has been put on the use of geographical attractions, wildlife and beaches for marketing tourism in Kenya. As such Kenya could possibly be missing out on opportunities to attract the cultural and heritage inclined dollar spenders from its current and other emerging tourism markets.

The most common local foods displayed in tourism marketing materials were fruits which were usually mixed with imported fruits in a basket or bowl while images of local food promoted in some of the marketing materials were *mutura* and *mukimo*

This study shows further revealed that local food plays a relatively limited role in the marketing and promotion of tourism in Kenya. The fact that there is little emphasis on local food was seen as an impediment to promote local food among tourists.

### **Recommendations of the study**

There is need to promote food tourism by:

- 1) Organizing special events such as food festivals and cooking holidays particularly at the county level cultural festivals.
- 2) Marketing of local cuisine and inclusion of locally grown food produce in the hospitality supply chain and promotion of local menu items
- 3) Documenting food taboos and superstitions from all Kenyan communities and using them to market Kenya as a unique food tourism destination.
- 4) Develop local food museum through collection and storage of local food items and artifacts.

### **Areas of further research**

Further research can be done in hotels in other regions and the restaurant sector to establish the extent to which local foods are promoted. It would also be interesting to establish the perceptions of tourists on local foods in a bid to promote local cuisines.

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## **Invertebrates as Indicators of Agricultural Use Integrity in a Highland Floodplain Central Kenya**

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Invertebrates play important roles in both provisioning and supporting services and can serve as indicator organisms for anthropogenic impacts on the integrity of ecosystems and for ecosystem monitoring. However, few available data exists for African ecosystems and particularly for wetlands that are increasingly contested by various user groups.

We monitored between 2015 and 2016 the seasonal abundance of Arachnida, Collembola and Insecta in the Ewaso Narok Swamp, a floodplain in the semi-arid central region of Kenyan highlands. Invertebrates were sampled during 6 sampling seasons in four land use units, representing different intensities of anthropogenic pressure on the wetland ecosystem (undisturbed, grazed, fallow and cropland), using pitfall traps and sweep net samplings.

From some 3000 samples, we collected nearly 36,000 individuals belonging to 3 orders of Arachnid, 4 orders of Collembola and 14 orders of Insecta. Some 67% of the individuals could not be identified to species level. Most abundant in terms of number of individuals was order of the Hymenoptera, while largest number of genera and taxa occurred in the order of the Coleoptera. At class level, largest abundance, both in terms of individuals and species, occurred within the class Insecta (51%) of all the individuals and (80%) of the species. Some of the collected species serve as indicators for ecosystem integrity or anthropogenic disturbance levels (hemeroby). This novel inventory of invertebrate provides the baseline data for continued monitoring of Kenyan wetlands

Keywords: Biodiversity, Ewaso Narok, Inventory, Indicators, Wetlands

## **Role of local foods in Tourism Promotion in Kenya**

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Tourism is a major income earner for many countries in the world. In Kenya, tourism is one of the leading sources of government revenue contributing to the social economic growth of the country. In order to reap more benefits from this sector, there is need to diversify tourism products and integrate cultural-based components in tourism, of which food and drink is a key component. In Kenya, such niche tourism products are under-developed and thus the main aim of this study was to assess the extent to which local foods feature in tourism promotion. This paper employed content analysis research approach focusing on relevant print and e-marketing materials from Kenya Tourism Board (KTB), Kenya Tourism Federation (KTF) and websites of five star hotels found in Nairobi County. The results were then validated by discourse analysis. The study found out that wildlife safari and beach tourism were the main forms of tourism marketed by KTB and KTF. It was also found that cultural and heritage tourism was promoted across all the marketing materials examined with emphasis on urban culture and village visits. A review of the Kenya National Tourism Strategy (2013-2018) showed no explicit mention of local foods as one of the products to be marketed. Out of the 455 images from 10 hotel websites, only 43 had images of food. Discourse analysis on the website texts revealed that only 2 out of 10 hotels specifically mentioned local Kenyan foods while 7 hotels had non-local foods mentioned. Frequency of websites on textual content and images on various themes revealed Only 2 images out of 35 featured local Kenyan foods. It was concluded that local foods plays a relatively limited role in the marketing and promotion of tourism in Kenya, considering the fact that the extent to which local Kenyan foods have been used in tourism print and e-marketing is relatively very low.

### **Key words**

Sustainability, Culinary Tourism, Local foods, Cultural and Heritage Tourism, Promotion

### **Introduction**

Tourism has become a major income earner and one of the internationally recognized trade categories ranking high along with fuels, chemicals and automotive products. In Kenya, tourism is the mainstay of the economy. In fact, in 2017 the direct contribution of travel & tourism to GDP was KES 294.6bn (3.7% of GDP) and generated 429,500 jobs directly (Travel and Tourism Economic Impact, 2018).

The main tourism products offered in Kenya are customary wildlife safari and beach tourism attractions which on their own may not sustain the industry in the long run thus necessitating for diversification of tourism products. This may include the need to integrate more sustainable cultural components into the tourism product packages, of which food and drink is.

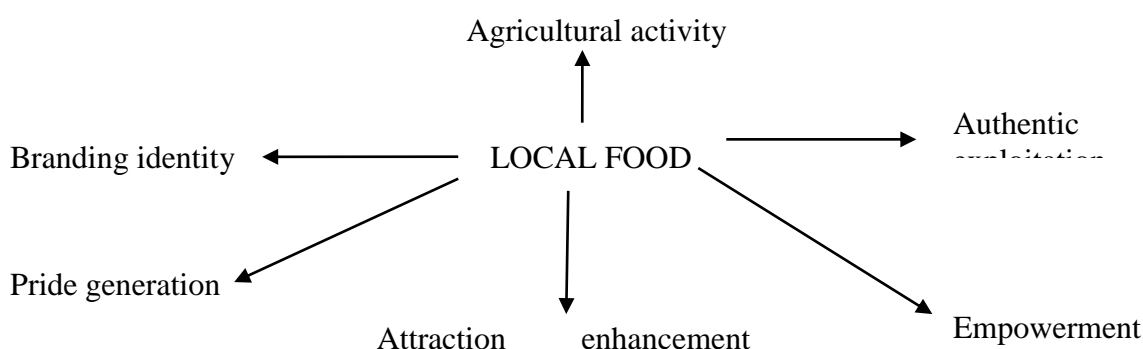
Food is a basic need that every human being needs. Therefore, all visitors must eat when they are travelling regardless of their purpose of travel (Wijaya, 2014). Local food eaten at a destination can bring tourists physical, cultural, social and prestige



experience (Meladze, 2016). Food and its related tourist activities he asserts, have been described into a new category of tourism called food tourism.

Increasingly, local food is used in tourism as an integral part of the visitor attraction to enrich tourist experiences. The food acts as a differentiating feature for destinations to enhance their competitiveness. The close relationship between local food and culture enables the promotion of cultural heritage through promotion of local foods. Thus, linking local food and tourism has the potential to create more sustainable tourism practices and outcomes. Local food, as part of the tourism experience, involves a number of benefits that reflect the principles of sustainable development.

**Figure 1: The contribution of local food to sustainable development**



Source: du Rand et al., (2003)

Food tourism also called Gastronomic tourism, culinary tourism, or enogastronomic tourism, is a niche area of the fast-growing tourism market (Hjalager, 2002; Hall & Sharples, 2003). Food Tourism has grown considerably and has become one of the most dynamic and creative segments of tourism such that both destinations and tourism companies have realised the importance of gastronomy in diversifying tourism and stimulating local, regional and national economic development (Meladze, 2016).

According to the UNWTO Second Report on Gastronomic Tourism (2017), gastronomy tourism contributes positively to the tourism value chain thus linking gastronomy and tourism. According to the report, it provides a platform for the promotion of cultures through their cuisine hence promoting sustainable tourism.

Gastronomy tourism has been recognized in many destinations because it presents an opportunity to constantly revitalize and diversify tourism (UNWTO, 2017). However, previously, many destinations overlooked the potential benefits of promoting food and often food is marketed as a subsidiary service, or as a secondary component, of the destination experience (Wijaya, 2014.)

There are many forms of tourism practiced in Kenya, some of which could be said to be fully developed while others are yet to be developed to their full potential. Culinary and food tourism are some of underdeveloped niche tourism sub-sectors in Kenya. Culinary tourism is a sub-set of agro-tourism which focuses on the search for, and enjoyment of, prepared food and drink. Food tourism on the other hand

encompasses the “travel to experience a particular type of food or the produce of a specific region” ( Hall, 2003).

Food tourism can be an important driver for regional development by strengthening local production through backward linkages in supply tourism chain partnerships (Renko, 2010) and is regarded as an important vehicle in delivering sustainable tourism (Everett, 2013). Food attractions may include special events such as food festivals or cooking holidays (Di Domenico, 2012) or the promotion of local food through farmers’ markets, enhanced local menu items and the inclusion of locally grown food produce in the hospitality supply chain (Torres, 2002). Local cuisines represent a core manifestation of a destinations intangible heritage and through its consumption tourism can gain a truly authentic cultural experience (Renko, 2010). Studies have shown that for effective food tourism development, pre-existing tourism infrastructure is a prerequisite. It has also been argued that proximity to urban areas is important in developing local food tourism. (Dougherty, 2013).

Local foods have much potential to enhance sustainability of the tourism industry. The potential of culinary as a theme to sharpen a destination image should not be underestimated. Culinary can give destination uniqueness where specific local foods can be presented as an iconic feature for particular destinations. Kenya being a culturally diverse nation, local Kenyan foods have the potential to provide her with a unique brand.

#### **List of unique cultural attributes in Kenya**

1. Local people's traditional practices
2. Local languages
3. Tales and legends
4. Dressing
5. Traditional architecture
6. Wood carvings
7. Soap stones
8. Beads and jewellery
9. Weavings
10. Music and dance
11. Food and drinks
12. Religion

Source: Adapted from Okech (2014, p. 4)

From the above list, food and drinks appear to be an important aspect of culture which should be incorporated in promoting and marketing cultural heritage tourism in Kenya.

In Kenya, the promotion of local Kenyan food as a component of its destination attractiveness is still in its embryonic stage (Okech, 2014). The contribution of local foods in marketing the country as a tourism destination has largely been ignored in spite of its apparent importance .with an ecosystem that is being degraded in the country and which has traditionally been the key attraction marketed over the years, promotion of local foods as an alternative tourism attraction is vital.

On the background of the above facts, this study was done to find out the role of local foods in tourism promotion in Kenya. The aim was to establish the extent to which local foods feature in Kenya's tourism print and e-marketing materials.

### **Methodology**

This paper employed content analysis research approach focusing on relevant print and e-marketing material from Kenya Tourism Board (KTB), Kenya Tourism Federation (KTF) and selected five star hotels in Nairobi. The two institutions above (KTB and KTF) were selected because they are legally mandated to promote and market tourism in Kenya. The aim of the study was to find out the role of local foods in tourism promotion in Kenya. Websites of the two institutions were keenly analyzed, particularly with respect to information relevant to the themes that had been established. Additionally, policy documents relevant to tourism were analyzed to establish the extent to which policy guidelines have emphasized diversification of tourism products and in particular the promotion of local Kenyan foods as components of Kenya's attractiveness. To increase objectivity of the study, secondary data was obtained from websites of five star hotels in Nairobi County.

The pictorial and textual content of tourist brochures and websites were analyzed. The results from this analysis were then validated by a discourse analysis conducted on the same printed materials and websites. Content analysis according to Wood & Kroger

(2000), are used on texts, and pictures obtained from the website and print materials to get the hidden meaning of images where a set of themes have been established. Discourse analysis was used to understand the background and identify the embodied meanings from the images. KTB, KTF and all the 10 five-star hotels in Nairobi (according to Tourism Regulatory Authority (TRA) classification of 2017) comprised the sample for the study.

## RESULTS AND DISCUSSION

### Discussion for discourse and content analysis for promotion of local cuisine by Five Star hotels in Nairobi County

Out of 455 images from 10 five star hotel websites only 43 had food either local or international or both. Discourse analysis on the website texts revealed that only 2 out of 10 hotels was specific on local foods while 7 hotels had non local cuisines mentioned as shown in table 1 below.

**Table 1: Hotels with Text and Images Specifically on Local Food**

Five star hotels in Nairobi	Website text		Website images	
	Local food	International food	Total number	About food
Hotel 1	No	Yes	6	1
Hotel 2	No	Yes	36	4
Hotel 3	No	Yes	45	6
Hotel 4	No	No	105	3
Hotel 5	Yes	Yes	39	4
Hotel 6	No	Yes	44	7
Hotel 7	No	No	45	3
Hotel 8	Yes	Yes	45	2
Hotel 9	No	No	45	3
Hotel 10	No	yes	45	10
<b>Total</b>			<b>455</b>	<b>43</b>

**Source, (Researcher, 2018)**

Through content analysis, the words and images depicting food and food-related activities were put in different themes and the frequency of occurrence of textual content and images were recorded. In order to portray the extent to which food featured in tourism marketing materials, the most frequently used themes from the texts and images were identified and their frequency of occurrence recorded.

One of the most frequently portrayed images of food in the marketing materials were fruits. Only 2 images out of 35 had local Kenyan foods namely *mukimo* and *mutura*.

Restaurants and bars were also a frequently featured image. Minor attention was given to food and dining by limiting the information provided to only the name of the restaurant and the opening hours of the restaurant. Some texts did not have any information or link to food or dining and generally lacked detailed information on food as shown in table 2 below.

**Table 2: Frequency of website on textual content and images on various themes**

Themes	Frequency
Food display with local food	7
International foods	22
Restaurant/bar as facility	5
Dining experience	1
Total	35

Source: researcher, 2018

Most of the marketing materials did not place much emphasis on portraying food as an important part of the tourist experience. Moreover, in all the marketing materials the scarceness of information about local food and local food related activities was evident.

### **A Review of Kenya Tourism Board (KTB) and Kenya Tourism Federation (KTF) Websites**

It is important to note that even though the study combined both print and e-marketing materials, there was heavy reliance on website information. Most of the materials and information contained on the websites were not up-to-date. Further, e-brochures and newsletters were not accessible even though the websites had indicated that they are available. To counter this challenge, hard copies were used, though very few were available.

The study found out that wildlife safari and beach tourism were the main forms of tourism marketed by Kenya Tourism Board and the Kenya Tourism Federation. Kenya has been promoted as the ideal safari destination. Some of the attractions and products featured included the vast plains with abundant wildlife and unique cultures, the tropical coastline of warm waters, coral reefs and powdery palm-fringed beaches. Unique attractions such as the annual wildebeest migration among others were also regarded highly in making Kenya the ideal wildlife safari destination. Specific safaris promoted included: Masai Mara balloon safari, walking safaris, camel safari, dhow safari, helicopter safari, snake safari and birding safari.

Sports tourism was the second most featured tourism type. Specific emphasis was put on water sports with the main sporting activities being diving, kite surfing, big game fishing and white water rafting among others. Playing golf was the other sporting activity

promoted across all the available marketing materials that were accessed by the researcher. Wonderful photos of different golf courses were featured to offer magnetic visual appeal to golf lovers.

Cultural and heritage tourism was promoted across all the marketing materials examined. Emphasis was however mainly on urban culture and village visits. Under the umbrella of village visits, focus was placed on traditional ceremonies and handicrafts particularly from the Masai in Amboseli and Masai Mara and the Samburu communities in the northern rangelands.

Other tourism forms promoted included active travel involving activities such as mountain biking, hiking and trekking and skydiving. Special interest travellers were also targeted through promotion of Kenya as a destination offering opportunities for filming, photography, archaeological tours, agro-tourism and business travel. Events and festivals were also promoted through Maralal camel derby, Lamu cultural festival and the rhino .

The study found out that, recognitions and awards have been used to a great extent by KTB to market Kenya as an authentic, world leading safari destination. Some of the awards and recognitions highlighted included:

1. Kenya's award of the World's Leading Safari Destination at the 20th World Travel Awards (WTA) grand finale in Doha, Qatar.
2. Kenya Airways recognition and award as Africa's Leading Airline
3. Masai Mara national reserve recognition as Africa's Leading national park Brand.

Hotel recognitions highlighted included:

- a. Africa's leading Meetings, Incentives, Conferences and Exhibitions (MICE) Hotel which was awarded to Safari Park Hotels & Casino
- b. Africa's leading Eco-Hotel awarded to Amboseli Serena Safari Lodge
- c. Africa's leading Eco-Lodge awarded to Il Ngwesi lodge
- d. Africa's Leading green hotel awarded to Aberdare Country Club
- e. Africa's Leading new hotel awarded to Villa Rosa Kempinski Nairobi
- f. Africa's Leading resort awarded to Alfajiri Villas.

These awards and recognitions present Kenya as the ideal place for holiday makers, eco-travellers and conference planners. There was no explicit mention of local Kenyan food in tourism promotion

### **A Review of WILK magazine**

WILK is the official magazine of the ministry of tourism and wildlife and the Kenya Tourism Board. The magazine is primarily used for marketing by the ministry of tourism and wildlife and KTB. The study found out that like all other marketing materials this magazine has also fallen short of the need to diversify tourism products since it focused on the wildlife safari and beach tourism. Though, to a small extent the magazine highlighted culture and heritage as some of the attractions, it did not market local Kenyan food explicitly as a product to be enjoyed by tourists while in Kenya.

# Why I Love Kenya

By David Lekuta Rudisha

## Meet Kenya's 'King David'

In this issue we meet Kenya's legendary middle-distance runner, David Lekuta Rudisha. Known in Kenya as 'King David' he is the 2012 and 2016 Olympic Champion, World Champion and World Record Holder in the 800 metres. He is also the first and only person to run the event in under 1h.41m. Winner of a record three consecutive 'Track and Field Athlete of the Year' awards, David won the IAAF World 'Athlete of the Year' award in 2010 and the 'Association of National Olympic Committees' award for 'Best Male Athlete' of London 2012. A proud Maasai, David was also awarded the Moran of the Burning Spear award from the Government of Kenya.

### Tell us why you love Kenya?

Kenya is a great country, and so diverse – I just love it. If you travel from north to south you'll find everything you need to see in the world. There are deserts, forests, beautiful rivers, mountains and highlands. And there's the Great Rift Valley – which means home to me. There's also a unique richness of culture and wildlife. My favourite area is Maasailand – it's so peaceful and natural – and I love nature.

### What about the people?

I love the Kenyan people; they have such spirit. They smile even when times are hard. I'm Maasai – and the Maasai have a unique character.

### How does it feel to represent Kenya on the world stage?

To represent a country like Kenya is very special. The most exciting part is when they play the Kenyan national anthem. I always feel very emotional then – like I am carrying 40 million people with me.

### Tell us about your background

I grew up in Kilgoris, bordering the Masai Mara. My dad, Daniel Rudisha, loved sport. He represented Kenya in the 1966 Commonwealth Games (400 meters) and in the 1967 World Championships. He took home a silver medal in the 1968 Mexico Olympics. That medal really sparked my passion. My Dad trained me for my early school competitions – every evening – up and down the hill.

### What is your favourite animal?

The lion, without a doubt. It plays a great part in our Maasai culture. In the past we had to perform the ritual killing of a lion with a spear – to show we had courage. Today I am the patron of a programme run by the Big Life Foundation in Amboseli that has reduced lion killing to zero. Since 2012, we've demonstrated our courage by our sporting achievements in the bi-annual Maasai Olympics. It not only mobilizes awareness for wildlife conservation but it also helps to resolve animal vs. human conflict.

### What does the future hold?

I might retire from running after the 2020 Olympics in Tokyo. I want to concentrate on other things. I'd like to write a book about my father's legacy and pursue my work with the Maasai Olympics. I'd also like to raise awareness about how everyone should have the right to emergency medical care: it's something I feel strongly about. But I'll always be connected to athletics. When I watch an 800 meter race on TV, my heart pounds, I want to be there – pushing my countrymen along – I feel such a connection.

Photo: Yutaka/Aflo Sport / Alamy Live News

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## An Excerpt from WILK magazine

This excerpt shows that very few people if not none, recognise local foods as one of the unique products that should be marketed.

As such, local Kenyan foods are not mentioned when Kenyan celebrities are asked to explain why they love Kenya.

## A Review of the National tourism policy 2013 - 2018

The strategy was developed to help identify key tourism products that can be marketed to bolster tourism arrivals in Kenya. A review of the products identified by the strategy showed no explicit mention of local Kenyan foods as one of the products that should be marketed.

### *Tourism Products identified by the strategy*

*The SSA has a number of tourism products on offer: Wildlife Tourism, Scenic Tourism, Birding Tourism, Hiking, Resort and Beach tourism, Water sporting, Cultural and heritage tourism, Business and Convention tourism. Safari tourism is a key product for East Africa and Southern Africa. The main East Africa safari destinations are Kenya and Tanzania. Resort tourism is also a key product in East Africa. The main East Africa resort destinations are Mauritius, Seychelles, and Mozambique. West Africa has small pockets of resort tourism in Cape Verde, Senegal, and The Gambia but mainly attracts*

*business tourists. In Central Africa there is almost no resort or safari tourism, but business tourism is growing. Angola, Cameroon, Chad, and Republic of Congo are business destinations. Cultural tourism is perhaps the most underdeveloped key product. Every country has some cultural heritage attractions, indigenous culture, and/or craft products. Cultural tourism has the most potential in the Sahel countries of West and East Africa. Where SSA appears to have a distinct competitive advantage, is in the delivery of combination products. Combo holidays which combine and extend traditional products with experience-based add-ons, are SSA's emerging —trump card. Combo-holidays offer multiple experiences, and appeal to the growing segment of the market that is well-travelled, active, and interested in holidays that combine relaxation with adventure, culture, nature, or business.*

Excerpt from the strategy 2013 -2018: Source: Government of Kenya, (2013)

The strategy was developed among other things, to help identify key tourism products that can be marketed to bolster tourism arrivals in Kenya. The products identified include; Wildlife Tourism, Scenic Tourism, Birding Tourism, Hiking, Resort and Beach tourism, Water sporting, Cultural and heritage tourism, Business and Convention tourism.

A review of the products identified by the strategy showed no explicit mention of local foods as one of the products that should be marketed. Most of the marketing materials did not place much emphasis on portraying food as an important part of the tourist experience. Moreover, in all the marketing materials the scarceness of information about local Kenyan food and local food related activities was evident.

## **Conclusion**

This paper attempted to establish the extent to which local foods are used in tourism promotion with specific focus on tourism print and e-marketing materials in Kenya.

In Kenya, the promotion of local Kenyan food as a component of its destination attractiveness is still underdeveloped. The country is yet to realize the impact of local foods in marketing tourism since almost none of the tourism marketing materials analyzed had tapped into the potential of tourism marketing through local foods.

It can therefore be concluded that the extent to which local foods have been used in tourism print and e-marketing is almost zero. This study shows further revealed that local food plays a relatively limited role in the marketing and promotion of tourism in Kenya. The fact that there is little emphasis on local food was seen as an impediment to promote local food among tourists visiting various destinations in Kenya.

## **Recommendations**

1. KTB and KTF should include local Kenyan foods in their print and e-marketing materials to promote gastronomic tourism thereby positioning Kenya as a unique tourism destination.



2. Hotels in Kenya should market local Kenyan foods in their websites and marketing materials
3. Local Kenyan food, as a key component of cultural heritage should be included and explicitly be addressed in the National Tourism Policies.
4. County Governments in Kenya should organize special food-related events such as food festivals and cooking holidays to promote local Kenyan foods.

#### **Areas of further research**

Further research can be done on hotels found in other regions outside Nairobi, and the restaurant sector too, to establish the extent to which local foods have been used to promote tourism. It would also be interesting to establish tourists' perceptions of on local Kenyan foods in a bid to promote local foods as tourism products.

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2018/kenya2018.pdf retrieved on 6<sup>th</sup> November, 2018.

# Dung Beetles Abundance and Diversity as Indicators of Environmental Quality at Dedan Kimathi University Wildlife Conservancy

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## ABSTRACT

Dung beetles are important in provision of a suite of critical ecosystem functions and services in several ecological processes. They can therefore be used as excellent indicators of environmental quality. Despite their importance, dung beetles are currently facing multiple conservation threats, particularly from landscape conversion due to high demand for farming land, climate change and other human activities. Studies on their diversity are essential in the conservation efforts of the various species and their preferred habitats. The study highlights the use of dung beetle observable parameters as indicators of human-generated influence on conservancies, and its effects on composition, diversity and richness of the species. The parameters will help understand the effects of fragmentation, logging and other major human-generated influences at Dedan Kimathi University Wildlife Conservancy, Kenya. Intense collection of dung beetle was done using baited pitfall in three major habitats within the conservancy. The habitats were categorized based on the level of disturbance documented. It included the disturbed forest, undisturbed forest and the open grassland. Species diversity, abundance and richness were determined in the three habitats to determine the composition and structure of the habitats. Influence of mammal's abundance had a positive effect on the richness and composition of dung beetles in the three habitats. This interaction suggested there was a positive influence between environmental factors, climatic factors and mammal abundance with the diversity, abundance and richness of dung beetle in an ecosystem. The results suggested that an increase in species abundance in a habitat does not mean improved environmental factors but temporal availability of resources for the dung beetles. The management of the conservancy should enforce the necessary measure to improve the conservation of the ecosystem as required by the law to reduce the impacts generated by human activities.

**Key-word: human-generated, diversity, ecosystem, abundance, disturbance**

## 1. INTRODUCTION

Wildlife conservancies' acreages have been decreasing worldwide at an alarming rate and human-generated disturbances have contributed to the fragmentation of these systems (Letai, 2011). Changes of land use and increased population have caused a great loss in species composition, biodiversity and abundance in wildlife conservancies across the globe (Nancy B. Grimm1, 2008). Consequently, there have been several studies that have been undertaken to study the effect of change of land use on the change of species composition, diversity and abundance in various parts of the globe (Jonathan, Ruth , & Gregory , 2005). Wildlife conservancies are important ecosystems for a diversity of wildlife species, they provide habitat and sanctuary to wildlife animals and plants (Dickman, 2010) and they are sensitive to change in the land use (Metzgerac, 2006). They are characterized by rich diversity of fauna and flora and extensive landscape (Nyamsuren, Bayarbaatar, & Bazaar, 2014). Wildlife conservancies are self-sustaining ecosystem that not only support the diverse fauna and flora diversity but also provide other ecosystem function like carbon sequestration (McAlpine, 2016).

Species diversity and abundance are important parameters in ecosystem conservation (Maes, Paracchini, Zulian, Dunbar, & Alkemade, 2012). It is necessary to protect the diverse ecological functions of conservancies like habitat for different fauna, food sources and species diversity (Cardinale, 2012). The acreage of conservancies or any protected area is a jurisdiction of the central government of many states or countries (Kluvánková-Oravská, 2009). Although conservancies were established to protect wildlife resources from pressure of extortion, it may not possible to maintain the status which would be comparable to undisturbed sites (Fiona Flintan, 2013). Several studies have shown that many conservancies are located in dry areas where the climate is not sustainable enough to maintain regeneration of vegetation cover and water for the growing population of the wildlife in the conservancy (Metzgerac, 2006).

In Kenya, conservancies fall under the ministry of wildlife which has strict regulations on the maintenance of the protected nature reserves and parks (Krug, 2001). The law ensures there is little or minimal disturbances of the conservancies which mainly are surrounded by communities (John Letai, 2011). In the recent past, there have been great disagreements between the pastoral community around the conservancies, ranchers and farmers in parts of the country. This has been fueled by the limited resources around the conservancies like pasture and water (Okello, 2009).

Biological indicator species is an important conservation tool that can contribute to conservation activities and management of conservancies and natural reserves (Chape, 2005). Arthropods are sensitive to changes in the environment thus are good indicators of both climatic and environmental changes. They possess characteristics of high species diversity, plant host specificity, seed dispersion and many more (Johanna Rainio J. N., 2003), (Bale J. S., 2002); (Bird I. D., 2004).

Dung Beetles are a small group of Scarab beetles estimated to be around 7,000 species worldwide. The most common dung beetle families are Scarabacidae, Histeridae and Carabidae. They are a group that is widely distributed globally, diverse and abundant in both warm temperate and tropical ecosystems. Their diversity is enormous in Africa and occurs in more than 2,000 species. They occur on every continent but lack in Antarctica. (Hanski & Cambefort, 2014) .

They are very important bio-indicators because they are very sensitive to ecosystem changes, they are easily sampled, broadly distributed, and have a relatively stable taxonomy (Philips, Pretorius, & Scholtz, 2004) and their ecological roles are well understood. (Nichols, et al., 2007; Hanski I. &, 2014). They are also an ideal taxon for biodiversity monitoring because they rely on a wide range of food resources including rotten fruit, carcasses and feces of other animals (Spector S. , 2006). By using dung as food and nesting resource, they influence a diverse array of ecological processes which includes secondary seed dispersion, mixing and or burying of organic matter in the soil, soil aeration, nutrient cycling, control of detritus-feeding flies and vertebrate intestinal parasites, and sometimes pollination (Chapman, Chapman, Chapman, Vulinec, Zanne, & M, 2003), (Nichols, Spector, Louzada, Larsen, Amezcuita, & Favila, 2008), (Bustamante-Sánchez, 2004); (Nadeau P. , 2015) and may thus be important in agricultural productivity and forest regeneration.

Micro-climate factors like humidity, light, temperatures, vegetation cover and soil characteristic influence the abundance and distribution of dung beetles in an ecosystem (Alejandra & Perotti, 2009); (Villet M. H., 2011). Since dung beetles are dependent on mammals feces as food source thus their distribution and abundance in a habitat is influenced by the distribution pattern of vertebrates in the same habitat and the availability of feces. Changes in vertebrate community, change of land use, loss or fragmentation may cause change in the diversity, abundance and distribution of dung beetles in an ecosystem (Cordo G. C., 2000; G.A. Vale I. G., 2004).

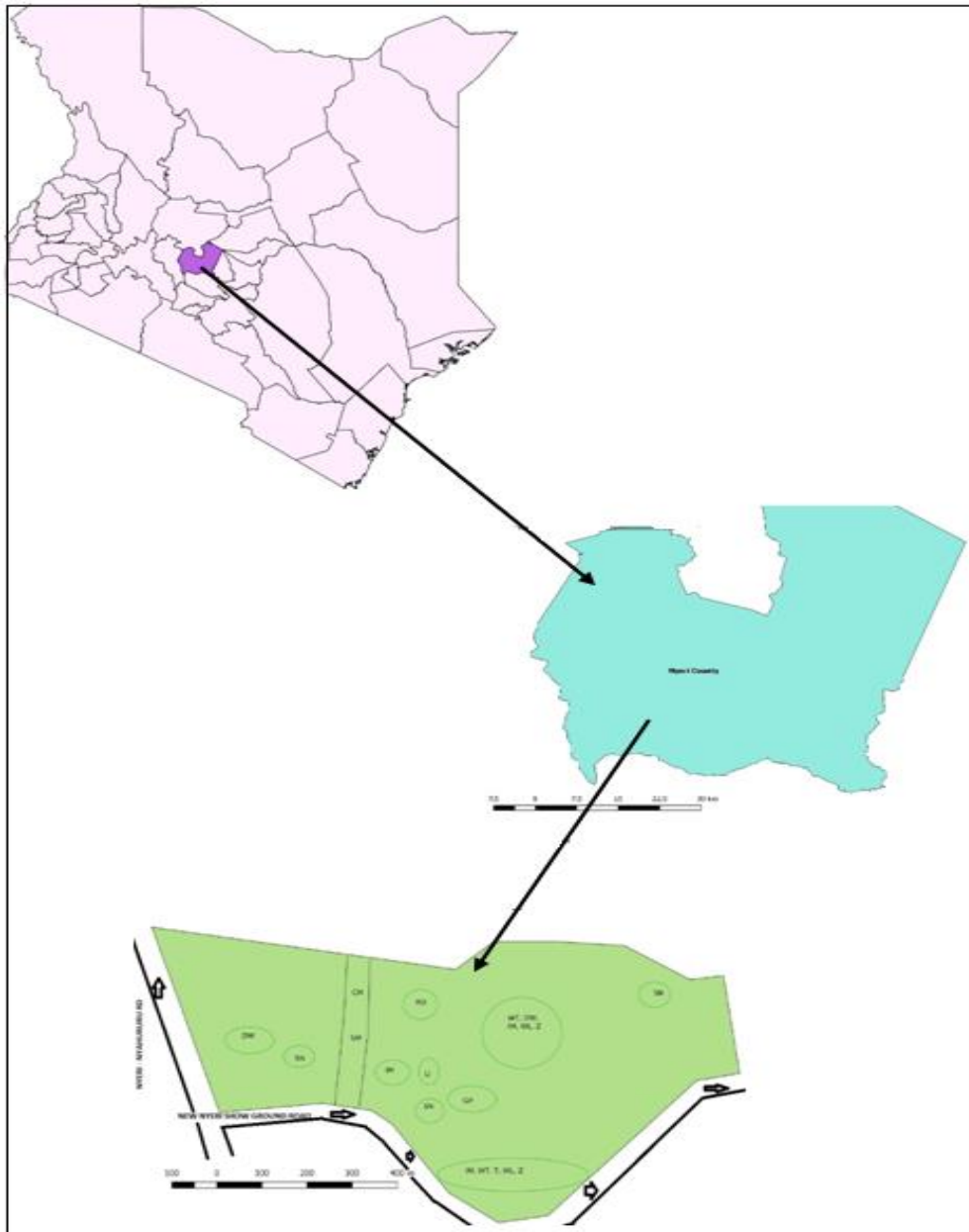
Different families and orders of dung beetles have been implied in several ecological studies which evaluate the human-generated impacts like habitat modification, change of land use and fragmentation (Chivian E. &, 2003). Changes in the richness, diversity and abundance of dung beetles is good biological indicators of health of a habitat which might be caused by human-generated disturbances within the ecosystem have been documented in many studies (Cordo G. C., 2000; Kremen, Colwell, Erwin, & Murphy, 1993)

Many studies and researches have shown a negative response of dung beetles to impacts of human-generated disturbances in different ecosystem like forest, riparian, agro-ecosystems (Abrol D. P., 2011; Herbert Sukopp U. S., 2009) The study was designed to investigate relationship between the abundance and diversity of major families of dung beetles in three habitats (disturbed forest, undisturbed forest and open grass land) within the conservancy to dynamic changes in vertebrates population in the conservancy.

## 2. MATERIALS AND METHODS

### 2.1 Study area

This study was conducted at the Dedan Kimathi University Wildlife Conservancy (0036°S 36057'E) located within Nyeri County in the highlands of Central Kenya (Fig. 1). The conservancy borders Nyeri forest, the forest that initially connected the Aberdare and Mt. Kenya forests.



*Figure 22: Map of the study area (Dedan Kimathi University Wildlife Conservancy in Kenya)*

The study area consists of loamy soils characterized by heavy clay soils content with impended drainage in some flat areas. Some parts are characterized by rich volcanic soils (Ciira wa Maina, 2016). Vegetation consist of *Combretum* species and large evergreen shrubs, Acacia trees, *Themeda* grass or derived semi-evergreen or deciduous bush land (Ciira wa Maina, 2016). The study area falls within the Highlands Equatorial Climate zone of Kenya where temperatures are lower than typical equatorial zone (modified by relief). It is close to a warm temperate climate in terms of global classification. Nyeri County has an altitude that varies between 1580 and 2700 m above sea level (Gachahi, 2016). The environs of Dedan Kimathi University Wildlife Conservancy are intensively used for agriculture, cultivation of coffee especially the Arabica species. Coffee is the local cash crop and covers large fields. Also in the area are planted and natural forests and small scale farmlands that are structurally highly diverse. Farmers on these small subsistence farms neighboring the conservancy grow food crops such as maize and beans vegetables. They also keep cattle, goats and sheep next to their homesteads (Karanja, 2006).

## **2.2 Scarabaeinae Sampling and Identification**

The study site was classified into three categories based on the level of human disturbance (disturbed forest, undisturbed forest and open grassland). In each habitat category identified, three transect lines with pitfalls traps were placed on the transect line on a systematic random sampling technique (Len Thomas S. T., 2010). The line transect were 300m long and the distance between transect was around 50m in the entire samples site. The area covered for each sampled site was about 12 Ha and ten pitfall traps were established in each transect. Six (6) sampling points were located, three in each linear transect, placed at 50m apart and the sampling points within each habitat were 50m apart along a line transect. At each sampling point a quadrant of 20×20m was set up in each corner of the quadrant. Two (2) pitfalls trap, one (Janos Podani, 2006) baited with 300g of fresh dung of zebra and the other baited with 300g of fresh dung of impala. The traps were placed at a minimum distance of 30m from the edge whenever possible and left in the field for 24 hours prior to collection. A total of 2304 samples were collected to ensure an adequate pool of data for an effective statistical analysis (AntoineGuisana N. E., 2000)

The study was carried out seasonally between September, 2014 and April 2015. Baited pitfalls were used to collect dung beetles. Pitfalls are considered to be most efficient sampling method for collecting dung beetles (Larsen, 2006). Pitfalls are best for trapping surface active invertebrates and are prone to producing non-qualitative data (Huertas, 2005). The traps were placed at a minimum distance of 30m from the edge whenever possible and left in the field for 24 hours prior to collection. These cylindrical containers were 9 cm in diameter and 20 cm high. They were sunk into the ground until the lip of



the container leveled with the ground surface. Dung beetles sampling was done twice per month for a period of eight (8) months resulting to sixteen (16) sampling periods.

Several studies have shown that different baits are used to attract different species of dung beetles. Some were baited with fresh zebra dung and others were baited with fresh impala dung to attract coprophagous invertebrates (Stewart, 2001). The Scarabaeinae samples collected were packed and conserved in 70% ethanol and transported to National Museums of Kenya laboratory where they were preserved in entomological blankets and identified to the species level using a specialized bibliography (Vaz-De-Mello, 2011).

## **2.2 Clustering From Distance Matrices**

The use of cluster analysis for dissimilar matrices has been widely used on ecological studies to produce long presenting structure familiarly called trees (Janos Podani, 2006). In this study group average (UPGMA) was used to produce a classification inform of a dendrogram with meaningful weighs on the branches (branch lengths). Species diversity, richness and composition are mainly used for the clustering (Gachahi, 2016). According to Blackburn et al., 2005, dendrogram is method used to find the best clustering strategy to determine a functional diversity in mammals.

## **2.3 Mammals Population Count**

Impala and zebra were the majority mammals in the conservancy. The population data of the mammals in the three habitats within the conservancy was available at the Conservancy. The data showed population changes within the three habitats with season changes. Weekly population data from September, 2014 to April, 2015 in the three habitats within the conservancy was used to test species abundance in the three habitats.

## **2.4 Data analysis**

Species richness and abundance were tested for the different habitats sampled within the conservancy. Shannon diversity (H) and Simpson evenness (E) indices were also tested to using R-Genestat to compare the parameters among the different habitats (Nichols, et al., 2007). Kruskal-Wallis was used to evaluate the differencies in the diversity and eveness of dung beetles, Zebra and Impala species among the three habitats within the conservancy. Linear regression was used to determine the influence of Zebra and Impala abundance on Scarabaeinae richness and abundance in the three habitats within the conservancy. The linear equation  $Y=a+bX$  describes the linear relationship between two variables (Y is a linear function of X). Linear regression model has two parameters in it,

“0 and 1”, which are called the intercept and the slope of the line. The intercept (0) is the value of the function when X = 0, and the slope (1) measures the change in the Y variable for each unit change in the X variable (Aaron M. Ellison, 2004). To ensure normality before statistical analyses of the data, the abundance of dung beetle was square-root transformed before statistical analyses to ensure the normality and less weight to the few dominant species.

### 3. RESULTS

#### 3.1 Zebra and Impala Species Abundance

A total count of 41 animals (Zebra and Impala) was observed in this study. The abundances of Zebra and Impala in the three habitats is tabulated (Table 1) where open grassland had the largest herd occurring for Zebra and Impala. The Impala were less abundant than Zebra in the disturbed forest and undisturbed forest. Open grassland had a relative abundance of Zebra of 24.4% and 19.51% Impala, in disturbed forest, Zebra had 17.07% while Impala had 9.75%, while in undisturbed forest zebra had 12.19% while Impala had 17.07%.

*Table 42: Zebra and Impala Abundance*

Habitat	Species	Total count	Relative Abundance (%)	Wet Season Abundance	Dry Season Abundance
<b>Open Grassland</b>	zebra	10	24.39	6	4
	Impala	8	19.51	5	3
<b>Disturbed Forest</b>	zebra	7	17.07	5	2
	Impala	4	9.76	3	1
<b>Undisturbed Forest</b>	zebra	5	12.20	5	0
	Impala	7	17.07	7	0

#### 3.2 Scarabaeinae Richness Dominance and Relative Abundance

A total of 73,220 specimens were collected, which were distributed to 12 dung beetle species belonging to 3 families (Scarabacidae, Histeridae and Carabidae) comprising of individuals were recorded across the three habitats (Table 1). In the undisturbed forest, all the twelve species were present while in open grasslands, 11 species were found and only five species were present in the disturbed forest. The dung beetles were more abundant (52,284 individuals) in the undisturbed forest, which represented 71.40% of the total, followed by open grasslands (15,044 individuals) representing 20.55%, while the disturbed forest had the least abundant (5,892 individuals) that represented 8.05% of the total dung beetle population collected (Table 2).

Undisturbed forest had dung species richness of 12 species, open grass land had 11 species, whereas disturbed forest had species richness of 6 species. Dung beetles richness varied significantly between the habitats within the conservancy and this variation also was evident among the two seasons sampled ( $F_{12, 36} = 8.431, p < 0.05$ ) (Fig. 2). High species richness was recorded during the wet season in the undisturbed forest, followed by open grassland then least at disturbed forest. Scarabaeinae richness did not reduce in the dry season but abundance reduced in the three habitats. Richness was positively influenced by the mean relative abundance of Zebra and Impala in the three habitats ( $R_2 = 0.576, F_{1, 24} = 11.387, p < 0.05$ ).

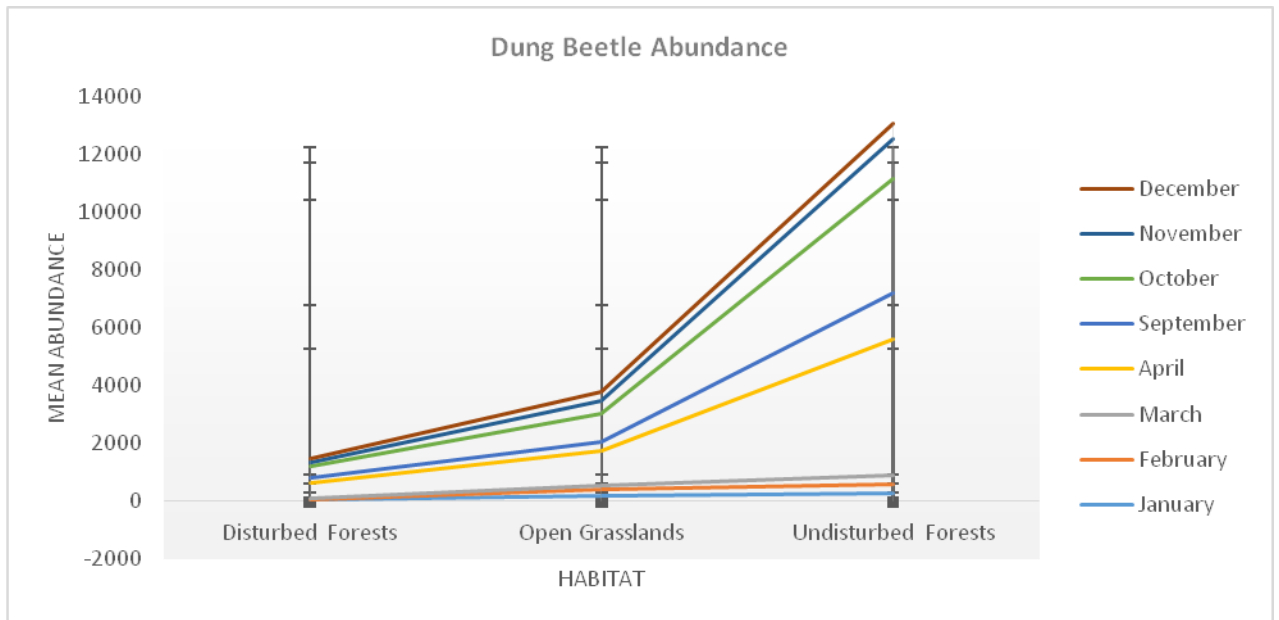


Figure 23: Chart showing Dung beetle abundance in the three habitats sampled in the conservancy

Table 43: Scarabaeinae Richness and Relative Abundance

Dung Beetle Species	Undisturbed forest (dung beetle numbers)	Open grassland (dung beetle numbers)	Disturbed forest (dung beetle numbers)	Individual species totals	Dominance (D)
<i>Malichus picticollis</i>	17509	3463	785	21757	29.7
<i>Onthophagus multicornis</i>	6890	5295	3088	15273	20.8
<i>Hister</i> sp.	7660	3876	1585	13121	17.9
<i>Abaectus</i> sp.	8497	800	54	9351	12.8
<i>Proagoderus sexcornutus</i>	3047	11	0	3058	4.2
<i>Onitis arrowi</i>	1837	778	380	2995	4.1
<i>Oniticullus traangulatus</i>	2059	88	0	2147	2.9

<i>Aphidius</i> sp.	2022	64	0	2086	2.8
<i>Coprils orion</i>	1521	480	0	2001	2.7
<i>Phalops</i> sp.	813	19	0	832	1.1
<i>Coprils harrisi</i>	423	211	0	634	0.9
<i>Sisyphus</i> sp.	6	0	0	6	0.1
Number of Individuals	<b>52284</b>	<b>15085</b>	<b>5892</b>	73,220	
Number of species	<b>12</b>	<b>11</b>	<b>6</b>		
Number of species	<b>12</b>	<b>11</b>	<b>6</b>		

An overall measure of dung beetle abundance at each habitat site was estimated by summing the counts of all species. Species dominance (D) was calculated according to (Munyuli, 2012):  $D = (\text{abundance of a species} / \text{total abundances recorded}) \times 100$ . If D was  $> 5\%$ , the species was considered dominant, if  $2.5\% < D < 5\%$ , the species was considered an accessory species/ species of intermediate abundance, and if  $D < 2.5\%$ , the species was considered an incidental species. Rare species were the ones that had less than 5 individuals dung beetle and/ or sampled from only one land cover type.

### 3.3 Scarabaeinae Diversity and Evenness

The diversity of dung beetle varied in the three habitats with the highest recorded at the undisturbed forest and the least being recorded in the disturbed forest (Table 3 and Figure 3). The dung species evenness was not so different across the habitats sampled in the conservancy, although the highest was found in the disturbed forest habitat.

*Table 44: Species richness, abundance, relative abundance (%), Shannon diversity (H) and evenness indices (E) of dung beetle in the Habitats*

Habitat	Richness	Abundance	Relative abundance (%)	Shannon diversity index (H)	Simpsons evenness index (E)
Undisturbed Forest	12	52,284	71.40	2.063	0.003
Open Grassland	11	15085	20.55	0.325	0.004
Disturbed Forest	6	5892	8.05	0.203	0.093

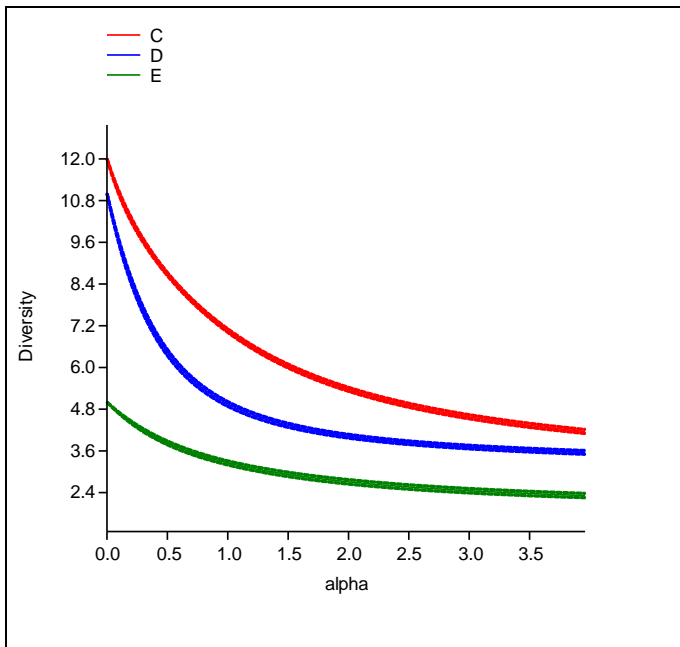
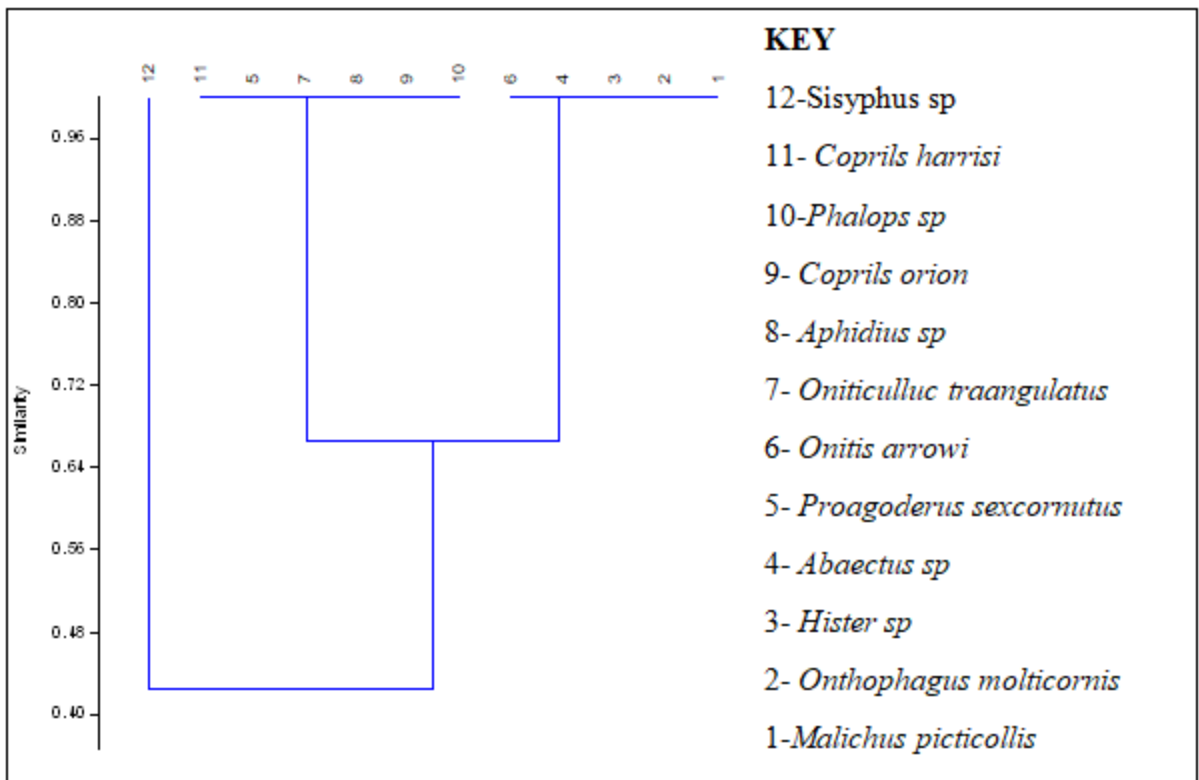


Figure 24: Diversity ordering of three land cover types using Renyi's index family. Land cover

To the result showed that dendrogram length and species richness have a positive relation. The clustering of species into different branches has shown that there was specificity in the composition of the dung species in the three habitat sampled (Figure 4).



*Figure 25: Cluster dendrogram for the species diversity*

## **4. DISCUSSION**

### **4.1 Dung Beetles Abundance and Diversity**

Habitat comparison for species richness and abundance in three habitat sampled could cause biased data because of micro-climatic effect or surrounding environment or effects related to micro-topography (Rai, Adhikari, Rawat, & Bargal, 2012). Similar studies have been undertaken in several part of the globe on the use of dung beetles as biondicators (Escobar, Halffter, Solís, Halffter, & Navarrete, 2008; Gerlach, Samways, & Pryke, 831–850; Marsh, Louzada, Beiroz, & Ewers, 2013).

In the study it showed that the beetle richness and diversity were observed to be higher in the undisturbed forest than the other habitats sampled. The abundance increased during the wet months of the year. There were no major differences in the species evenness among the three habitats in the conservancy. Species richness and abundance was influenced by the Zebra and Impala abundance in the habitats sampled. The results were similar to previous studies undertaken in the savannas in the Southern Africa which have found a positive relationship between Scarabaeidae richness and wildlife abundance (Tshikae B. P., 2008).

### **4.2 Effects of Temperature and Rainfall on Dung Beetle Abundance**

Dung beetle composition, richness, diversity and abundance showed to vary over the entire period of the study. The abundance of the dung beetles increased with change in seasonality where abundance increased in the wet months and decreased in the dry months of the study period (Neves, et al., 2010; Silva, Costa, Moura, & Farias, 2010). (Hernández & Vaz-de-Mello, 2009; Liberal, de Farias, Meiado, Filgueiras, & Iannuzzi, 2011) urged that seasonality affects the dung beetle richness and abundance and that more species were captured in the warmer wet season than cold season this shows human generated disturbance influences land use yet affects species composition, diversity and abundance. These changes push the disappearance of specialist species and later replaced by more tolerant species that can survive in the disturbed habitat (Darío Navarrete, 2008).

The use of dendrogram gave an insight on the perspective of species composition and diversity. The interpretation proved that the species with the longer branch appeared to contribute more to dissimilar than the others. If *Sisyphus* sp. disappeared or from the ecosystem, the species composition might be interrupted or change completely thus ecosystem disintegration (Janos Podani, 2006).

## 5. CONCLUSIONS

The results from the study suggested that the changes in the dung beetles abundance in the three habitats were influenced by the presence of the mammals in those habitats at Dedan Kimathi University Wildlife Conservancy. The abundance of both mammals and dung beetle were affected by seasons with high abundance during the wet season and low during the dry seasons. Undisturbed forest had twice (12) the dung species abundance than the disturbed forest (6) as observed during the study period. The study showed that the dung beetle composition, richness, and abundance are indicative parameters which that could be linked to environment changes as documented in several studies (Nichols, Spector, Davis, Escobar, & Vavila, 2007).

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## **The influence ICT procurement tools on effective procurement operations in hospitality industry**

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### **Abstract**

Procurement operations in business success have changed considerably due to the advances in information technologies and information systems. Effective procurement is a deriving benefit attained from the use of ICT procurement tools and technological enhancements rather than traditional paper based method in procurement operations. It has been noted that development, use, adoption and implementation of e-Procurement has not been as easy as some of the solution providers have suggested, nor has it necessarily brought the anticipated benefits. Nevertheless, as technology alone does not ensure successful adoption, the success of any Organizational e-Procurement initiative depends on users and buyers making use of the new information technological processes and systems, when used effectively enhances performance of an organization. In this study, explanatory research design was adopted to determine the nature of disciplinary procedure that exists, by determining the influence ICT procurement tools on effective procurement operations in public hospitality institutions. The target population consisted of procurement managers and clerks. The sample size constituted of 35 respondents sampled out from the target population and used to make defined analysis. The study employed simple random sampling and utilized both primary and secondary data, where primary data was obtained through self-administered questionnaires. The data collection instrument was validated through content validity whereas; a reliability cronbach alpha coefficient of 0.70 was obtained. The data collected was analyzed using SPSS. With a mean of 4.6 the findings of the study indicated that, ICT procurement have a significant influence on effective procurement. In conclusion, access of information in a timely and reliable manner is very critical to suppliers who depend on the function of procurement and in this respect, ICT ensures that this critical role is achieved and access to information is also ensured at a cost effective manner. In recommendation, Public institutions should adopt ICT-tools as it fast tracks procurement and ensures there is effective operations. The result of the study is significant to practice, academia and policy making so as to strategically improve on polices relating to ICT in procurement systems in the hospitality industry, which can help organizations attain success in the face of turbulent e-procurement environment.

**Keywords:** ICT Procurement Tools, Effective Procurement Operations

## PGD

### Referent Social Power in Mariama Ba's *Scarlet Song*

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### Abstract

This paper aims to establish the dynamics of referent social power among literary characters in the familial spaces of the fictional societies depicted by Mariama Ba in *Scarlet Song* (1981). The research problem handled is the lack of clarity on how reference works in the creation of social power. The objectives of the study are to expose the characters with referent social power and demonstrate how they exercise such power over other characters. Character sampling is limited to those characters whose interaction demonstrates existence of referent social power. The study is justified by the fact that a study on the workings of reference in the creation of character social power in the mentioned text has not been done. The paper argues that character social power exercise relies more on instruments of reference, rather than on other models of power exercise. Michel Foucault's Panopticism and Feminism are the theoretical approaches used. The study is descriptive and analytical and employs the qualitative research design, which involves close reading of the novel as well as other related material. The analysis on how and why different characters acquire and exercise referent social power over one another constitutes data that has been analyzed in a descriptive manner. The key finding in the paper is that the characters in the text exercise control over each other through the appealing and innocuous use of reference. This leads to the conclusion that in familial set-ups, role modeling is the main way through which social power is exercised. A recommendation is then made that in the shaping of behaviour and personality, doing something admirable is an effective way of subjecting a party to do one's bidding.

**Key Words:** *Influencee, Influencer, Panopticism, Reference, Social power.*



## 1. INTRODUCTION

Ideological studies on social power have centered around the idea of domination and control anchored on subjugation of one group over another. Secord and Backman (1974) argue that in an interaction between an influencer and influencee, an exercise of social power relies less on the agent's characteristics but more on the relationship between the agent and the target and the place of that relationship in the context of the larger social structure. A sharing of contextual traits between two groups reduces chances of one group exercising prejudice towards the other one in the creation of social influence (Baron & Branscombe, 2012). Fairclough (2003) explains that ideologies are appearances of worldly phenomena that in one way or another shape power interaction. Ideology constructed around the question of gender and how it determines social relations concerns Butler (1999) who postulates that sexual practice has the power to destabilize gender. Foucauldian studies on the workings of power in group interaction lean towards the significance of disciplinary power in penal institutions. Engelmann (2011) writes that disciplinary power based on panopticism and surveillance is Foucault's synecdoche for modern disciplinary power.

The foregoing studies establish a canonicity of social power studies predicated upon the concept of hegemony creation where one group unwillingly surrenders instruments of control to another. Lears (1985) writes that ideas around the concept of cultural hegemony are used to address relations between cultures and power under capitalism. The studies therefore leave the academic hiatus on whether hegemony creation and exercise of social power can be achieved through innocuous and acceptable models that are devoid of bellicosity or nuances of aggressiveness. A critical excavation into the use of referential models of power to achieve hegemonic control in Marjane Satrapi's *Scarlet Song* is therefore the discursive site of this paper.

## 2. METHODS

In this paper, qualitative research type as espoused by Kothari (1985) is used. This is deemed apt as the paper makes enquiries on culturally specific information on values, opinions and behaviours in the social context of the study text. Kabale and Mumah (2010) note that scientists and social researchers studying human behaviour and habits where there are no simple 'yes' or 'no' answers to research questions prefer the qualitative research type. The research design used is descriptive in line with Peter (1994) who proposes that research in humanities, of which literature is a part of, is conceptual-analytical in nature and so based on description. Data is collected through an in-depth reading of the primary text and other secondary sources. The data collection tool used is the thematic question on existence or absence of referent social power within character interactions, a probe into the agencies used to acquire or diminish the power of reference and how the facility of language is used create or destroy reference. Open coding is used in data analysis, cognizant of Kerlinger (1973) who indicates that the coding categories should be related to the research problem and should be mutually exhaustive.

### 3. RESULTS AND DISCUSSION

According to Raven & Rubin (1976), referent social power depends on the extent to which one party seeks to identify himself or herself with a second party. If the first party is attracted towards the second one, then he or she will attempt to model their behaviour, thinking and even looks on the second party. Once referent power has taken root in an individual, the continued display of the desired behaviour is independent of the influencing agent's surveillance. This paper zeros in on particular character traits in individuals, traits that are transmuted and made to find residence in another individual in the narrative, leading to the first character being seen as exercising a power of reference over the second character.

Yaye Khady, Ousmane's mother, has a form of maternal love that creates referent power directed at Ousmane. This reference is achieved through the habit of Khady taking special care of her son despite the fact that Ousmane has left that young age when such tender motherly care is customary. For instance, every morning, she wakes up early to warm the bath water for her son besides preparing his breakfast. She makes it her duty to ensure that her son is ready for school on time, an action that finds reciprocity in her son's love for her. This care directed to Ousmane by his mother makes him to admire her and spend most of his free time with her, a habit that other young men and women find as being inappropriate. Males in the society tend to discourage other young men from spending too much time with their mothers because of the "The incest taboo that bars the son from the mother..." (Butler 1999, p.7). A closeness between son and mother is regarded as having some oedipal undertones but with Ousmane, his mother's care towards him has produced enough power of reference to extirpate the aforementioned cultural restriction.

Referent power is not restricted to originating from animate bodies only. Inanimate bodies also exert their power of influence over the individuals who interact with them. For instance, Harvey (1996) identifies time and space as being examples of social constructs that have an effect on people's lives. In connection with Harvey's identification of space as an important influencer of social concepts, it is noted that the serene and idyllic environment in which Ousmane has been brought up is a source of referent power. Ousmane is attached to his town of birth and breeding, with the result that he does not want to leave it, even for purposes of getting his further education abroad. The fact that his district of Usine Niari Talli is an influencer in his life can be deduced from the way it is personified in the text. For instance, in the morning, the narrator says that "Usine Niari Talli was shaking off its nocturnal torpor in the first quiver of morning sunshine, and objects resumed their normal shapes and colours as the last shadows faded" (Ba 1986, p.1). According to Glotfelty & Fromm (1996), there exists a link between the environment and literature. This ecocritic description of Ousmane's town of birth is what gives the district power over its influencees, chief among them being Ousmane and his adolescent sensibilities.

The reference of Khady's power over Ousmane blends with the idyllic environment in which Ousmane has grown. The environment that surrounds Ousmane in his district of birth comes out as imbued with the power of acculturation that will later be tested by the possibility of severance, when Ousmane falls in love with Mireille. It is only the existence of minor discrepancies, such as the existence of the mad man in the street that

mar the sublime ambience of the streets of Usine Niari Talli as felt in Ousmane's sensitivity.

There is repetitive mention of the importance of an individual's roots in *Scarlet Song*. For this reason, negritudist injunctions produce a power of reference that drives Ousmane to ensuring that he does not fail those who epitomize the sanctity of his religion and traditions. Adeoti (2015) writes that the proponents of the negritude philosophy, Senghor, Césaire and Damas sought to counter the effects of colonialism in French West Africa, a place that provides the setting for *Scarlet Song*. School teachers in the school that Ousmane attends encourage Ousmane to take pride in his origins and not get swallowed by aspects of Westernization. While on the one hand, Yaye Khady is credited with shaping Ousmane's like for domesticity and what others consider to be effeminate predisposition, the school master is behind Ousmane's manly sense of duty as well as steadfastness in his religion and sense of belonging. Ousmane is cast as emulating his school master with regard to being diligent at work, a position that is interpretable to mean that the school master exercises referent power over Ousmane.

The acceptability of hard work and diligence as part of Ousmane's character can therefore be traced to his school master. The moulding of Ousmane's personality as a character whose life is governed by the sanctity of familial fidelity is also aided by his father, Dgibril Gueye. Gueye's referent power directed towards his son is what gives rise to the combination of Ousmane's humility and ambition as the latter feels drawn to emulate his father in both his mannerisms and social idiosyncrasies. There is an air of masculine uniqueness between Ousmane, his father and other male members of the society that later makes Mireille, Ousmane's wife, to face the kind of marginalization directed at the lead female character in Harold Pinter's *The Homecoming* that Rowe (1991) suggests is based on the Freudian condition known as mother fixation. In this condition, male members of a family abhor any younger female who seems to be in contention with their mother's position. Gueye is thereafter credited as being the force behind Ousmane's humility and ambition. He repeatedly tells his son that "Work is the only path to self-advancement" (P.5) The argument advanced in this paper is that Gueye's indoctrination of his son Ousmane contains more reference than whatever injunctions are directed towards Ousmane by his contemporaries, top among them being taunts from girls of his age that he is too attached to his parents.

The substance of Gueye's referent power towards his son is further weighted by the fact that Gueye had received his training at the revered Koranic schools under the instruction of the respected marabout. In the text, it emerges that fulfillment of religious ancestral requirements makes a character more admirable by his acquaintances and family members. Gueye's father had instructed that Gueye should serve as a mosque official his whole life. Barry (2002) explains that religion is a superstructure which forms part of the cultural world in a society. Other components of this cultural world are law and art. That Gueye had adhered to the foregoing filial stipulation on the family cultural path in turn makes him exercise a power of reference towards his own son Ousmane, the latter who now feels obligated to follow in the footsteps of his father.

From the eyes of the former French colonizer, Gueye has the power to control the ongoing in his locality because he demonstrated his loyalty to the France by participating in the second world war. The French officials therefore reward him by giving him a plot

over which to settle with his family. The status of being a war veteran, coupled with expansive traveling is also an admirable historical quality in Gueye that earns him the title of “the man who had seen Paris (P.6). An appreciation and understanding of a community’s history creates referent power in the individual concerned because such a person has the power to transmit the community’s history to younger generations by use of language (Mukundi, 2010). To Ousmane, Gueye has a paternal power of reference because of a mixture of his kindness, devotion to Islam, philanthropy and his array of medals of decoration that he had been given for his service in the army.

In *Scarlet Song*, the way characters handle their marital lives either end up casting them as having power of reference to control the actions of others or else render them picayune with regard to how they affect the lives of those that they fraternize with. This means that an evaluation of a married character by his or her contemporaries results to the character under appraisal being adjudged as either consequential or inconsequential as far as meaningful power reference is concerned. A character in point is Gueye, who, although not prohibited by religion or customs to marry a second wife, has decided to remain in a monogamous union with Yaye Khady. Ousmane reads his father’s monogamous marriage as an indicator of his sagacity since his modest means would not afford him another wife. Whereas the Muslim faith provides for the institution of polygamy, Gueye remains admirable to his son Ousmane because Gueye has accepted that a polygamous marriage would put his first family under undue financial crisis. His monogamy as an African is therefore a challenge to the white man who introduced Christianity and its attendant monogamy and yet early settlers in Africa did not exercise fidelity to monogamous unions. According to Ogude (1999), settler communities in Africa were associated with sexual excesses and other degenerate values and so Gueye’s adherence to a faithful monogamous marriage further reinforces the idea of negritude as being a return to acceptable societal values. His decision stands well with Ousmane and other members of his family who admire his selflessness that in turn has ensured that they have not experienced a life of squalor that would have resulted had he been taking care of a larger household.

In this regard therefore, a polygamous man of modest means is shown as not being an influencer in the shaping of other people’s views on marriage. In line with what Tyson (2006) proposes, financial well-being then becomes a source of referent power in a man as both the co-wives and children of a polygamous man live in contentment and admiration of the man in question. Conversely, the referent power of a polygamous man is emasculated by the lack of enough resources in the household, which means that the children are in most cases poorly fed as the choicest of the dishes go to the adults. In Gueye’s household, his monogamous marriage has therefore given him the power of reference to shape the general thinking of his son Ousmane, who, learning from his own father, has not seen the need to be unduly over-preoccupied with indulgence with women. The argument mooted here is that Gueye has acted as a positive role model to his son with regard to showing Ousmane the (in)significance of women in a man’s life.

In recognition of the fact that Gueye has resisted the temptation to take a second or third wife, Yaye Khady reciprocates by playing the role of an uncomplaining and demure wife. The academic argument built from a scrutiny of Khady’s acquiescent domesticity is that her domesticity is engendered by the fact that Gueye has exercised his patriarchal power on her, not from an oppressive perspective but in a loving and accommodative way. We

therefore see Ba as having cast the character of Gueye to fit the mantra of motherism. Motherism is a coinage of the Nigerian African feminist, Catherine Acholonu. Bassey & Elton (2012) explain that African women have increasingly departed from the Western concept of feminism and increasingly adopted a non-aggressive version of African feminism. This is the situation that subsists between Gueye and Khady. The evidence of the foregoing thesis on the relationship between Gueye and Khady is the fact that the narrator has noted that Khady goes about her domestic chores without complaining or nagging her husband. She fetches many bowls of water from the public water point, her eyes are reddened by too much firewood smoke and the broom she uses to sweep has increasingly become shorter, tiring her as she bends to use it. The conclusion drawn is that domesticity with its attendant discomfiture has attained acceptability with Khady on account of the fact that her husband has also accepted a monogamous marriage to her. This is despite a possibility of Gueye putting himself at the risk of being ridiculed by his peers, who have more than one wife. Khady's acceptance of a lifestyle that is less than luxurious is an offshoot of the power of reference working from Djibril Gueye towards her, a power that is predicated on the idea that a man does not have to fulfill all his hedonistic inclinations especially if such a move would disadvantage those who are dear to him.

Ousmane is portrayed as an idealistic character whose need to succeed where odds are stacked against him drives him towards a destiny that is against his preordained negritudist path. It therefore becomes ironic that though he adheres to negritudist loyalty of his ancestry, he nevertheless falls prey to the wiles of Mirielle's exoticism. Of importance is the fact that Mirielle is a character who is diametrically estranged from the African experience. The cultural difference between the two young people provides a power of reference that is fueled on an idealized quest for love from across the racial divide. The irony of Ousmane's loss of rationality and self-control is clear when one reads that:

And Ousmane Gueye, who had rejected all sentimental adventures, surrendered. Ousmane, Gueye, who had mistrusted all women, threw himself at the mercy of a woman, and a white woman at that. All it had needed was a handshake and a flutter of eyelashes (P. 18).

In this paper, it is argued that Ousmane's dislike for Oleymatou and a preference for Mirielle is based on the premise that a love that springs from novelty has more reference than one that comes from a customary situation. Ousmane therefore falls in love with Mirielle in his pursuit for love whose power of reference is based on the vicissitude of love autochthonous to a white skin. Based on events that unfold later on in the novel, we aver that Ousmane discovers that he is incompatible with Mireille. His initial attraction to her is based on positive reference power but unbeknown to Mireille, Ousmane's attraction towards her is mostly self-serving. His is a controlling variety of love, a type of love that does not entertain challenges. It has been found that:

... controlling people want power over others. They use "love" to manipulate and exploit those who care about them... Whether the control is well intended or malicious, it ensures the controller's happiness, not the well-being of the person being controlled (Benokraitis, 2005, p.158).

When later, Ousmane realizes that he prefers his traditional Wolof culture to the neoteric love associated with Mireille, Mireille exerts a negative power of reference towards Ousmane.

On the other side of the Ousmane-Mirielle relationship, an examination of the referent power at work from Ousmane towards Mirielle is made. Mirielle is a young lady from an Aristocratic French background who finds the ways of her Aristocratic forebearers as being steeped in hypocrisy. She finds her parents and their lineage as living the life of middle-class pretentiousness. Instead, with Ousmane, she detects a genuineness that is encapsulated within a straightforward mien that for a long time she has not encountered within her social circles. Ousmane's openness and unpretentiousness is what creates a referential power that Mirielle responds to. It is worthy of comment that Mireille herself confesses that her attraction towards Ousmane is not based on the postcolonial concept of 'the exotic other' where people from the metropolitan Western culture might at times get attracted to Africans, the latter who occupy the place of unique souvenirs in the minds of the former. At first, Mireille takes Ousmane through her entire life with the help of photographs from her collection of her memorable moments in life. It is our postulation that at first, albeit unknowingly, Mireille's Aristocratic background produces a negative power of reference that makes her want to be unlike her parents. She therefore goes against the cultural norm of body materialization which Massey (2011) explains is what makes individuals want to copy the behaviour of their peers in order to feel accepted in social situations. We witness Mireille turning against her own past, seeing it as a shameful and pretentious legacy. Through her rejection of her privileged ancestry, Mireille becomes subject to the referent power coming out of Ousmane's own family history with its own shortcomings. Ironically, this happens after Ousmane finally reveals his true self and invites Mireille to appreciate that his is a humble background that will rob her of her high social class status if she decides to get married to him.

Mireille's character comes out as a foil to that of her father with regard to the imperialistic French relationship with its former colonies. We avow that monsieur de la Vallee is an epitome of the neo-colonialist's condescending attitude towards French West Africa. For the foregoing reason, the love that Ousmane feels for Mireille is in part shaped by the fact that Mireille has rejected the societal stratification that is based on class and colour. The power of her love that binds Ousmane to her is therefore influenced by her turning against the doctrine of social classism that has elevated her father to a patronizing level with regard to how he treats the black people in whose country he is a diplomat. We argue that Mireille has in part accepted Ousmane's attachment to his roots, an attachment that even sees him turn down a chance to attend University in France on a scholarship. While in France, Mireille writes a love letter to Ousmane, a letter in which she commits to always love him. Young girls who commit themselves to love, through the use of letters threaten the paternal order in which they have been raised. (Ringrose, 2006) (Djebar: In dialogue with feminism). It therefore comes out as an exercise of referent power that Mireille's rejection of her background is what gives her love to Ousmane acceptability.

In this study, it is demonstratable that Ba explores the reference of corporeality power as pitted against socially constructed power paradigms. Patterns of character behavior

emerge where what the society has vetoed as being the acceptable way in which power is exercised is oftentimes challenged by the innate and primordial drives of the human flesh and spirit that do not recognize externally applied restraints on human motives. As a privileged child of a diplomat, Mireille is socially constructed within the Aristocratic culture of social conservatism that discourages her from immersing herself in the contaminating activities associated with the Dakar hoi polloi. Her father, following the dictates of his forebearer, attempts to limit Mireille's association with those who might interfere with his image of gentility. Instead of letting Mireille find her own direction and purpose in life, he panoptically controls her space, a restriction that is symbolically represented by her chauffeur driven trips to school. Monsieur de La Vallee keeps Mireille's feelings under confinement, a position in tandem with Ringrose (2006) who states that in Islamized cultures "Desire (women's) must be more than kept in check; it must be imprisoned (p.60) This image of social confinement given the guise of paternal protectiveness is also given more credence by Monsieur de La Vallee's deportation of Mireille back to France after he discovers her affair with Ousmane. Her flight to France, in the First-Class section of a plane is monitored by a stewardess, prevailed upon by Mireille's father to ensure that Mireille does not fail to reach France. When Mireille finally reneges against her father's control and surrenders to the dictates of Ousmane's Islamized world, it becomes clear that a negative reference power exists between her and her father, negativity that makes her to strive to be unlike her father in all means. In the same manner, there exists a negative reference power between Ousmane and his native Wolof girls, a fact that makes him strive to be unlike them despite clear indications from such girls' mothers that they would like their daughters to find favour in Ousmane's eyes.

When Monsieur de la Vallee escorts Mireille off to France, he exchanges pleasantries with people at the airport, some of them being of the negro extraction. He offers what Mireille views as being perfunctory greetings and exchanges hypocritical pleasantries with the coloured people. These affected gestures in the public eye stand in sharp contrast with his dismissal of Ousmane as 'that thing', a bigoted and xenophobic attitude towards the people among whom he serves as a diplomat. It therefore becomes a matter of interest to find out why Mireille has not assimilated her father's dislike for Africans. A look into her academic life provides the answer to this negative reference and discordance between father and daughter. As student of Philosophy, she has come to realize that racial supremacy is a mirage that provides false power appearances for the Caucasian to subjugate the Negro, the Semite or the Oriental. In an angry outburst at her father, she decries the fallacy that leads to one race appropriating the power to elevate itself to transcendence while condemning other races to villainy. She reminds her father that if his skin were to be cut, the blood that would issue forth would be red, just like that of Ousmane. We posit that Mireille's knowledge on the equality of humanity, gleaned from her studies in Philosophy, has given her negative reference power against her French ancestry leading to her decision to love Ousmane, despite opposing views from her father. She goes against the panoptic principle of omnipresent surveillance that Engelmann (2011) proposes was designed by Jeremy Bentham with the intention that once a subject realized (s)he was under constant surveillance, (s)he would even in the absence of that surveillance continue to exhibit the desired behaviour.

In that respect, the traditional Francophone expectation that the former colonizer exercises the power of reference towards the Negro through the French policy of assimilation is subverted when Mireille decides that Ousmane's intelligence, heart and

virtue are more acceptable human attributes than those of Pierre, a young French man whose overtures her parents encourage.

In Mireille's absence from Ousmane's life, the power that her physical presence would have on him is elicited by the presence of a framed portrait of her that he keeps and guards closely. It becomes of interest that Mireille's framed image also exerts a power of reference over Ousmane because its resemblance to her is in itself a powerful influencer on how he continues to keep her in his mind. Ousmane demonstrates the power of the portrait on his sensibilities through his constant gazes at it. Whereas a photograph is only a two dimensional and inactive representation of a human being's face, Mireille's image encased in glass assumes the power of Mireille's corporal being in Ousmane's mind. Here, the power of the photograph on Ousmane becomes a subverted power exercise since it is Mireille herself who should engender the kind of affection that her image does. When later, Mireille falls out of favour with Ousmane and his Wolof relatives, a subverted form of referent power exercise is deduced. This is because the person of Mireille when close to Ousmane ends up losing the power of reference that her mere image (when she was far away) had at one time produced on Ousmane.

Whether an image of an icon has the power reference to affect the lives of real people is a philosophical question that is answered through a comparison of Ousmane's attachment to Mireille's portrait with that of Mireille as he she secretly guards and glosses over Ousmane's photograph. Ousmane is described as being in a red shirt, with his black skin colour accentuated by the sunny background against which the photograph was taken. Ousmane's image is part of the discourse on the pareto principle where what would ordinarily be less momentous in terms of power reference achieves a greater effect than it customarily would. The power of the camera comes out of the fact that the viewer of an image has attained a power over the viewed subject (Hiddlestone, 2006). Whereas Khady playfully dismisses Mireille's picture as being that of a pop star with whom her son is obsessed, Monsieur de la Vallee becomes livid when he comes across Ousmane's portrait. The love caption inscribed at the back of the portrait assumes a great significance in the eyes of Monsieur de La Vallee. De La Vallee's reaction is disproportionate with the danger that a mere photo poses to his family stability. His anger is directed at a mere portrait, what he refers to as 'that thing'. This asymmetrical and misdirected anger is a subverted operation of reference power where the image has more power than the substance.

The power of image over substance is a narrative that Ba continues with her characterization of the Madame de La Vallee and her husband. With regard to the fact that Mireille is an only child and without the author proffering some medical reason as to why she has no siblings, our postulation is that Ba seeks to cast Mireille as part of the leitmotif of subverted referent power. Just like the photos mentioned earlier, Mireille's person is iconic if she is viewed through the supremacists' lens of her parents. She fails the test of children's sanctity and warmth in the institution of marriage and is instead shown to be a human souvenir in the de La Vallee's collection. Her attendance of school in Senegal is part of her father's larger scheme to paint himself as a benevolent other who has condescendingly decided to fraternize with the natives, Mireille's schooling in Senegalese institutions completing this patronizing picture. His is therefore a subverted exotic other that Tyson (2006) explains is attractive due to its dissimilarity with what is



habitual. For the foregoing reason, a conclusion is reached that de La Vallee's diplomatic power reference is a facade that is supported by an image of a Caucasian family that is ostensibly happy to be among the Africans.

In order to avoid besmirching the ideal picture of diplomacy power in the person of monsieur de La Vallee, the narrator relates that Madame de La Vallee closely watches over her diet, her intention being to avoid a scenario where careless gastronomical indulges might alter her figure to the detriment of the portraiture that is part of her husband's referential power. The fact that Madam de La Vallee's intended image is not necessarily in agreement with what her innate biological dietary drives are subverts the power of the body over the image, so that the image assumes greater significance over the body. The Western concept of female beauty is made to be more powerful than the natural inclination to eat whatever the body craves for, resulting to a body that might be viewed by Monsieur de La Vallee as being discordant with a diplomat's wife. Here then is a case of negative power reference at work: that Madame de La Vallee strives to be what she does not desire to be in order to please her husband. However, Mireille refuses to bow to this negativity of referential power while taking up a career. The narrator says that:

Like Ousmane, she took a teaching post, in spite of her father's exhortations: 'You could go on and do your doctorate! You are not short of money. We can maintain you. What are you going to do with your miserable salary?' (p.52)

The use of the phrase "Like Ousmane" should be read within the interpretive paradigm of power reference in that the career she chooses is not just guided by the monetary benefits so accruing but by the likeness of it to what her lover also does for a living.

The panoptic control of Madame de La Vallee's body continues in France when one examines the manner in which she is made to fit the social mould created by her husband. In more than one instance, the narrator suggests that she acquiescently agrees to whatever direction her husband proposes as the correct position. Madame de La Vallee is portrayed as a woman who has surrendered to the idea of surveillance. Gabriele (1998) writes that in the exercise of power, "surveillance is examined as a means of maintaining social structures of gender, race, and class (p. 3). When the de La Vallee's visit their family friends with an intention of forging closer ties between Pierre's family and theirs, Madame de La Vallee readily agrees that Pierre is a suitable match for their daughter, not because she believes so herself but because she has accepted a subjacent position where her role with regard to decision making at home is to chorus her husband's statements. As a lady in a well to do family, a deduction is reached that her lady status has lost the power of reference that she should have used to direct her daughter's sensibilities.

The subversion of the traditional expectations in a patriarchal society where the man exercises power to the detriment of the female members of his household is demonstrated by Yaye Khady's spaced pregnancies. In what Ousmane refers to, after hearing snide remarks on the same, as "one pregnancy in five years like an elephant," Yaye Khady and Gueye have planned their family so as to ensure that they do not expose their children to too much suffering by bringing many of them forth too quickly and yet they do not have the means to sustain them. The imagery of an elephant, in this context a matriarch in its

herd lends itself well with the protective role played by Khady within her family. It is therefore Yaye Khady's success in subverting the patriarchal body sexage of women that makes her power over Ousmane have reference. Ousmane sees his mother as an admirable matriarch who has not allowed the chauvinistic male society to relegate her to body sexage. Body sexage is described by Tyson (2006) as being a feminist believe that male members of a family subject the women in their spaces to forms of corporeal exploitation meant for economic gain, one of which is a bearing of many children, children who will finally belong to the men.

Khady's attainment of freedom from masculine exploitation has however not been achieved through recourse to bellicose feminine agitations but rather through amicable decision making with her husband. Her matriarchal power is thence exercised within the motherist orientation that this study identifies as a West African alternative to militant feminism. Khady's acceptance of her domestic role finds complementarity in her husband's relinquishing of his patriarchal rights, top among them being a polygamous marriage. On his part, Ousmane's dabbling with domestic chores attracts snide remarks from his peers but like his father, he has subverted the traditional expectation of patriarchy that a boy should not engage in feminine duties. His father's lack of masculine machoism has had the effect of giving reference to his own acceptance of roles associated with women. Both Gueye and Ousmane have negated the negative reference power of oppressive patriarchy by demonstrating that they can defy its dictates and still be none any worse off as men.

## **Conclusion**

In this paper, it has been argued that in terms of social power exercise and group control, use of coercive models of power are ineffectual. Such ways of creating hegemonic control result to an ephemeral and transient state of acquiescence that does not stand the test of time. Instead, the paper has examined the idea of referent power where one individual seeks to gain control over the second one through a display of attractive and hence replicable characteristics. Dgibril Gueye's family members in Mariama Ba's feminist novel, *Scarlet Song* have provided the discursive site to illustrate the foregoing. A paucity as to what is the best method of exercising power within familial spaces has been addressed.

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## HSC

### **Enhancing the Sustainability of Dairy Goat Projects through Institutional Linkages in Tharaka Nithi County, Kenya**

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#### **Abstract**

The ultimate goal of any project is to achieve sustainability. Dairy goat projects are not excepted. However, sustainability is seldom achieved and there exist inadequate understanding of the critical drivers of sustainability. This paper advocate for enhanced institutional linkages that promote sustainability in dairy goat projects. The paper is based on a study conducted in Tharaka Nithi, Kenya that sought to establish the extent to which institutional linkages influence the sustainability of dairy goat projects. The study is grounded by the Structural-Functional Theory and based on the pragmatism paradigm. Cross-sectional descriptive survey and correlational research design supported by the mixed mode approach was used. Multiphase or sequential sampling and stratified random sampling technique were used to sample 196 dairy goat farmers. A total of 12 key informants and 4 self-help groups were sampled purposively. A Five-point Likert type scale questionnaire was used for quantitative data while interview and FGDs guides used to collect qualitative data. Descriptive data were analyzed using frequencies, percentages, arithmetic mean and standard deviation while inferential data were analyzed using Pearson's Product Moment ( $r$ ) and simple regression. Results indicate that  $r= 0.179$  and  $R^2=0.0320$ ,  $t=2.479$  at  $p=0.014<0.05$ ,  $H_1$  was accepted and concluded that there is a significant relationship between institutional linkages and sustainability of dairy goat's projects. The study recommends that stakeholders in the dairy goat's development sector need to design and implement projects that have a comprehensive mechanism for institutional linkages such as veterinary services, markets and social linkages for sustainability of the projects.

**Key Words:** Institutional Linkages, Sustainability, Dairy Goats, Dairy Goat Projects

#### **1.0 INTRODUCTION**

Livestock production remains a critical sector in the agricultural economy of developing countries. Among the livestock production systems, dairy goat production has increasingly gained popularity as a significant contributor to this important sector. Innovation and adoption of new technologies such as the promotion of dairy goat production, improvement of indigenous goats

for better production is poised to make an even bigger contribution. This is in particular to the newly adopted agenda for sustainable development focused to eliminate poverty, inequality, just as well as tackling climate change by the year 2030. Boyazoglu et al. (2005) observed that dairy goats contribute largely to the livelihoods of livestock keeping households of low and medium input farmers. Nevertheless, Adejobi and Kassali (2013), Kavoi et al. (2014) observe that dairy goat productivity in sub-Saharan Africa is on the decline and that this becomes a major bottleneck to the continents livestock development.

Globally, the higher producers of dairy goat milk by 2010 were India, Bangladesh, Sudan, Pakistan, France, and Spain, with 62.2 % of the goat milk produced in the world (FAOSTAT 2012). The main goat-producing countries in West Africa Region are Nigeria, Niger, Mali, Mauritania and Senegal (Olantunji and Adeyemo 2009) while locally key dairy goat producers are Sudan, Somalia, Kenya, Ethiopia and Tanzania (Luis et al 2012). Kenya did not lag behind in the development of dairy goat sub-sector which picked up in the 1980s and 90s and has since taken the lead.

Dairy goats were first introduced in Kenya in 1950s by British settler farmers in the highlands of Kenya (Shivairo et al 2013). Goat milk consumption accounts for a small but growing percentage of the Kenyan dairy market. FAO (2011) estimates that over 70% of the milk that is sold in Kenya originates from dairy cows with only 0.02% from dairy goats. Unlike in dairy cow milk where markets are organized, Alemayu (2011) observes that markets for dairy goat milk are dispersed with remote markets lacking price information.

Evidently, dairy goat farming has several benefits such as enhanced nutrition from the consumption of milk (Peacock 2008), the creation of jobs through provision of animal health, breeding, and water management services and improved household income from the sale of weaners, culls and breeding stock (Peacock and Hastings 2011). Further, Chenyambuga and Lekule (2014) asserts that social economic usefulness of dairy goats cannot be underestimated. Therefore, profound concern on the success and sustainability of dairy goat project is critical. Thomson et al. (2011) assert that projects lead to the production of goods and services to address specific community needs that require to be in consonant with the social and environmental context. In this sense, therefore, it is essential for dairy goat project designs to adhere to sustainability criteria so that they pass the sustainable test.

To mitigate this worrying trend, it is paramount that dairy goat projects incorporate sustainability goal in their design that Shenhar (2011) considers to be a pre-requisite to project success. However, evidence of the sustainability of dairy goat projects shows that sustainability is seldom achieved. Further, a review of the literature that has sprung up around the concept of sustainability of projects indicates, however, a lack of consistency in its interpretation.

Deficiency of appropriate definition and understanding of project sustainability drivers remains a challenge. Literature indicate that, even though the general and common definition of sustainability exist, to a large extent, sustainability is context specific. Gilbert (2014) considers sustainability as a process of change brought about by the implementation of sustainable projects that guarantees the utilization of resources, investment options, the focus of technological advancement and institutional capacity are all aligned to trigger the capability of the projects achieving both current and future needs. Consequently, dairy goat development projects are anticipated to generate similar outcomes if they qualify to be sustainable. Unfortunately, this is not the case with dairy goat production in Kenya. Therefore, the call for the persistent search for the drivers of sustainability in dairy goat projects. This paper hypothesizes that there is a significant influence of the institutional linkages on the sustainability of dairy goat projects.

Institutions considered here are those related to health service provision, market institutions and the social support institutions.

Adequate linkage and involvement of relevant key actors and institutions in a project at a different level are very significant. This is considered directly proportional to the success of development projects (Amir (2014). Bett et al (2013) conducted a study in Rift valley on institutional challenges in dairy goat management and found a gap in facilitation of animal breeding and veterinary services, coordination of research and extension, market organization. Onono (2013) conducted a study in Narok Kenya on health service provision and results indicated a serious challenge in linkage to health services. Similarly, Peacock and Hastings (2011) observes that the efforts by farmers to promote livestock production is affected by inaccessibility to crucial services such as veterinary services and breeding services. Further, linkages to markets is equally important for sustainability of dairy goat's projects. For instance, dairy goat milk consumption accounts for a small but growing percentage of the Kenyan dairy market. Advancement in livestock production and linkage to markets by smallholder farmers in Africa provides a good opportunity for poverty eradication for many families (Peacock and Hastings 2011). However, Alemayu (2011) observes that markets are dispersed with remote markets lacking price information.

There is a clear interplay between market institutions and the social networks and institutions. Villanueva et al. (2016) indicates that social networks are connections that link people and have the influence of the dissemination of information and adoption of technology. Therefore, social networks are organized type of social capital formed through linkages among individuals and organizations. Social networks are key to information and innovation transfer as well as enabling communication and coordination within the network (Tatlonghari et al. 2012). Functional social networks provide the necessary conduits for social learning to livestock producers, a situation that fastens the adoption of technology (Pali et al 2013).

This paper seeks to establish the influence of institutional linkages as indicated by linkages health services, markets and social networks. This paper looks at the influence of institutional linkages particularly linkages to health service, market and social institutions on the sustainability of dairy goat project

## **2.0 METHODS**

This study adopted a pragmatic paradigm integrating both positivism and interpretivism/constructivism philosophical foundation. Consequently, descriptive cross-sectional survey and correlational research designs were used supported by the mixed mode approach. This complementarity capability of mixed mode builds the strength of this study by allowing descriptive explanations while showing the relationship among variables through inferential analysis. A sample size of 196 dairy goat farmers was sampled using a combination of multiphase or sequential sampling, stratified random sampling technique. 12 key informants were sampled purposively from the department of veterinary (3), Livestock production (3), Social services (3), and project leaders (4). In addition, four focus group discussions (FGDs) were conducted involving 8 participants in each session. Questionnaires were administered to the respondents and variables measured by providing respondents with statements rated on a five point Likert scale ranging from Strongly Disagree (SD)  $1 < SD < 1.5$ ; Disagree (D)  $1.5 < D < 2.5$ ; Neutral (N)  $2.5 < N < 3.5$ ; Agree (A)  $3.5 < A < 4.5$ ; and Strongly Agree (SA)  $4.5 < SA < 5.0$ . The mentioned scales give an equidistance of 0.5.

Validity was enhanced through experts opinion, and conducting a pilot study. Based on the result of the pilot test, Content validity was achieved according to representativeness by examining objectives and comparing them to the content of instruments. To ensure reliability, the researcher used the test and retest method at an interval of three weeks. A Cronbach  $\alpha$  (Alpha) reliability coefficient that ranges between 0 and 1 was generated to measure the reliability. For the purposes of this study, where  $\alpha < 0.7$ , the research instrument was revised.

This study used a mixture of descriptive and inferential data analysis techniques. Descriptive statistics such as measures of central tendency, dispersion, percentages and frequency distributions were used to analyze the scores distribution, while inferential statistics tested the hypotheses. Simple linear regression was adopted in establishing the nature of the relationship between variable under study. The following correlation and regression models guided the data analysis with the variables and the indicators denoted as follows:

Sustainability of dairy goat projects = f (Institutional Linkage)

$$Y = \beta_0 + \beta_1 X_1 + \epsilon$$

### 3.0 RESULTS AND DISCUSSION

Dairy goat farmer's groups were the unit of analysis for this study. Table 1 presents the demographic information of the respondents.

**Table 45: Demographic Profile of the respondents**

Demographic profile	F	%
Gender	F	%
Male	107	56.9
Female	81	43.1
Total	188	100
Age bracket	F	%
Below 30 years	2	1.1
30-39 years	27	14.4
40-49 years	79	42.0
50 years and above	80	42.6
Total	188	100.0
Duration in the group	F	%
1 and below years	14	7.4
1-2 years	2	1.1
2-3 years	11	5.9
3-4 years	17	9.0
4-5 years	12	6.4
5 years and above	132	70.2
Total	188	100.0
Duration of keeping goats	F	%
1 and below years	16	8.5
1-2 years	5	2.7
2-3 years	19	10.1
3-4 years	8	4.3
4-5 years	10	5.3



5 years and above	130	69.1
Total	188	100.0

Majority, 107(56.9%) were male while 81(43.1%) were female. Men were more involved in dairy goat farming than females. The findings concur with Koskey (2008) that gender imbalance may be due to the fact that women normally shy away from livestock rearing. Further, majority 80(42.6%) were 50 years and above, 79(42%) were between 40-49 years, 27(14.4%) were between 30-39 years while only a small number of 2(1.1%) were below 30 years. This implies that the youth do not participate in dairy goat farming as opposed to the adults. This finding agree with Chenyambuga and Lekule (2014) that dairy goat projects are implemented by men and women who are mature and with a property like land against which the dairy goats can be kept and fed. Philemon and Maitho (2017) indicates that age factor has been found to play a key role in acceptability and application of sound management practices in dairy goat management.

### Descriptive Analysis of Sustainability of Dairy Goat Projects

Measure of sustainability was established through a descriptive analysis presented in Table 2

**Table 46: Descriptive analysis for Sustainability of dairy goats projects**

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic
Sustainability of dairy goats	188	2.50	1.90	4.40	3.2521	.03072	.42116
Valid N (listwise)	188						

Composite mean = 3.25, Composite standard deviation = 0.764, Cronbach Alpha Coefficient = 0.645

The mean score was 3.2521 and Standard deviation was 0.764. This indicates a neutral level of sustainability of dairy goat projects. Sustainability (dependent variable) was then correlated with institutional linkages (Independent Variable) to establish the relationship between the two variables. The indicators for institutional linkages were health service institutions, market institutions and social institutions.

### Health Service Institutions and Sustainability

The mean score for health service institutions and sustainability was 2.4574, and the standard deviation of 0.80843. This indicates that majority of the respondents disagreed that there were adequate linkages with dairy goat's health service institutions.

**Table 3: Health Service Institutions and Sustainability**

Statement	SD	D	N	A	SA	Mean	STD V	Total
	F %	F %	F %	F %	F %			F %
A1 Dairy goat health services are readily available	20	108	30	26	4	2.39	.928	100
	10.6	57.4	16.0	13.8	2.1			

A2	Dairy goat health services are of acceptable quality	17	83	51	31	6	2.61	.973	100
A3	Dairy goat veterinary services are affordable	16	110	42	16	4	2.37	.840	100
		8.5	58.5	22.3	8.5	2.1			
Composite mean = 2.4574, Composite standard deviation = 0.80843, Cronbach Alpha Coefficient = 0.859									

Results from FGDs indicated an inadequate and high cost of veterinary services, slower emergency response rate and the existence of quacks in service provision as the major obstacles to sustainability. indicate that health services are available but the cost is high with low emergency response rate. This is in agreement with Onono, Wieland, and Rushton (2015) that the average distance covered while seeking services from the drug stockiest and government veterinarians in Narok was 10.93 and 12.56 km, respectively. Key informants agree with this finding that there were few qualified health practitioners mainly para-vet professionals (animal health assistants) who mainly have agro-vet stores and rarely do they do the actual treatment. Due to this challenge, farmers resorted to purchasing drugs and treating their animals. Key informants noted that due to the privatization of veterinary service provision, the cost of veterinary services is determined by the market forces with minimal support from the government. This supports the findings in Ngeywa and Masake (2009) that the delivery of animal health services has been hampered by several challenges including lack of resources by government and the low incentives for setting up private practices.

#### Markets Institutions and Sustainability

The mean score for market institutions and sustainability was 2.4433 and standard deviation of 0.62885. This implies that majority of the respondents disagreed that there was proper linkage with the market institutions.

**Table 4: Markets Institutions and Sustainability**

Statement	SD	D	N	A	SA	Mean	STD V	Total	
	F %	F %	F %	F %	F %			F %	
B1 Dairy goat farmers have ready access to dairy goat markets.	18	114	38	16	2	2.31	.801	100	
B2 Dairy goat farmers have access to the right market information	9	80	57	39	3	2.72	.902	100	
B3 Dairy goat market facilities are favorable to dairy goats needs	4.8	42.6	30.3	20.7	1.6	2.30	.773	100	
		24	94	60	9	1			
		12.8	50.0	31.9	4.8	0.5			
Composite mean = 2.4433, Composite standard deviation =0.62885, Cronbach Alpha Coefficient = 0.635									

Focus group discussions (FGDs) confirmed that there is no specific market for dairy goats and their products. For instance, all the milk from dairy goats was being sold or consumed locally for domestic use. Further, sale of dairy goat must be done through the association who in addition charge them Kshs 2000 for every dairy goat sold.

## Social Institutions and Sustainability

Overall, respondents disagreed that there was appropriate linkage to social institutions. The mean score for social institutions and sustainability was 2.4433 and the 0.62885.

**Table 5 Social Institutions and Sustainability**

Statement	SD	D	N	A	SA	M	SD	Total
	F %	F %	F %	F %	F %			F %
C1 Farmers are linked to the government	126.4	10756.9	5931.4	105.3	00.0	2.36	0.683	100
C2 Farmer groups are linked to leaders	2613.8	11862.8	3418.1	94.8	10.5	2.15	0.733	100
C3 Self-help groups are linked to each other	115.9	10756.9	6534.6	52.7	00.0	2.34	0.630	100
Composite mean = 2.2633, Composite standard deviation = 0.45281, Cronbach Alpha Coefficient = 0.5793								

Focus group discussion indicated that there was less support from the government and other institutions like NGOs, and parastatals. The government only conducted occasional vaccination of animals but not on demand treatment. Self-help groups were organized in clusters of 5 groups who were then linked to the county level association. However, FGD indicated that some of the groups were too weak to support this arrangement.

### Regression Analysis

Regression analysis was done to determine the relationship between institutional linkages and the sustainability of the dairy goat's projects. The following hypothesis were tested:

**Hypothesis H<sub>0</sub>** Hypothesis H<sub>0</sub>: There is no significant relationship between institutional linkages and sustainability of dairy goat projects in Tharaka Nithi County.

The hypothesis was tested using the following linear regression model

Sustainability of dairy goat projects = f (Institutional Linkages)

$$Y = \beta_0 + \beta_1 X_1 + \varepsilon$$

Where

Y = Sustainability of dairy goat projects

X<sub>1</sub> = Institutional Linkages

β<sub>0</sub>: = Constant term

ε = Error term

**Table 6: Results of linear regression analysis.**

Model Summary									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.179 <sup>a</sup>	.032	.027	.41548	.032	6.146	1	186	.014
ANOVA <sup>a</sup>									
Model	Sum of Squares		df	Mean Square	F	Sig.			
1	Regression	1.061	1	1.061	6.146	.014 <sup>b</sup>			
	Residual	32.108	186	.173					
	Total	33.169	187						
Coefficients									
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		
		B	Std. Error				Beta	Lower Bound	Upper Bound
1	(Constant)	2.896	.147		19.735	.000	2.607	3.186	
	Institutional linkages	.150	.060	.179	2.479	.014	.031	.269	
Dependent Variable: Sustainability of dairy goats									
Independent Variable: Institutional Linkages									
t = 2.479 at level of significance p=0.014<0.05, r = 0.179, R2 = 0.0320									

Table 6 shows that  $r = 0.179$ , implying a positive slope between the independent variable (Institutional linkages) and the dependent variable (Sustainability of dairy goat projects). The R-Squared was 0.032 meaning that 32% of the variation in the sustainability of dairy goat projects was explained by variation in the institutional linkages. The other factors explained 68%. The ANOVA results indicated that the model was statistically significant at  $F(1,186) = 6.146$

The results indicate that the  $p\text{-value} = 0.014 \leq 0.05$ ,  $t = 2.479$ ,  $r = 0.179$  and  $R\text{ squared} = 0.032$ . Overall F statistics was  $F(1,186) = 6.146$ , this shows that there exists a positive correlation and the slope of the population regression line is not zero. Since p-value of 0.014 is less than 0.05, the null hypothesis was rejected and concluded that there is a significant relationship between institutional linkages and the sustainability of dairy goat projects.

Using the statistical findings, the regression model

$$Y = \beta_0 + \beta_1 X_1 + \varepsilon$$

can then be substituted as follows;  $Y = 2.896 + 0.179 X_1$

The beta value implies that for a one-unit increase in institutional linkages, sustainability of dairy goat project increases by 0.179. This, therefore, confirms that institutional linkage has a significant influence on the sustainability of dairy goat projects. The null hypothesis was rejected and the alternative hypothesis that there is a significant relationship between institutional linkages and sustainability of dairy goat projects in Tharaka Nithi accepted. This finding confirms that the predictor indicators; linkage to health services, linkage to markets and social institutions linkages are important in dairy goat project sustainability.

The findings of the current study concur with a study done by DFID (2004) that found out that appropriate institutions and stakeholders that are committed to honoring dairy goat development activities need to be established prior to any intervention activity for continuity and flow. Likewise, the current study agrees with Ahuja (2000) that key actors play a crucial role in linking projects and providing channels for knowledge sharing. Finding of this study agrees with earlier studies like Villanueva et al (2016), Pali et al (2013) that functional social networks provide the necessary conduits for social learning to livestock producers, a situation that fastens adoption of technology. On market linkages, Peacock and Hastings (2011) that efforts by farmers to promote livestock production are affected by inaccessibility to crucial markets and Alemayu (2011) that dairy goat markets are dispersed with remote markets lacking price information.

#### **4.0 CONCLUSION**

Descriptive statistics indicate that respondents were neutral that institutional linkages have an influence on the sustainability of dairy goat projects. Further, inferential statistics showed a significant positive influence of institutional linkages on the sustainability of dairy goat projects. Therefore, it can be concluded that institutions play a key role in promoting the sustainability of dairy goat projects. Dairy goat projects are heavily dependent on credible health services, of high quality, affordable and accessible to the beneficiaries. The study concludes that the cost of veterinary services was high and services inadequate, slower emergency response rate and the existence of quacks in service provision was the major obstacles to sustainability. In addition, dairy goat projects are commercially based, therefore market information and sound marketing network are important. These fundamental aspects of project design were inadequate in the dairy goat project under study. As such, it can be recommended that stakeholders in the dairy goat sector need to design dairy goat projects that incorporate a mechanism for institutional linkages. This will ensure that reliable, acceptable and high-quality dairy goat health and extension services are guaranteed, dairy goat market dynamics are addressed and that dairy goat farmers are properly organized and appropriately linked together for peers to peer support.

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***In vitro* anticancer efficacy and safety of *Spermacoce princeae* (k. Schum.) Verdec (rutaceae) against prostate and breast cancer cell lines**

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Prostate and breast cancer are the leading cause of cancer related deaths in Kenya and various methods of mitigation are currently being explored to curb the menace. Ethnopharmacological approach is one of the preferred options in drug discovery for many diseases including cancer. Kenyan Traditional medical practitioners claim use of *Spermacoce princeae* cures cancer. This claim requires scientific backing and warrant validation. It is against this background that a study was done to determine *in vitro* anticancer activity and safety levels of *Spermacoce princeae* water and methanol extracts against human breast adenocarcinoma (HCC 1395 and 4T1), prostate cancer (DU-145) and vero cell lines. The study was conducted using MTT assay and data obtained was expressed as a mean  $\pm$  SEM of the three independent experiments. Data analysis was done by computation of IC<sub>50</sub> ( $\mu$ g/ml) for cancer cell lines and CC<sub>50</sub> ( $\mu$ g/ml) for vero cells using Graph Pad Prism Version 7. The results revealed that both the water and methanol extracts of *S. princeae* had moderate activity and the extracts were nontoxic to the vero cells. The IC<sub>50</sub>=344.67 $\pm$ 6.7 (SI=1.7) and IC<sub>50</sub>=530.0 $\pm$ 67.64 (SI=1.09) values were revealed by the water extract against DU-145 and 22rv1 prostate cancer cell lines respectively, the same extract demonstrated IC<sub>50</sub> values 940.33 $\pm$ 53.3 (SI=0.6) and 562.00 $\pm$ 10.00 SI=1.0 for breast cancer cell lines HCC 1395 and 4T1 respectively. The methanolic extract also showed activity against the same prostate and breast cancer cell lines with IC<sub>50</sub> values 151.67 $\pm$ 16.7 (SI=1.3) and 430.0 $\pm$ 67.64 (SI=0.6) against DU-145 and 22rv1 respectively and 533.0 $\pm$ 56.6 (SI=0.4) and 204.0 $\pm$ 6.6, SI=1.0 for HCC 1395 and 4T1 respectively. The *in vitro* anticancer activity is reported for the first time in this study and it probably support the ethnopharmacological use of *S. princeae* for management of prostate and breast cancer. This study reveals that all the extracts had CC<sub>50</sub>>  $\mu$ g/ml against normal cell line (vero cells) and were considered to be non-toxic.

**Key Words:** Antiproliferative, Cell lines, IC<sub>50</sub>, Ethnopharmacology and Selectivity index (SI)



## **Factors Affecting Food Selection and Nutritional Status of the Elderly in Mathare Slums, Nairobi Kenya**

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### **Abstract:**

**Background:** Aging is a process experienced by every living creature as they approach their predestined lifespan. It begins when growth and development begins to cease and it is a uniquely individual experience that is affected by many factors over which individuals have no control. This study was conducted to investigate factors that affect food selection, intake and the nutritional status of the elderly in Mathare slums of Nairobi Kenya. The major purpose of this study was to examine the psychological, physiological and socio-economic factors that influence food selection and buying practices among the aged in Mathare. The specific objectives for this study were: to determine the nutritional status of the elderly in Mathare slums; to determine the food preferences, satisfaction, dissatisfaction with foods available in the market for the elderly in Mathare slums.

**Methodology:** Data were collected using an interview, anthropometric measurements, and food frequency questionnaire. Data were analyzed using the statistical package for social sciences (SPSS) for frequencies and percentages. Anthropometric data were analyzed using BMI cut-off point of 18.5kg/m<sup>2</sup> for underweight and MUAC cut-off points of 22cm for women and 23cm for men.

**Results:** The study composed of 57 (63%) men and 33 (37%) women. The most represented age group was 55-59 years. Most respondents were married and had at least some primary education. Forty one percent of the respondents had 4-6 dependents on their income. The physiological factors that affected their food selection and intake were dental problems, loss of taste and appetite and chronic diseases and 90% of them reported loss of weight. The psychological factors that affected food choices were loneliness and bereavement. The socio-economic factors that had most influence on the respondents' choices were income, cost of food, place where the food was bought, the cooking facilities available and the means of transport to the market place. 87% were satisfied with the foods available in the market, though they expressed a need for some specific modifications like reduction of prices, providing variety and improving the standards of hygiene. The nutritional status of the elderly in Mathare was generally fair though 31% were underweight using BMI whereas 21% were malnourished using MUAC standards.

**Conclusion:** The factors that influence food selection among the elderly in Mathare include: The cost of the food, income, availability of money, means of transport and availability of familiar foods in the market place.

Key Words: Elderly, Food Selection, Nutritional Status,

## 1. INTRODUCTION

In most third world countries, some of the retired elderly return to their rural homes and some remain in the urban centres. 22% of the elderly people migrate to the urban centres to live with relatives in the trend of rural-urban migration (Kurua, 1995). The elderly in the rural areas do not have many socio-cultural and economic problems since the traditional norms of caring for the elderly, based on family systems, still prevail (Waswa, 1985).

However, in the urban centres, the elderly are likely to suffer the rapid sociocultural and economic changes and western influence. These changes affect the food choices and intake by the elderly. In the older people, food patterns reflect life-long attitudes and habits as influenced by the changing environment. These factors include psychological, physiological and socio-economic factors (Schlenker 1984).

The psychological factors that affect food selection and intake patterns among the aged include loneliness, bereavement, social isolation, food aversion, symbolism of food, food faddism and knowledge on nutrition (Schlenker 1984). Food taboos may also hinder or prohibit the elderly from choosing and eating particular foodstuffs.

The physiological changes that occur in the elderly bring about loss of appetite, loss of taste, dental problems, chronic diseases, prescribed diets, food intolerance, changes in state of health, physical disability and a degree of physical exercise reduction (Kithinji, 1988). Socio-economic factors also contribute to the changing food patterns of the elderly. These include age, sex, level of income, cooking facilities, daily schedule, retirement and leisure time, level of education, distance to food store/market, availability of transport and the availability of familiar foods (Schlenker 1984).

Nutritional adequacy, the outcome of optimum nutrient intake and utilization, is dependent on factors which determine the selection and intake of food supplying both essential nutrients and sufficient energy.

A study done by Rashmi, found out that the inability of the elderly to take decisions about food intake was (47.8%), lack of funds was (48.4%) lack of awareness (38.4%). Physical and financial dependency thus definitely influenced nutritional status (Rashmi, et al 2015)

This study sought to address the nutritional issues related to aging and the interrelationship between food selection and nutritional status of the elderly.

The majority of the elderly have been neglected especially by their family members who do not meet their obligations towards them. This could be due to increased educational levels among people and the awareness of the rapidly changing traditional values due to westernization, modernization and individualism. This in turn has led to people migrating from rural areas to settle in urban areas where jobs are likely to be available. According to (Kithinji,1988), after retiring, many people fail to fit into their local communities. This leads to people settling in the urban areas after retiring. Because of reduced income due to retirement they resort to living in areas which have cheap housing, such as slum areas. Due to the disintegration of the extended family and the system obligations for interdependence, there is an emergence of poor and destitute elderly in urban areas (Waswa,1985).

For many years nutritional assessment and other primary health care components in Kenya have been directed to maternal and child health care. However, some other vulnerable groups such as the elderly in the population that are at risk in terms of nutritional deficiencies have received little attention.

*HIV/AIDS* on the other hand, will continue to have a huge impact on elderly people. Like any other population group, they might get infected with HIV, but current education campaigns do not target them. As more people from the working class die, older people are robbed of their main sources of support.

Because the majority of those that die come from the younger generation, older people are left to fend for themselves and take care of an increasing number of orphans. This happens when, in most cases, they have disposed of their wealth in an effort to care for their dying children (Chernoff, 1991)

This study was undertaken because conditions of the older people justify an investigation into factors that affect how they select their foods and how this in turn affects their nutritional status. Since food selection and intake impact on nutritional status, factors influencing food selection and intake have a role in determining nutritional risk within a particular population.

The major purpose of this study was to examine the psychological, physiological and socio-economic factors that influence food selection and buying practices among the aged in Mathare. The study also assessed the nutritional status of the elderly. Specifically, the study sought to achieve the following objectives: to determine the nutritional status of the elderly in Mathare slums; to determine the food preferences, satisfaction/dissatisfaction with foods available in the market for the elderly in Mathare slums and to determine the factors that influence food selection among the elderly in Mathare slums.

## **2. METHODOLOGY:**

A descriptive survey design was used in this study to determine the food selection and the nutritional status and the satisfaction or dissatisfaction with consumption patterns.

The study area was Mathare slums - both Mathare North and Mathare Valley were covered in the study. Mathare is the oldest slum in Nairobi and it has diverse ethnic groups living there. There are also people of different socioeconomic backgrounds and therefore it provided a fertile ground for this study.

The researcher obtained a list of elderly people (55 years and above) living in Mathare slums from the area Chief. This formed the sampling frame. The researcher then divided Mathare slums into 3 clusters using the existing divisions (areas 1, 2, 3 and 4). Systematic sampling was used to obtain 90 elderly people who comprised the sample size.

Data were collected using an interview schedule because the elderly have various literacy problems for example poor eyesight, illiteracy and language problems (HelpAge, 2000). Where necessary, the instrument was translated to Kiswahili. Where Kiswahili was not understood, a trained interpreter was used. Anthropometric measurements were taken, that is MUAC, weight and height. MUAC tape, bathroom scale, and stadiometer were used to collect anthropometric data.

Pre-testing was done in Korogocho slums on 10 elderly people to check the reliability and validity of the instruments. In case of any bias and flaws, the interview schedule and observation guide were modified for more clarity and accuracy.

Both qualitative and quantitative data were collected for the study. Data cleaning was done. Common themes were obtained from the data collected and clustered in a patterned order as addressed by the objectives so as to identify variables that depict general concepts. Inferences and conclusions were then drawn from the findings.

Quantitative data was analyzed using the SPSS (statistical package for social sciences). Descriptive statistics was used because it allows for meaningful description of a distribution of scores or measurements using a few indices or statistics<sup>7</sup>.

Frequencies, percentages and tables were used to present results.

Anthropometric data was analyzed and using the body mass index (BMI) cut off points, individuals were classified as severely obese, obese, normal, undernourished or severely undernourished. The BMI cut-off points given below were used to classify the individuals according to their Nutritional Status.

BMI cut-off points for classification of Nutritional Status BMI (kg/m<sup>2</sup>)

<16 severely malnourished

16-18.5 Borderline

18.5-24.5 Normal/adequate nutrition

25-29.5 Plump/Obese 1

30-39.5 Obese 2

>40 Severely Obese

**Source:** Ismail and Manandhar, (1999).

MUAC cut-off points of 23cm for men and 22cm for women<sup>8</sup> were used to assess the nutritional status of the respondents.

### **3. RESULTS and DISCUSSIONS**

Out of the 90 interviewed respondents 57 (63%) were males and 33 (37%) were females. 59% of the respondents fell within 55-59 years of age. Only 6% fell in the group of 75 and above.

Fifty nine percent of the respondents in the sample were married, 7% were single while 11% were separated. Twenty two percent were widowed and most of these were women. Only one person was widowed and remarried. Marital status does influence one's food choices and therefore intake. Single persons' food selection and consumption will differ from those of married couples because they can sometimes be lonely or just lack the motivation to prepare foods.

Fifty percent had primary education, 39% had no formal education; a majority of these being women, while 11% had secondary school education. Because this was a slum area, most people were of low educational level and therefore low income and sought cheaper housing in the slums. The educational level of an individual is normally associated with improved food consumption. However, this relationship is not always linear, because adequate food intake rarely results from knowledge alone. Normally, it is assumed that education enables one to get a good job and consequently the ability to afford most foodstuffs. However, this is not always the case because a number of educated people do not get jobs.

Four percent of the respondents had no dependents, 41% had 4-6 dependents, 29% had 7-9 dependents while 6% had more than 14 dependents. There was a case of a herbalist, aged 80, who had 53 dependents and 13 wives. A large number of dependents may not allow one to choose good quality foods especially if the income is low.

Twenty eight percent of the respondents were skilled workers and they used to do various types of work like masonry, carpentry and painting. Nineteen percent were unskilled doing odd jobs and especially manual work. Seven percent were housewives before coming to Mathare, 7% used to be security men whereas 6% were farmers. Twenty six percent were doing small business whereas 6% were professional workers.

Thirty three percent were earning their living from business. Most of these did odd businesses ranging from selling charcoal and firewood to selling cooked food on the streets outside their houses. Fourteen percent were security men, 12% homemakers while 10% were taking care of grandchildren. The occupation of an individual is believed to influence his/her food choices. Individuals with better paying jobs are expected to select

and consume better quality foods which are normally more expensive as compared to poor quality foods.

Seventy percent of the respondents bought food for themselves, 12% bought and were given by their children and friends and 9% solely depended on help from their children and friends. Three percent were given food by the church, the hospital and social groups while 4% were supported by these well-wishers.

Only two people were supplied with food from their farms upcountry.

Seventy three percent bought or were given food when money was available, 18% bought food when it was necessary while 6% bought food occasionally. Only one respondent used to stock food and others bought or were given food when money was available and the food was needed. The majority bought food for a meal depending on the money available. According to some of them they sometimes went hungry when there was no money.

Forty nine percent of the respondents bought food from the open-air markets within the slums, 20% bought from people selling foods from house to house and 6% bought food from the supermarkets. Seventeen percent got their food from both the open-air markets and the supermarkets whereas 7% bought from both open-air and people selling foods. This is because most foods were available locally in the open-air markets and they have fair prices than those sold in the supermarkets. Three percent never bought food because they depended wholly on well-wishers and therefore did not know the place where the food was bought from.

Fifty eight percent of the respondents did not buy food according to their preferences whereas 34% bought according to their preferences. The main reason given for not buying the desired food was lack of money. Some gave reasons like dental problems therefore making them unable to eat what they may desire. Eight percent of the people did not buy food for themselves and therefore did not have much of a choice.

Thirty eight percent of the respondents preferred to eat cereals and vegetables mainly because they are cheap. Sixteen percent preferred cereals and animal foods while 22% preferred vegetables, cereals and animal foods. Convenience foods were preferred by only 5% of the respondents. This could probably be because convenience foods are expensive. A food frequency questionnaire completed at the sisters of Tharbes project in Kibera by HelpAge International showed that plant sources formed the greater part of the elderly's diet, cereals being the main sources of their diet (Helpage, 2000). Fruit consumption was low and that low income was an impediment to proper nutrition.

It also revealed that food preferences were not met and that due to poverty, there were other competing needs for the limited income.

68% of the elderly experienced loss of appetite, 72% had taste and dental problems, which may make them, not choose and consume some particular food items. Thirty three percent of the respondents had physical disability while 67% did not have. This can be attributed to the fact that most of them fell under the 55-59 age category and therefore still strong to get their own foods.

Fifty two percent had chronic diseases while 48% did not have any diseases except occasional bouts of malaria, which is common in Kenya. Sixty two percent of the respondents complained of backache; a common problem in old age, and stomachache. A few had diabetes. There was one case with Tuberculosis and one case with liver problems. Some had swollen legs and arms.

Others had eye problems and earache. One respondent had a blocked bladder. The presence of chronic diseases, sometimes more than one at a time, can call for modified



diets as well as one's energy to perform daily routines. Modified diets are often expensive and difficult to follow, especially if the person does not fully comprehend the situation. Many people experience discomfort with the ingestion of certain foods. This discomfort may be biophysically based, but more often its cause is psychological factors (Ismail and Manandhar, 1999).

Bereavement affected 30% of the respondents while 70% were not affected. This could be due to the fact that only 22% were widowed. Majority of the respondents fell in the age group of 55-59 years and most of them had not lost their spouses and many of their children. The adjustment to loss of one's mate is difficult and can be the source of major dietary stress. Aside from the financial and management problems related to the loss of mate, the loss of companionship can seriously affect one's motivation to shop, cook, eat, remain active, or in some cases go on living. This loss of a companion may reduce physical activity or social participation that had previously diverted attention from many of the problems associated with old age.

### **Income**

Income is a primary factor in determining diet at any age. Income *is* greatly reduced in old age. Many elderly shoppers cannot buy food on the basis of past food habits or optimal nutrition because of lack of buying power.

Expenditures for food must compete with other necessary expenditures such as rent and utilities. Thus, there may be a tendency for the elderly person to purchase cheaper foods higher in carbohydrates rather than the more expensive, protective foods such as meat, fruit and vegetables (Kart & Manard, 1981).

Thirty three percent got a monthly income of a thousand and below whereas 30% got between 1001-2000. Twenty one percent got between 2001-3000, 4% got 3001-4000 while 11% got 4000 and above. One respondent did not have any source of income at all and relied on handouts.

An analysis of the relationship of financial dependency with nutritional status revealed a significant association. The intake of food is determined by the purchasing power, and moreover a person can be decisive about food intake if he or she is financially independent (Rashmi, et.al 2015).

### **Cooking Facilities**

The cooking facilities available may affect the type of food one chooses depending on the fuel one uses. For instance one may want to bake but due to lack of an oven one may not consume what one wants to. Some of the respondents expressed a liking for Githeri (boiled Maize and beans) but because of lack of fuel they could not consume it and, therefore, had to choose another type of food that cooks faster and uses less fuel. Lack of adequate cooking facilities may be a problem for those living in many kinds of low-cost housing.

Most respondents (42%) were using kerosene stoves only probably because they are faster and convenient as compared to charcoal because most of the elderly work late into the evening, while 17% combined charcoal and kerosene due to the cost. Charcoal was much cheaper than kerosene and the respondents preferred using it especially when cooking foods that take long to cook. Twenty one percent were using charcoal, kerosene and firewood, when there was no money to buy the more expensive kerosene and charcoal, while 10% used firewood only because it is much cheaper and it is locally available from the nearby Karura forest. Six percent used charcoal only whereas 4% combined charcoal and wood. Nobody was using gas or electricity to cook though some of them were living in houses with electricity. They were using whatever was available at

a particular time and not just sticking to one specific fuel save for those with a regular income.

### **Nutritional Status**

Nutritional status was assessed using MUAC and Body Mass Index (BMI). Anthropometry was conducted for height, weight, and MUAC. MUAC can be used as a quick method for nutritional screening in emergencies. Using MUAC cut-off points of 22 cm for women and 23 cm for men, 80% of the respondents were classified as normal whereas 20% were classified as malnourished.

A study done by Chilima (1998) in rural Malawi showed that 20.4% of the men and 10.0% of the women were malnourished. Another study done by Tesfaye, et. al. (2000) in Central Ethiopia showed that 35.7% of the elderly are malnourished.

**Body Mass Index:** BMI is calculated by dividing the weight in kilos by the height in square metres ( $\text{kg}/\text{m}^2$ ). Using the categories given by Ismail and Manandhar (1999), 6.7% were severely malnourished while 24.4% were on the borderline. Using  $18.5 \text{ kg}/\text{m}^2$  as the cut-off point for underweight, 31% of the respondents were malnourished or were underweight, 50% were normal or had adequate nutrition, 13.3% were plump/obese 1, whereas 5.6% were classified as obese 2.

In study done in rural Tamil Nadu, Vedantam et al. (2010) found that 14% of the elderly were malnourished.

## **4. CONCLUSIONS AND RECOMMENDATIONS**

The following conclusions can be made about the elderly in Mathare slums:

1. The elderly preferred to buy cereals and vegetables mainly because they are cheap as compared to animal foods. They were satisfied with foods available in the market.
2. The factors that influence food selection among the elderly in Mathare include: The cost of the food, income, availability of money, means of transport and availability of familiar foods in the market.
3. The elderly in Mathare can be said to be of good nutritional status. Using MUAC, 20% were malnourished whereas using BMI, 31% were malnourished.

Elderly people especially those living in slum areas should improve on their food selection. For them to do so there is a need for organizations to create jobs and give elderly people pension so as to raise their monthly income. Only then will they manage to meet the rising cost of foodstuffs. Having an occupation and also being able to carry out income generating activities may ensure that the body is kept active which is key to maintaining functional ability. On the other hand, if older people rely on other relatives for income, they may reduce their own activity and hence their nutrient intake and functional ability may dwindle overtime.

This study had some limitations. No assessment of biochemical parameters of nutritional status and hemoglobin were done because of constraints of resources. It was also not possible to look into morbidities which might affect nutritional status.

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## **Role of Horticulture Therapy in Mental Health and Stress Management**

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Horticulture therapy is generating popularity and its value is convincing. Its role in mental health and stress management cannot be overemphasized. Unlike the conventional mental health medication models which isolate patients in private corners, horticulture therapy engages patients actively in animal and plant care. This provides them with an opportunity to nurture mental health while significantly contributing to community development. This farm work undertaken during horticulture therapy involves strenuous physical exercise which offsets emotional trauma, provides an intervention for cerebral palsy, schizophrenia, musculoskeletal pain and an improved ability to cope with chronic pain (Verra et al, 2012). Despite the significant contribution of horticulture therapy, a number of challenges exist. These include limited knowledge concerning use and benefits of this therapy, limited land available for gardening and low productivity. Studies have been conducted to expound on the role and effectiveness of horticultural therapy, however a knowledge gap still lies on how horticulture productivity can be stimulated. The present study therefore assessed factors influencing technical efficiencies of Open Field tomato production among small scale farmers in Kiambu. A multistage sampling technique was used to draw a sample of 120 respondents who participated in the study. A two stage analysis using a Cobb Douglas stochastic frontier analysis and a Tobit regression was used to compute the mean technical efficiency and determine factors influencing technical efficiency respectively. Results indicated a mean technical efficiency of 65.5% ranging from 24% to 95%. Education, family size and Experience positively influenced technical efficiency while gender and farm size had a negative significant influence. The study recommends that the government and other responsible bodies should invest more in farmer education through organizing agricultural trainings so as to enhance their education and experience. Also all inputs used positively influenced efficiency therefore the study recommends that the government should put in place policies which enable farmers acquire such needed inputs at affordable prices. This may be through subsidization of inputs and creating room for private distribution of these inputs.

**Key Words: Technical Efficiency, Horticulture therapy, Emotional trauma, mental health**

## AST

### **Factors Hindering the Implementation Of Permaculture By Farmers In Tharaka-Nithi County, Eastern Region-Kenya, East Africa**

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#### **Abstract**

The overall aim of the study was to establish the factors hindering the implementation of permaculture by farmers in Tharaka Nithi County. Permaculture, which is described as working with, rather than against nature in agriculture; involves thoughtful observation rather than thoughtless labour; and looking at plants and animals in all their functions. Unlike the commonly practiced conventional agriculture, permaculture has the potential of contributing to the attainment of the sustainable development goals, arresting climate change and contributing to food security. The paper explains the basis of permaculture which are organic farming and organic ways of maintaining animals. It further enumerates the three basic ethics of permaculture namely: care for the earth, care for the people and fair share. It was established that land ownership, sex, age, grazing method and government policy influence implementation of permaculture. The methods used during research were observation, literature review and face to face interviews. Other findings were that promotion of sale of subsidised fertilizer by the government, insufficient training of agricultural extension officers on permaculture and promotion of agro chemicals was a hindrance to permaculture. Some of the recommendations contained in the paper are, training agriculture extensionist and farmers on permaculture, enacting and implementing policies promoting permaculture, Both men and women should be given equal decision making powers on agricultural practices and land use. Finally, the government should take a leading role in promoting permaculture. In conclusion, since there is need to promote permaculture as a major contributor to ecological balance and sustainable development, there is need to address all the hindrances to use of permaculture.

Keywords: Permaculture, Agro-Ecology, Sustainable Agriculture, Gender, Agro Chemicals and Sustainable Development.

#### **1. INTRODUCTION**

The main objective of the research was to establish the factors hindering the implementation of permaculture in Tharaka Nithi County. The specific objectives were: To establish whether uncontrolled system of grazing, slash and burn system of land preparation, land ownership, Age, sex and government policies influence the use of permaculture.

Food security has been threatened by climate change, use of inappropriate agricultural systems and soil infertility. Now than ever before, there is need for the world to agree on a common farming system that can solve the global food shortages in an environmentally friendly manner. Based on the sustainable development goals principal of leave no one behind, both men and women, the youth, people living with disabilities, the elderly and all other categories should be involved in adopting and applying farming systems that best suit the environment and respond to nutritional needs of all.

In the world, there are many people living in extreme hunger. Food and Agriculture Organisation (2016:1) states that hunger in the world is increasing with a hooping 777 million people without food in 2015 and 815 million in a similar condition in the year 2016. Severe hunger affected some parts of Sub Saharan Africa, South Western and Eastern Asia.

Deutsche welthungerhilfe e.v, International Food Policy Research Institute and concern Worldwide (2017:2) argue that in the year 2017 global hunger index indicated that hunger increased in fifty one countries and that the condition was worsened by various forms of inequalities.

This report is an indicator that solutions to hunger should be sought as the only way the sustainable development goal number one and two can be achieved. Among others, proper farming systems should be utilized in order to maximize food production.

The researcher concurs with the two authors. This is because even in Tharaka Nithi County there are many people who are depedent on relief food. This may be as a result of use of conventional agriculture among many farmers.

Many farmers in the world practice conventional agriculture. Appropedia (2018:1) defines Conventional farming, also known as industrial agriculture, “as farming systems which include the use of synthetic chemical fertilizers, pesticides, herbicides and other continual inputs, genetically modified organisms, Concentrated Animal Feeding Operations, heavy irrigation, intensive tillage, or concentrated monoculture production. Thus conventional agriculture is typically highly resource and energy intensive, but also highly productive. Despite its name, conventional agricultural methods have only been in development since the late Nineteenth Century, and did not become widespread until after World War 2. Conventional farming is usually contrasted to organic farming (or sometimes sustainable agriculture or permaculture), as these respond to site-specific conditions by integrating cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity. Rather than using synthetic fertilizers, pesticides, growth regulators and livestock feed additives, organic farming systems rely on crop rotation, animal and plant manures as fertilizers, some hand weeding and biological pest control. Some conventional agriculture operations may include limited poly-culture, or some form of Integrated Pest Management”.

Permaculture appears to be a new concept for many farmers generally and in Tharaka Nithi County. Although a few old people practice it, they do so in line with traditional practices without knowing that they are practicing this system of agriculture. Permaculture may be the panacea to climate change, food insecurity and desertification.

Wikipedia (2017) defines Permaculture as a system of agricultural and social design principles centered around simulating or directly utilizing the patterns and features observed in natural ecosystems”.

According to the same source, permaculture was coined in Australia in 1978 by Bill Mollison and David Holmgren who were from Tasmania Australia. They studied and advocated for utilization of the intellect of nature in the farming systems. It has grown into an international movement. It is made up of traditional practices and scientific knowledge and ideas of practices that have endured the test of time. The proponents of permaculture support it as a solution to hunger. Despite the many benefits associated with it, it is not as widely practiced as it should. Instead, conventional agriculture is practiced.

It is true that permaculture ensures mimicking of nature and respecting the natural ecosystem. Some people argue that it is farming the “GOD’s” way. However there are some writers who are against relating spirituality to this method of farming since not all people are religious.

According to the same source, Permaculture is all about working with instead of working against nature in agriculture. It takes into consideration the wellbeing of the earth, the people and ensures fairness in exploitation of resources.

Gardenerdy (2018:1) describes permaculture as an agricultural system which follows the natural cycle of the ecological system, to produce agricultural goods in a way that the agricultural productivity as well as sustainability is maintained.

Wikipedia (2016) explains that Permaculture mimics nature by following the patterns and features observed in natural ecosystems. The word permaculture refers to permanent agriculture or permanent culture.

Greenblott (2012:2) states that permaculture nurtures diversity in the ecosystem. Diversity is the best way to ensure nutritional security and ensures food availability since the different food are harvested in different times in the year. This is different from mono-cropping. Permaculture also encourages layering of trees and plants into canopies. The layers are basically made up of [understory](#), [ground cover](#), [soil](#), [fungi](#), insects, and animals.

The principles of permaculture as given by Mollison in permaculture Wikipedia are: Observe and interact, Catch and store energy, Obtain a yield, Apply self-regulation and accept feedback, Use and value [renewable](#) resources and services Produce no waste, Design from patterns to details, Integrate rather than segregate, Use small and slow solutions, Use and value diversity, Use edges and value the marginal, Creatively use and respond to change.

According to percific edge (2007:10) The knowledge of permaculture brought to the lime light the need to care for the physical and cultural environment and it gave rise to the world’s first green political party called the United Tasmanian Group in 1972. It later became the Tasmanian Greens . Permaculture made its first appearance on the world stage in 1976 in an article in *Tasmania’s Organic Farmer and Gardener* newsletter published by the Tasmanian Organic Gardening and Farming Society. It was titled *A Permaculture System for Southern Australian Conditions – Part One* and was written by Bill Mollison and David Holmgren.

In Kenya, there are some individuals and organizations that have been promoting permaculture. For example according to permaculturemag.org(2016) on permaculture in Kenya, Moses Omukunda is a trained mason and permaculture designer who has been doing research in the community and understands the many ways that permaculture can help regenerate the agricultural system and environment, while helping support a more fair and equitable social setting in Western Kenya. Other players in this area are: Permaculture research institute, Laikipia Permaculture centre and Kangemi slums permaculture project.

The sustainable development goal on zero hunger can only be achieved if appropriate agricultural methods are applied in order to maximize food production without causing any harm to the earth or the people. According to Holtz (2017:7) global hunger levels have declined more than a quarter since the year 2000 but the progress has been uneven. Famine, conflict and climate change continue to hit the poorest hardest. The International Food Policy Institute Global Hunger Publication indicate that there are long term obstacles to reducing hunger threatening attainment of the goal of zero hunger.

Peeters (2011:423) explains that Permaculture design is a proactive and creative response to the need to change our world for the betterment of the nonliving and living things on it. Therefore, permaculture will only make sense if we start implementing it in the human sphere and apply it to our fields of interaction with other living and nonliving things. Even animals learn how to use simple tools or manipulate nature to get things done. From a permaculture point of view, the goal is to use as little energy as possible to get things done.

Permaculture has three ethical considerations namely care for the earth, care for the people and fair share. [According](#) to Wikipedia (2016) Permaculture puts great importance on taking care of people.

Greenblott (2012:2) quotes Mollison who states that “Permaculture is the conscious design and maintenance of agriculturally productive ecosystems which have the diversity, stability, and resilience of natural ecosystems.”

Syano (2015:5) Some of the factors limiting use of permaculture are: government policy, ignorance among extension workers, over grazing and inadequate awareness among community members.

The research concurs with Syano because lack of promotive policies, knowledge among extension workers and farmers may lead to limited adoption of permaculture.

Gardner staff (2018:1) highlights benefits of permaculture as reduced Cost, less waste, chemical resistance, reduced pollution, developing community values, encouraging zoning, promoting self-reliance and diversity, promoting green living, helpful in improving environmental conditions, applicability in already functioning systems and last and not least, permaculture is good in maintaining ecological systems.

According to the same source, there is need for democratic governance of national food systems, broadening participation in international food policy debates, guaranteeing rights and space for civil society, protecting citizens and ensuring standards in business

and trade, analyzing power to make better policies, increasing support for small scale food producers, advancing equality through education and social safety nets, holding governments accountable with timely data, investing in the sustainable development goals and those left behind.

Eco-conquest (2016:ix) states that There has been increasing severity of arid and semiarid conditions in some parts Tharaka Nithi County over the past decade. This has resulted to the diminishing of ecosystem based livelihood support systems and reduced resilience to Climate Change shocks. This means that the sustainable supply of ecosystem goods and services is no longer assured because the ecological integrity of the ecosystem has been negatively affected by Climate Change impacts and poor land and resource management practices.

Ecological integrity is the core to sustainable supply of ecosystem goods and services. This integrity is assured when the interactions of nature and man remain within a given threshold that ensures ecosystem functionality that is characterized by the interactions of biogeochemical cycles. The cycles include water cycle, nutrients cycle, food chains and food webs and transfer of energy through the trophic levels of primary producers, secondary producers and tertiary consumers. This is the basis of an ecosystem as a source of livelihoods and well-being. The Sustainable Development Goals (SDGs) strives to link ecosystems with the demands that people make from the environment. Looking keenly permaculture is can contribute immensely in the attainment of sustainable development goals namely: No poverty, No hunger, Wellbeing and good health, Education for all, Gender equality, Clean water and sanitation, Affordable and clean energy, Decent work and economic growth, Industry, innovation and infrastructure, Reduce inequalities, Sustainable cities and communities, Responsible consumption and production, Climate action, Life below water, Life on land, Peace, justice and strong institutions and Partnerships for goals.

Permaculture directly contributes to goals numbers goals number 1, 2, 3, 6, 7, 11, 12, 13, 14 and 15.

A combination of climate-related hazards and poor land and resource management practices that reduces ecosystem resilience remains a serious threat to development in Kenya where over 75% of households rely on subsistence farming. Over the past two decades droughts have become more severe and frequent, having a negative effect on all rural households and especially those in the arid and semi-arid lands.

Unfortunately, Permaculture has not been embraced in many parts of the world. The conventional agricultural practices promote commercial agriculture that emphasizes use of agro-chemicals, mono culture, fertilizers, deforestation and general practices that interfere with the natural eco-systems.

In her thesis Abigail (2014:1) states that farmers who use permaculture realize agricultural, environmental, livelihood and food security benefits than farmers who use conventional methods.

In the most recent 12<sup>th</sup> International conference on Community Based Adaptation to climate change held in Lilongwe-Malawi as from 11<sup>th</sup> to 14<sup>th</sup> June, 2018 organized by International Institute for Environment Development in partnership with global resilience partnership, Practical action, United Nations Development Programme, Irish

Aid, The International Development Research Centre, Climate Justice Resilience Fund, the government of Malawi and United Nations Framework Convention on Climate Change. With the theme “local experience driving climate action.” Permaculture was highlighted as a climate change adaptation strategy by one of the participants who works for Trocaire.

Although there are few recent authors in the area of permaculture, all the writers quoted above have built a strong case in support of permaculture. They clearly present it as a better option compared to the conventional agriculture. Looking at government policies both at the national and county levels, there is no policy framework for the adoption of permaculture. Agricultural extension officers are also not well equipped to promote permaculture. The curriculum at all levels of education in Kenya has no mention of this system of agriculture that seems to be a solution to food shortages, land degradation and climate change.

## **METHODS**

This research was done using sample survey design. The sampling method used was systematic sampling. This entailed dividing the total number of the 1000 farmers being targeted for a resilience building project by the 100 desired sample size. Using this method from the 1<sup>st</sup> unit, every tenth unit was picked.

### **2.1 RESEARCH DESIGN**

This study will adopt the convergent parallel design (also referred to as the convergent design). Convergent design is where the researcher uses concurrent timing to implement the quantitative and qualitative strands during the same phase of the research process, prioritizes the methods equally, and keeps the strands independent during analysis and then mixes the results during the overall interpretation (Creswell & Plano Clark, 2011). This design was appropriate for this study because it enabled the researcher to collect both quantitative and qualitative data concurrently. The design was also chosen because it allowed concurrent quantitative and qualitative analysis of data collected and merging the two sets of results and report on the factors hindering implementation of permaculture.

### **2.2 STUDY SITE/LOCATION OF THE STUDY**

Located in the former Eastern province, Tharaka Nithi County borders three Counties; Meru County to the North and North East, Kitui County to the East and Embu County to the South and South West. The County has an area of about 2,838.8 square kilometres. The Population of Tharaka Nithi County is estimated to be 365,330 persons according to the results of the 2009 National Population Census. Tharaka Nithi County has vibrant ecosystems ranging from a major mountain, rivers, hills, arable lands, fertile soils, wildlife, forests, diverse geological resources all of which offer opportunities for economic, social and cultural development. However, due to the increasing severity of arid and semiarid conditions over the past decade, the ecosystem based livelihood support



systems have been diminishing the resilience to climate change shocks. Efforts have been directed to developing coping mechanisms to boost that diminishing resilience

### **. 2.3 TARGET POPULATION**

The target population were peasant farmers in the semi arid Tharaka North and Tharaka South.. A sample frame of one thousand farmers was developed.

### **2.4 SAMPLE SIZE AND SAMPLING TECHNIQUES**

The sampling design employed was systematic sampling. The researcher used a beneficiaries' register of one of the leading social development services organization working on farmers' resilience building. Systematic random sampling was used, from the identified women and men groups in the farmers' register, a sampling frame was developed and a calculation done to arrive at the sample size. The desired sample size was 100 hence the one thousand was divided by 10. Therefore from the first farmer in the list, every tenth farmer was picked as a respondent.

### **2.5 DATA COLLECTION INSTRUMENTS/TOOLS**

The data collection tools used were questionnaires for key informants, interview schedules for the farmers and observation.

### **2.6 VALIDITY OF THE INSTRUMENTS**

A pilot study was conducted to identify items in the questionnaire and interview schedules that may be ambiguous or unclear to the respondents and change them effectively. Assistance was sought from the supervisor in order to help improve content validity of the instruments.

### **2.7 RELIABILITY OF THE INSTRUMENTS/CONSISTENCY**

The Spearman's Co-efficient of Correlation was used to determine the reliability of the questionnaires.

### **2.8 PILOT STUDY**

A pilot study was carried out at the researcher's home sub-County (buuri) in Meru County. The pilot study assisted in testing the reliability of the tools of data collection.

### **2.9 DATA MANAGEMENT AND ETHICAL CONSIDERATIONS**

For the purpose of the research, data was managed properly and ethical considerations maintained.

Informed consent was sought from the respondents. Measures of ensuring confidentiality were put in place; anonymity of the respondents was respected. Moreover, safety of the respondents was given utmost priority.

#### 4. RESULTS AND DISCUSSION

It was established that uncontrolled system of grazing, slash and burn system of land preparation, land size and land tenure system, overstocking, Age, level of education, sex and government policies influence the use of permaculture.

The participants were asked to describe grazing method during dry seasons. Table 4.1 below shows the results:

Table 1: Respondents practicing permaculture

Responses	frequency	Percentage (%)
YES	60	60
NO	40	40
total	100	100

Table 1 above shows that 60(60%) practice permaculture while 40(40%) do not. Those who practice it explained that they started as from the past two years due to influence of a project being implemented in their area by a faith based organization called Caritas Meru. Those who do not practice it explained that it takes time for reasonable yields to be acquired and that they are not yet convinced that it is an appropriate system. They also disclosed to the researcher that the agricultural extension officers were training them on the use of fertilizer as way of enhancing soil fertility and use of agro chemicals to eliminate pests, especially the fall worms that were prevalent in the area.

Those who practice permaculture explained that the reason they embrace the systems is that they are convinced that in the long run, it will increase their food production by increasing soil fertility and improving the climatic conditions.

Table 2 below summarises the sex of those who practice permaculture

Table 2: Sex of respondents' practicing permaculture

Sex	Frequency	Percentage (%)
Male	40	66.7

Female	20	33.3
Total	60	100

Table 2 above shows that out of the 60 respondents' practicing permaculture, 40 (66.7%) were males while 20 (33.3%) were females.

These finds indicate that although majority of those attending permaculture trainings within the area are women, more men were actually implementing it. When the women were probed on the reason many of them were practicing it, they explained that their husbands or male relatives make decisions regarding land usage.

The findings are a clear indication of power inequalities as far as land ownership and control is concerned.

A question was asked to determine land ownership. Table 4 summarises the results

Table 3: Land ownership

Land ownership	Frequency	Percentage (%)
Men	98	98
women	2	2
total	100	100

According to table 3 above, Out of the one hundred respondents, only 2(2%) indicated that women owned land whereas 98(98%) said that land belonged to men.

Land ownership, control and access has a significant influence on decisions regarding usage. Since land is generally owned by men, most of the time they have control over how the same can be used. Therefore, it is mainly men who can dictate the agricultural system and the crops to be planted. Women have access but most of the time they cant decide on usage.

Figure 1: Use of permaculture by age

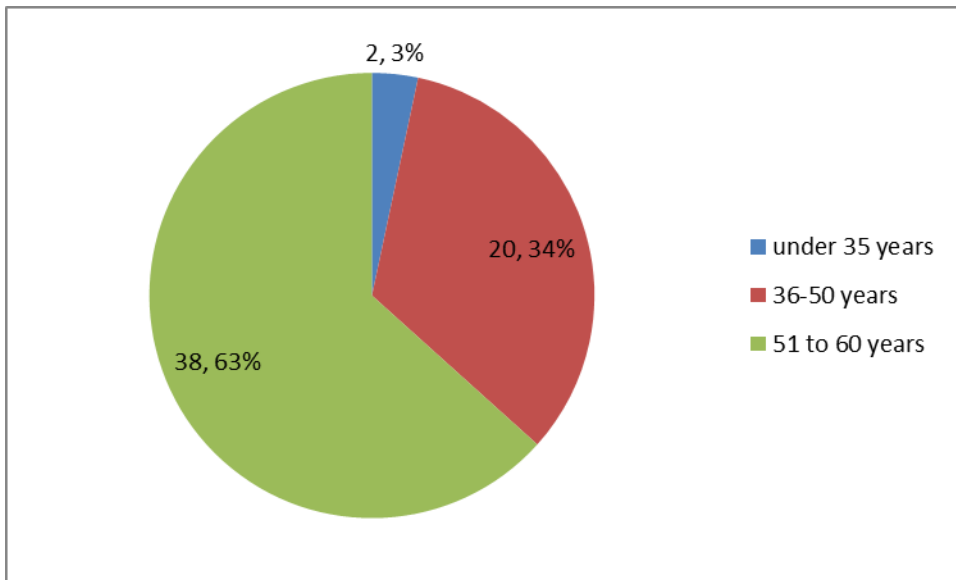


Figure 1 above shows that 2(3%) of the respondents practicing permaculture were under 35 years of age, while 20(34%) were between 36 to fifty years while 38(63%) were aged between 50 to 60 years.

These findings insinuate that the most elderly respondents had accepted to adopt permaculture. Those most elderly respondents explained that the reason they embraced the systems is that it is close to what they had witnessed their parents and grand parents were practicing in the past. This shows that the elderly can be used as promoters of permaculture.

**Table 4: Respondents' grazing methods**

Method of grazing	Frequency	Percentage (%)
Tethering	43	43%
Free range	57	57%
Zero grazing	0	0
total	100	100

Table 4 above shows that 43 (43%) of farmers described the grazing method to be tethering, while 57 (57%) indicated that they practice free range grazing, while none practiced zero grazing. The respondents explained that during dry seasons, cattle, goats, sheep and donkeys are left to roam all over, sometimes causing destructions.

Free range method of grazing may interfere with permaculture because the livestock may destroy trees or other perennial crops. There are usually many conflicts emanating from this uncontrolled method of grazing. Another consequence of uncontrolled grazing is that it makes it hard for the farmers to collect and use manure.

A question was posed to the respondents to establish land preparation methods used by the respondents. Table 6 below summarises the findings.

Table 5 Land preparation method

Land preparation method	Frequency	percentage
Slash and burn	19	19
Tractor	20	20
Manual	61	61
Total	100	100

According to table 5 above, 19 (19%) of the respondents use slash and burn method, 20(20%) use tractors while 61(61%) use manual method of land preparation.

Slash and burn method of land preparation is destructive since it interferes with natural regeneration. It also contributes to death of both micro and macro organisms. Use of tractors may also interfere with permaculture.

A question was posed to three agricultural officers regarding whether they were taught permaculture in school. The three of them answered to the negative. This implies that the government extension officers have limited knowledge and skill on permaculture. This may explain the reason few farmers practice the system.

Three lecturers in tertiary level of education and three teachers in secondary schools were interviewed. They all explained that permaculture does not form part of the curriculum. Therefore majority of agricultural extension officers have not been trained on this agricultural system.

One of the other finding was promotion of sale of subsidised fertilizer by the government and promotion of agro chemicals was a hindrance to permaculture. It was also established that the national and the county government has been in a spree to give subsidized artificial fertilizer within the county. For example Tharaka Nithi County indicates in its webpage: <https://tharakanithi.go.ke/agriculture-water-irrigation-livestock-and-fisheries/> it distributed to farmers 3,922 (25kg) bags of fertilizer, 2,390 (50kg) bags of agricultural lime and 1,000 litres of agro-chemical. In the same breath, according to

<https://www.pressreader.com/kenya/daily-nation-kenya/20171129/282050507382517> the Daily nation newspaper of 29<sup>th</sup> Nov, 2017 stated that the the county government of Tharaka Nithi had an intention of constructing a KES 950M fertilizer plant.

A thorough review of both national and county policy documents and related work was done. At national level, the researcher reviewed the following agricultural policy documents: Food and agricultural policies in Kenya between 2005 to 2011 a country report, Strategic plan for agricultural statistics-Kenya 2015 to 2022, Agricultural policy reforms in Kenya 2000-2016-Turning vision into law and Agricultural policy in Kenya-issues and processes.

At the County level the County Integrated Plans 2013 to 2017 and 2018 to 2022 coupled with all annual development was reviewed. In all these plans, there is no where permaculture is even mentioned

This may explain why many farmers do not practice permaculture. The subsidies may be making farmers opt for convention agriculture.

Healthy ecosystems are important in enhancing natural resilience to the adverse impacts of climate variability as well as reducing community vulnerability by providing goods and services that enable them cope with stresses and shocks. Ecosystem degradation therefore erodes the coping capacities of communities and social systems.

Geographically, Igambang'ombe and Gatunga wards fall in a semi-arid area which is disproportionately vulnerable to effects of climate variability. Degradation of the ecosystem components such as soils, vegetation, water and its sources only adds to this vulnerability. This degradation is caused by both natural and anthropogenic/human induced factors. Some of these factors include; natural and anthropogenic causes such as cutting down of trees, overstocking, over abstraction of water, slash and burn, monoculture, cultivation of steep slopes, increased population density, over harvesting of sand and fish.

It was established that Communities Tharaka Nithi County were affected by harsh conditions under which they undertake their livelihood activities and are unable to cope with additional stress factors. Communities in arid and the semi arid parts of Tharaka Nithi degrade their natural environment due to pressures of drought (a major hazard), low crop yield and increased population. These causes lead to communities opening up more agricultural land, resulting in crop failure and livestock deaths forcing them to engage in short-term coping activities such as charcoal burning and sand harvesting. This has led to depletion of ecosystems goods and services that support the communities' livelihoods.

## 5. CONCLUSION

Despite the fact that permaculture is a good agricultural system, the researcher found out that it has very little adoption in Tharaka Nithi County. Those practicing had done so for less than an year due to the influence of a faith based development organization.

It was established that land ownership, sex, age, grazing method and government policy influence implementation of permaculture.

The researcher also found out that the school curriculum at all levels lacks content on permaculture and that government agricultural extension officers have never received formal training on this agricultural systems.

Some of the recommendations are, that training agriculture extensinist and farmers on permarculture, policies promoting permaculture should be enacted and implemented, Both men and women should be given equal decision making powers on agricultural practices and land use. Finally, the government should take a leading role in promoting permaculture.

The areas recommended for further research include: how the current Kenyan agricultural training curriculum can be improved to promote adoption of permaculture coupled with possibilities of having government policies that promote this sustainable system of agriculture.

## ACKNOWLEDGEMENT

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## **Critical Agricultural Extension Interventions Aspects for Rice Smallholders in Ahero Irrigation Scheme, Kisumu County**

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### **Abstract:**

A consensus on the approach to enhance agricultural production in Kisumu County has pointed to the necessity of prioritizing areas of intervention including provision of extension services and other agricultural investments. Ahero Rice Irrigation Scheme is one of the major agricultural investments in the county whose potential of 30,000MT of rice annually is rarely met, achievement averaging about 27% of the potential. A survey was administered to rice farmers in Awach area of the irrigation scheme, Nyakach Sub County with an aim of prioritizing production challenges that required extension intervention. Descriptive statistics was used to rank the prioritized interventions. Most farmers, 68% ranked the most important intervention as rice pests identification. Other interventions among the 18 which were ranked highly for immediate interventions include: rice disease identification (67%), rice disease management (67%), land preparation (62%) and rice pests' management (60%) among others. Farmers' socio-economics were characterized to provide options in intervention. About 65% of the household heads are male and a third of household heads have completed secondary education. Most of the farmers are self-employed, with only 10% being in the formal employment. Most of the farmers are living in abject poverty, despite being burdened by education investment averaging KES 66,903 in 2017. On average, in 2017 farmers invested a mere KES 43,355 in agriculture. Apart from rice production, 43% of the farmers keep livestock and 20 % grow sorghum and maize with little olericulture being practiced. With the current devolved governance, the national government plays a minimal role at 12 appearances in agricultural extension service delivery while a higher appearance being taken by NGOs at 53. Most farmers also found farmer groups more educative. Crop protection is noted as the key area for intervention and more emphasis should be put into it.

## Rooting Sandalwood stem cuttings using low cost technology employed in commercial propagation of *Camellia sinensis*

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### Abstract

*Osyris lanceolata* (East African Sandalwood) is a semi-parasitic plant that yields highly valued sandalwood oil which is used in manufacturing cosmetics and medicines. This species is endangered in the wild due to overexploitation through uprooting. Further, its domestication has been hampered by unreliable supply of seeds and lack of silvicultural knowhow on propagation of semi parasite plants. A study was conducted at Kangaita to test whether the technology used in the commercial production of tea bushes through rooted stem cuttings can be adopted for producing *O. lanceolata* seedlings. Four locally available soils of different pH (3.81, 4.33, 5.46 and 6.03) were tested as rooting media and rooting monitored at 60, 90,120 and 150 days after establishment. The experimental layout was a Split-plot in Randomized Complete Block Design. Data was collected on rooting, length of the root, height of new shoots and number of roots and new shoots. The data was analyzed for variance. The effect of rooting media pH and incubation time were significant for rooting ( $p < 0.001$ ,  $p < 0.001$ ), number of roots ( $p < 0.001$ ,  $p < 0.001$ ), length of the longest root ( $p < 0.001$ ,  $p < 0.001$ ), height of the tallest shoot ( $p = 0.004$ ,  $p < 0.001$ ) and also the number of shoots ( $p = 0.002$ ,  $p < 0.001$ ). The root media with pH 5.41 and 6.03 were superior in all the parameters assessed. The best rooting was 37% achieved after incubation of 120 days in the rooting medium with pH 5.46. There was no rooting in the rooting media with pH of 3.81 and 4.33 at 60 days and the subsequent rooting remained suppressed to 150 days. The results indicate that *O. lanceolata* stem cuttings can be rooted using the technology for rooting tea bushes but rooting media pH should be at least 5.46. Rooting media with pH higher than 6.03 should also be tested.

KEY Words: stem cuttings, rooting media pH, rooting, incubation period

## Introduction

The East African Sandalwood (*Osyris lanceolata* Hochst. & Steud. ex A. DC. ) is a shrub or a small tree growing to a height of six meters. It belongs to the semi-parasitic plant family Santalaceae and its roots will always be found associating with those of host plants (Mwang'ingo *et al.*, 2005). *Osyris lanceolata* is known by various local names in Kenya; Msandali (Swahili), Muthithii:(Kikuyu), Mberegesa (Chaga), Olseyeayyesi (Maasai) and Kithawa, Munyungai mai (Kamba), Kepurwet (Kipsigis), Kijulu (Taita), Muchai(Meru), Mutero (Mbeere) and Jemokabyl (Marakwet) (Maundu and Tengnas, 2005; Beentje, 1994). It is dioecious and indigenous to East and South African regions. The *O. lanceolata* tree grows at an altitudinal range of 900 to 2550 m above sea level (Maundu and Tengnas, 2005; Beentje, 1994). The East African Sandalwood produces fragrance-scented wood and essential oil (Walker, 1966; Iyenga, 1968; McKinnell, 2008; Mukonyi *et al.*, 2011). Sandalwood oil is used in various cosmetics and fragrance industries and in medicine (Encyclopaedia Britannica, 2018). Traditionally the tree has different uses among different tribes in Kenya, including making of red dye, smoking milk containers, use of bark powder to heal wounds, treating stomach-ache, tonsils, diarrhoea, ulcers, snakebites and rashes (Maundu and Tengnas, 2005, Beentje, 1994). The global demand for Sandalwood has by far outstripped its supply (Subasinghe, 2013). Sandalwood is harvested in the wild by uprooting. This mode of exploitation interferes with its natural regeneration and thus not sustainable and hence conservation and domestication of this tree is a priority.

Demand for East African Sandalwood has been fueled by a search for an alternative to the diminishing resource of the Indian Sandalwood (*Santalum album*) (Subasinghe, 2013). Indian Sandalwood resources have dwindled and the price skyrocketed. Trade has now shifted to other sandalwoods; Australian sandalwoods (*Santalum spicatum*) and the East African Sandalwood.

Success in the propagation of Sandalwood is often faced by various constraints especially lack of understanding of its silvicultural requirements. Although propagation through seed is feasible (Kamondo *et al.*, 2014), propagation through seed is hampered by unavailability of seed as the species is a poor seeder and the country does not have any seed sources for the species. The seeds has a short shelf life. The limited time of seed storage of about one year means that the planting programmes cannot be based on storing of large quantities of seed for a long period of time, as any seed stored for more than one year would have low viability (Kamondo *et al.* 2018).This calls for development of an alternative method of raising *O. lanceolata* seedlings to complement seeds. Vegetative propagation through rooted stem cuttings is one of the most viable options. Already many plant species from tropical and temperate regions are commercially produced through rooted stem cuttings (Mesen, 1993; Shiembo *et al.*, 1996; Larsen and Guse, 1997; Takoutsing *et al.*, 2014). Tea bushes (*Camerai sinensis*) is one of plant propagated commercially through rooted cuttings, compared to the other species, the commercial propagation of *C. sinensis* through rooted stem cuttings is relatively simple and cost effective since most of the materials required are available locally (Kamunya *et al.*, 2003;Teshome *et al.*, 2016). Rooting media are primarily the local soils of low pH and good drainage. There are, however, some minor variations in the composition of the rooting media to suit the prevailing local conditions, in Australia for example, a mixture of sub-soil, composted pine-bark and sand has proved to be suitable for good rooting and growth of green tea cuttings (Angela, 1999), whereas in India, soil thoroughly mixed with cattle manure and rock phosphate is the recommended medium (Barbora *et al.*, 1996). In East Africa and Malawi a layered profile with sub soil on top of surface soil is the preferred rooting and growing

medium (Green, 1964). The cuttings are incubated under polythene tunnels and shaded using local materials such as bamboo mats or branches of trees. The objective of the research reported in this paper was to determine the applicability of the technology used in the commercial production of tea bushes through rooted stem cuttings in the propagation of *O. lanceolata* and the effect of time on rooting.

## Materials and Method

The study was undertaken at the Kenya Tea Development Agency's' (KTDA)Kangaita Tea plantation nursery.Kangaita is in Kirinyaga County and it lies on the western side of Mt Kenya. It is on a relatively high altitude of 2036 meters above sea level approximately  $\frac{1}{2}^{\circ}$  south of the equator and approximately along the  $37.3^{\circ}$  E longitude. The cool calm climate is quite conducive for tea production with a double maxima rainfall of 1500 mm – 1800 mm annual average between March – April and October – December and a relatively cool tropical temperature of  $15^{\circ}\text{C}$  –  $20^{\circ}\text{C}$  annual mean. The coldest months are July – August with mean temperature of  $12^{\circ}\text{C}$  –  $19^{\circ}\text{C}$  and the hottest being September and February with mean temperature of  $22^{\circ}\text{C}$  –  $24^{\circ}\text{C}$ . During the cold months, the tea zone is normally foggy with near minimal visibility. The soils in the catchments are deep well drained brown to dark brown Nitrosols and Andsols with acidic humid top soils.

*Osyris lanceolata* stem cuttings were harvested from seedlings that had been raised in glasshouse at the Kenya Forestry Research Institute (KEFRI), Muguga research nursery. The seedlings had been sprayed with systemic fungicides to reduce endogenous fungal load in the cuttings (Machua *et al.*, 2008). The big cuttings were reduced to an average size of 10-12 cm long and a number of leaves with approximate  $25\text{ cm}^2$  surface area were left intact on each cutting. The cuttings were surface sterilized using as suspension of Bavistin and inserted into the rooting media consisting of top and sub-soils collected at different sites within Kangaita tea plantation and the adjacent natural forest which had prior been established to have different soil pH levels. The rooting media pH levels were; top soil from tea plantation 3.81, subsoil from field covered by grass/fern (natural forest) 4.33, top soil from field covered by grass/fern natural forest 5.46 and topsoil from a site of former cattle shed 6.03. The chemical properties for each rooting medium were determined prior to setting the experiment (Table 1). . The experimental layout was a Split-plot in Randomized Complete Block Design. The main plot treatment was the assessment time (60, 90, 120 and 150 days). Each rooting medium of was replicated three times in each main plot (time) and each replicate had 30 leafy cuttings. Each of the main plot treatment (assessment time) was covered separately within a polythene tunnel to create mist condition and minimize exposure of cuttings before their assessment date was due. The experiment was shaded using bamboo mats. The trial was inspected fortnightly for fungal infestation and watering. Data was collected on 60<sup>th</sup>, 90<sup>th</sup>, 120<sup>th</sup> and 150<sup>th</sup> day after establishment. A cutting was scored as having rooted if it has root of at least 0.5cm long.

Data was collected on the number of cuttings that rooted, number of roots per rooted cutting and the length of the longest root (centimetres). Data on the number of new shoots (sprouts) and the height of the tallest shoot per every sprouting cutting was also captured. The whole set of data was organized using Ms-excel and analysed using GenStat 18<sup>th</sup> edition. Analysis of variance (ANOVA) was done to determine the significant differences between rooting media pH levels and different incubation periods on the proportion of cuttings that rooted, number of roots per rooted cutting,

length of the longest root (centimetres), number of new shoots and height of the tallest shoot per every sprouting cutting. For the proportion of cuttings that rooted, the data was arcsine transformed before subjecting to ANOVA. Data on the number of roots and number of sprouts was log transformed too before being subjected to ANOVA. Mean separation was done using Tukey post hoc test. Significance differences were declared at 5% for the pH level and incubation period.

Table 1. Chemical characteristic of rooting media of different pH levels

Field pH of rooting media	E.C. (mS/cm)	%C	%N	P ppm	K ppm	Mg ppm	Ca ppm	Zn ppm	Cu ppm	Mn ppm	Fe ppm
4.33	0.139	2.9	0.5	21	86.492	251.053	258.937	4.380	3.886	69.715	239.330
3.81	0.089	5.27	0.825	55	136.215	379.138	1354.024	4.319	4.112	124.264	255.006
5.46	0.071	3.17	0.62	19.5	903.389	482.332	2559.768	5.493	2.379	Traces	165.199
6.03	0.093	6.37	0.95	53	982.176	544.737	1380.843	25.115	5.006	126.81	482.959

## Results

The rooting percentage at the closing of the experiment was significantly different in respect to time ( $p < 0.001$ ) and rooting media pH ( $p < 0.001$ ) but their interaction was not significant ( $p = 0.214$ ). The rooting percentage at 60 days was significantly low compared to rooting at 90, 120 and 150 days while the rooting at 90 days was significantly lower compared to rooting at 120 days but was similar to rooting at 150 days (Table 3). The highest mean rooting percentage was 37.8 % recorded at 120 days in pH 5.46 followed by 31.1% recorded at 150 days in pH 6.03 (Figure 1, Table 2). The rooting percentage in rooting media with pH 5.46 and 6.04 was not significantly different but both were significantly higher compared to rooting in the more acidic media (pH 3.81 and 4.33) (Table 2).



Plate 1. Rooting experiment shaded with bamboo mat



Plate 2. A rooted cutting of *O. lanceolata*

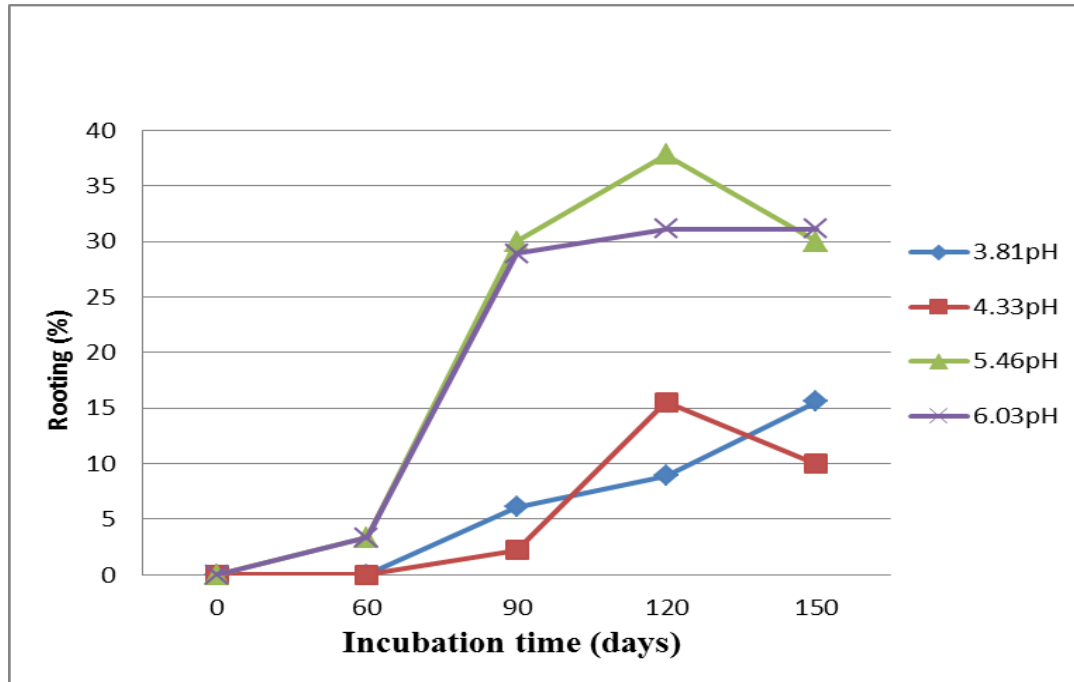


Figure 1. The rooting trend of *O. lanceolata* stem cuttings in rooting media with different pH at incubation time to 150 days

Table 2. Effect of rooting media pH on number and length of roots and shoots.

Rooting media pH	Rooting (%)	Mean number of roots	Mean root length (cm)	Mean number of shoots	Mean length of shoot
4.33	7.50 <sup>a</sup>	1.43 <sup>a</sup>	0.32 <sup>a</sup>	<u>2.92<sup>a</sup></u>	<u>2.32<sup>a</sup></u>
3.81	6.67 <sup>a</sup>	1.77 <sup>ab</sup>	0.43 <sup>a</sup>	3.04 <sup>ab</sup>	2.32 <sup>ab</sup>
5.46	23.61 <sup>b</sup>	4.07 <sup>b</sup>	4.70 <sup>b</sup>	3.30 <sup>b</sup>	2.54 <sup>ab</sup>
6.03	25.00 <sup>b</sup>	3.85 <sup>b</sup>	5.48 <sup>b</sup>	3.32 <sup>b</sup>	2.69 <sup>b</sup>

Letters in superscript in the same column indicate no significant difference at  $p < 0.05$  using Tukey post hoc test

### The number of roots

The number of roots per rooted stem cuttings was significantly affected by incubation time ( $p < 0.001$ ) and rooting media pH ( $p < 0.001$ ) but interaction of incubation time and rooting media pH was not significant ( $p = 0.506$ ). The mean number of roots was significantly higher at 150 days compared to 60 days (Table 3, Figure 2). The mean number of roots in the rooting media of pH 5.46 and 6.03 was significantly higher compared to those rooted in rooting medium of pH 4.33 but not to those rooted in rooting medium of pH 3.81 at 150 days (Table 2).

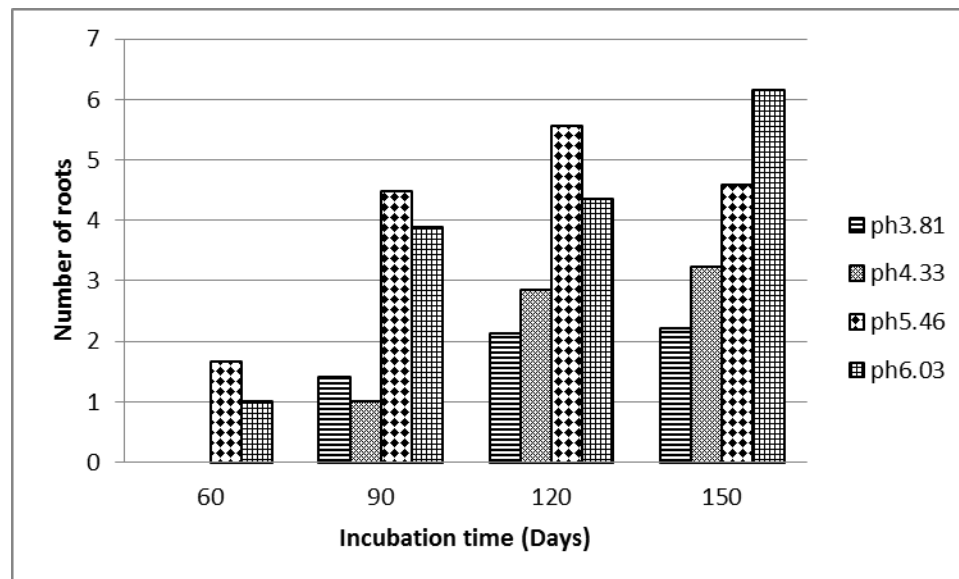


Figure 2. Effect of rooting media pH on the number of roots at different incubation time to 150 days

### Length of the longest root

The length of the longest root per rooted cuttings was significantly influenced by incubation time ( $p < 0.001$ ), rooting media pH ( $p < 0.001$ ) and the interaction between incubation time and rooting media pH ( $p < 0.031$ ). There was no significant difference in mean root length of the cuttings rooted in the rooting media of pH 3.88 and 4.33; however, their mean root length was significantly lower compared to that of cuttings rooted in the rooting media with higher pH (5.46 and 6.03) (Table 2, Figure 3). The mean root length of the rooted cuttings at 150 days was significantly higher compared to the roots length of the rooted cuttings at 60 and 90 days but not at 120 days (Table 3).

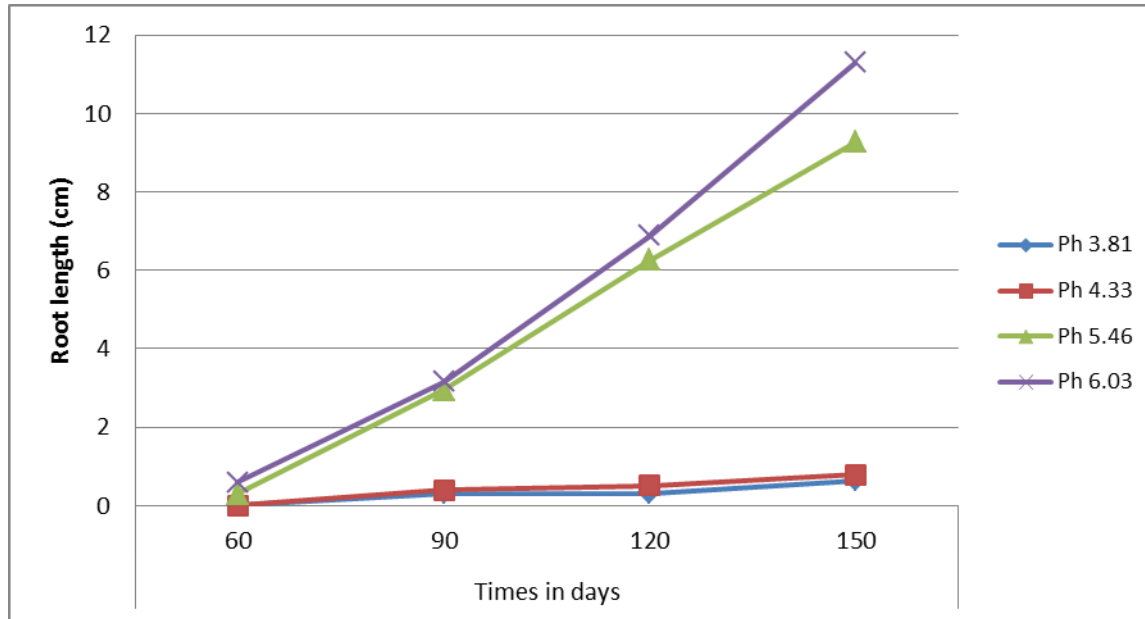


Figure 3. The trend of root growth in the rooted cuttings under different rooting media pH on the length of the longest root at different incubation time to 150 days

### Number of new shoots

The number of new shoots formed was significantly influenced by time ( $p < 0.001$ ) and the pH of the rooting media ( $p = 0.002$ ) but interaction effect was not significant ( $p = 0.459$ ). The least number of new shoots was recorded in rooting medium of pH 6.03 and it was significantly low compared to shoot numbers recorded in the rooting media of pH 5.46 and 4.33 (Table 5) but was similar to shoot number in the rooting medium of pH 3.81. The mean number of new shoots at the close of the experiment was significantly higher compared to the intermediate assessments while the number of shoot at 90 days was significantly lower compared to all the other assessments (Table 5).



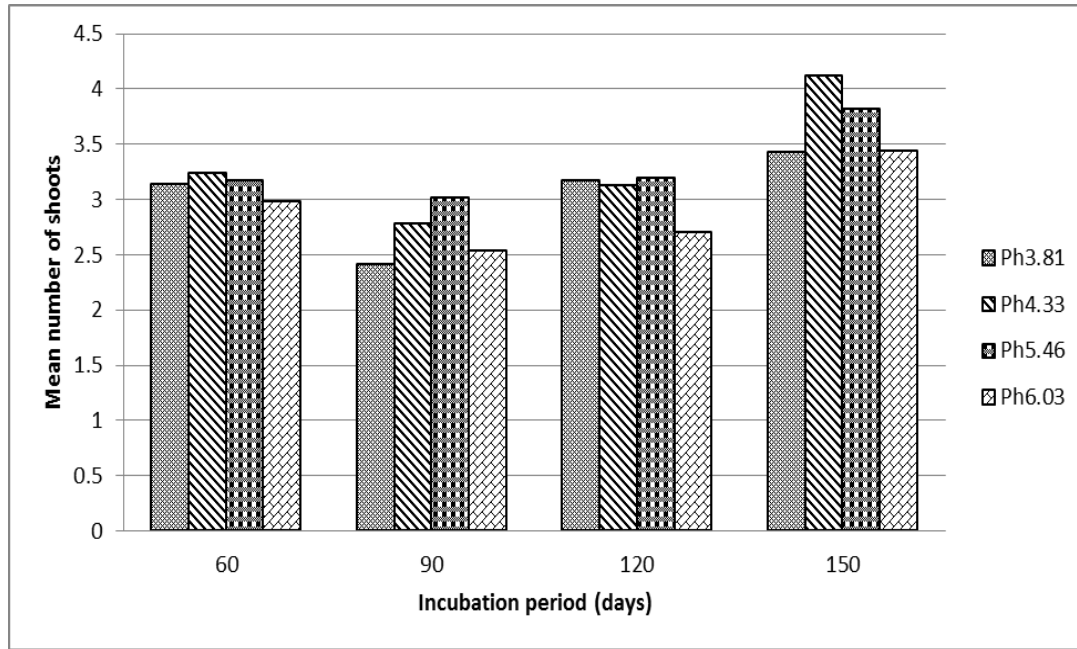


Figure 4. The number of new shoots in rooting media of different pH levels at different incubation time to 150 days

### Height of the new shoots

The height growth of new shoots was significantly influenced by incubation time ( $p < 0.001$ ), rooting media pH ( $p = 0.004$ ) and the interaction between time and rooting media pH ( $p < 0.006$ ). The lowest shoot height was about 1 cm recorded in rooting media of pH 3.81, 4.33 and 5.46 at 60 days and the highest was 3.67 cm followed by 3.57 cm in rooting media of pH 5.46 and 6.01 respectively at 150 days.. The height growth of new shoot was significantly higher at each incubation time compared to the preceding one. The increase in shoot height in rooting media with different pH was almost the same with exception of cuttings incubated in rooting medium of pH 6.03 which was significantly taller compared to that rooted in rooting medium of pH 4.33.

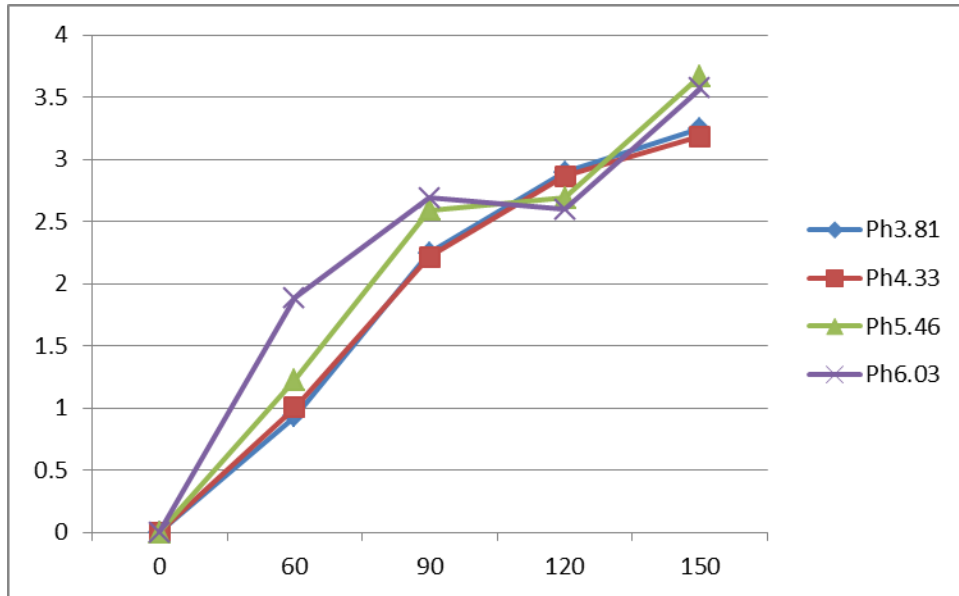


Figure 5. The trends in height growth of new shoots in rooting media of different pH levels at different incubation time to 150 days

Table 3. Effect of incubation time on number and length of roots and shoots.

<u>Incubation time (days)</u>	<u>Rooting (%)</u>	<u>Mean number of roots</u>	<u>Mean root length (cm)</u>	<u>Mean number of shoots</u>	<u>Mean shoot length</u>
60	1.67 <sup>a</sup>	0.67 <sup>a</sup>	0.23 <sup>a</sup>	2.68 <sup>a</sup>	1.26 <sup>a</sup>
90	16.39 <sup>b</sup>	2.69 <sup>ab</sup>	1.71 <sup>ab</sup>	3.05 <sup>b</sup>	2.44 <sup>b</sup>
120	21.39 <sup>bc</sup>	3.72 <sup>ab</sup>	3.49 <sup>bc</sup>	3.12 <sup>b</sup>	2.76 <sup>c</sup>
150	23.34 <sup>c</sup>	4.04 <sup>b</sup>	5.50 <sup>c</sup>	3.70 <sup>c</sup>	3.42 <sup>d</sup>

Letters in superscript in the same column indicate no significant difference at  $p < 0.05$  using Tukey post hoc test

## Discussions

The result shows that it is possible to root *O. lanceolata* stem cuttings employing low cost technology used in the commercial production of *C. sinensis* seedlings through rooted stem cuttings.

The *O. lanceolata* stem cuttings rooted poorly in the rooting media with low pH (4.33 and 3.81) compared to those rooted in the rooted media with high pH (5.46 and 6.03). It appears that low pH do not favour rooting in *O. lanceolata* stem cuttings. The low pH could have affected negatively the physiological processes that influence root initiation and growth thus reducing the number of roots formed and possibly slowing down their growth. Further, low pH could have directly or indirectly inhibited formation of other roots altogether. According to Visser (1959); Banerjee (1992) and Hamid *et al.*, (2006) stem cuttings of *C. sinensis* incubated for rooting in rooting media of pH range outside 4.5-4.8 induced over callusing and suppressed rooting. Hamid *et al.*, (2006) further indicated that for the roots of *C. sinensis* to grow and develop well, acidic growing medium is essential, this is contrary to what was observed with *O. lanceolata* stem cuttings, in which less acidic media supported vigorous root growth compared to the more acidic media. The rooting trend in *O. lanceolata* stem cuttings was also opposite to that of Rhododendrons spp cuttings in which a rooting of 85 - 100 % was recorded in a rooting medium of pH 4.1-4.5 while no rooting was obtained at pH of 7-8 in a non-mist propagator (Thomas *et al.*, 1998). Further, majority of the roots on the rooted cuttings of *O. lanceolata* in the rooting media with low pH were short and thick (club root) whereas the growth of root in the rooting media with high pH was normal.

The length of the roots was highest in the rooting media with high pH than in the media which were more acidic. These may indicate that the physiological processes influencing root growth and elongation in *O. lanceolata* operate best in the media with high pH compared to the more acidic one. The root growth of *O. lanceolata* cuttings rooted in the rooting media with high pH developed rapidly with time, this was opposite to what was reported with *Ocotea usambarensis* coppice stem cuttings in which root growth was insensitive to time (Giathi *et al.*, 2017). The rapid growth of the roots in the rooted cuttings of *O. lanceolata* can be attributed to evolutionary strategy for survival in the semi-parasites. Semi-parasitic plants develop root system very fast in search of potential host plant to attach to for its continued growth and survival (Westwood *et al.*, 2010). The highest rooting in the *O. lanceolata* stem cutting was achieved after incubation of 120 days. This was a much longer period compared to 40 days reported by Teklehaimanot *et al.*, (2004). taken to achieve a rooting of over 50 % in *O. lanceolata* stem cuttings harvested after a rainy season in Tanzania.

Though the mean number of new shoots was affected by both rooting media pH and time there was no clearly observable trend. This could be due to the fact that formation of new shoots on the severed cuttings is primarily influenced by the level of stored food in the cuttings rather than the external environment (Ofori *et al.*, 1996). In addition the new shoots formed could have develop apical dominance by inhibiting formation of more shoots thus masking effect of time.

The growth of new shoots increased significantly with time in all the rooting media pH levels but it was higher in the less acidic ones. This could be due to ease of translocation of water and mineral nutrients to the above ground parts of the cuttings in the less acidic rooting media.

### **Conclusion and recommendations**

*Osyris lanceolata* stem cuttings rooted best in rooting media consisting of ordinary soils at pH of 5.46 and 6.03. The highest rooting was achieved after an incubation period of 120 days. The stem cuttings of *O. lanceolata* can be rooted using ordinary soil with pH range of 5.4 - 6.0 and incubated for 120 days. Further research should be conducted to test the suitability of ordinary soil with higher pH levels than 6.03 and changes of pH with incubation time should be monitored.

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## Short-Term Assessment of Potential of Integrated Soil Fertility Management Technologies to Improve Soil Fertility in Tharaka-Nithiand Murang'a Counties, Kenya

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### Abstract

Soil fertility degradation remains a primary threat to global food security and an important concern in Sub-Saharan agricultural systems. Central Highlands of Kenya is one of the densely populated regions in Kenya and faces soil degradation as a major challenge to agricultural productivity. The problem of low soil fertility affects food and fodder production and as a result, threatens the basic elements of food security. The aim of this study was to assess the potential of different integrated technologies as a soil fertility enhancing approach. The experiment was an on-farm trial conducted in Meru South and Gatanga Sub-counties, laid out in completely randomized block design. The experiment involved fourteen soil fertility management technologies replicated thrice and two controls (minimum and conventional tillage without inputs). The selected soil fertility inputs were sole mineral fertilizer, crop residues plus mineral fertilizer, crop residues plus mineral fertilizer plus animal manure, crop residues plus *Tithoniadiversifolia* plus animal manure, crop residues plus animal manure plus *Dolichos lablab* and crop residues plus *Tithoniadiversifolia* plus animal manure. Results showed that the technologies had no significant effect on soil bulk density in the short-term but significantly increased total N, Mg Na and Mn but decreased Ca, Cu, and Zn in Meru South and Gatanga. Significant changes on soil organic carbon was observed where different soil fertility management technologies were implemented under conventional tillage in the two sites indicating that short-term soil fertility can be improved by integrating various soil fertility management technologies under conventional tillage. However, long-term study is needed to assess the impact of the soil fertility management technologies under minimum tillage method.

### **Keywords:**

Soil fertility  
Food security  
Minimum tillage  
Conventional tillage  
Soil organic carbon



## Mrenda (Jew's mallow) Germplasm characterization by morphological traits in Kenya

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### Abstract

Mrenda or Jew's mallow is widely grown in Africa with its species being highly variable in their morphological traits. In Kenya many local varieties are widely grown as indigenous leafy vegetable for its high nutrient contents and medicinal value. The rich genetic variation in local land races has so far not been fully exploited nor characterized, leaving room for development of improved accessions. The objective was to do characterization of Mrenda morphotypes. Mrenda seed Germplasm was collected using stratified random sampling technique from various counties and planted in pots at green house and morphological traits taken, grouped and analyzed. Characterization results showed presence of two morphotypes based on color and two based on plant height named: Morphotypes 1 (Green Short), Morphotypes 2 (Green Tall), Morphotypes 3 (Brown Short) and Morphotypes 4 (Brown Tall). Early maturing plants were short with Morphotypes 1 at 28.3 cm and Morphotypes 3 (29.0 cm) and differentiated by stem color. Shortest plants were from West Pokot County on both Morphotypes 1 and Morphotypes 3 at 26 cm, while tall accession was from Nandi on Morphotypes 1 (31 cm) and Morphotypes 3 (33 cm). The highest pod count per plant was from Morphotypes 1 at 14 pods from Simlaw seed while lowest was 5 pods (West Pokot, Keiyo and Trans Nzoia counties). Late maturing varieties were tall with Nandi having tallest plants at 93 cm from Morphotypes 2 and 84 cm from Morphotypes 4. Generally the Green accessions were taller than Brown types. The highest Pod count per plant was from Nandi on Morphotypes 2 at 19 pods and lowest was from West Pokot on Morphotype 4 (16 pods). It is concluded that there was variation in traits of Mrenda Germplasm thereby needing purification of accessions to separate them into various morphotypes for farmer's crop production purposes.

**Keywords:** Characterization, Morphological, Mrenda, Traits.

### Introduction

*Corchorus* species also called Jew's mallow are cultivated leafy vegetables though in different areas e.g. South East Asia it is used as fibre crop (Stewart, 2011, Asif, 2011). In Africa, it is well adapted to a wide range of environmental conditions in both warm and dry regions. *C. olitorius* also called mrenda is widely grown in Kenya (KARI, 2011) as an indigenous African vegetable due to its important contribution to diet by supplying nutrients and rendering food more palatable (Grubben and Denton, 2004). It is reported to be demulcent, deobstruent, diuretic, lactagogue, purgative, and tonic (Ayodele, 2005). It can meet major protein-calorific nutritional needs especially in children, sick, elderly and both expectant and lactating mothers in rural areas (Smith and Eyzaguirre, 2007). Cooked leaves form a mucilaginous substance that has a character that is highly appreciated especially in areas where people depend on rather coarse food such as millets. Mrenda leaves are normally mixed with cowpeas to reduce their coarseness or to neutralize the bitter taste in *Crotalaria brevidens* (Abukutsa-Onyango, 2004). In characterization, the process consists of recording those parameters that are highly and less highly heritable (Bolibok *et al.*, 2005). They include plant height, leaf number and number of branches, number of flowering plants per plot, leaf yield and seed yield (Branco *et al.*, 2007). Generally, growers, farmers and breeders

would like to know the variation in plant traits to assist when grouping or selecting cultivars for planting or breeding (Grubben and Tahir, 2004).

Most of the germplasm of indigenous vegetables in most parts of the world, including Mrenda, has not been systematically characterized and their plant trait variation not established (Akoroda, 1995, Guo, *et al.*, 2007). This has caused a major knowledge gap. Apart from the local land races, there are little known described improved varieties of Mrenda in Kenya (Abukutsa-Onyango, 2003). This is because there is no official breeding in place for these indigenous vegetables (Bhattacharjee, *et al.*, 2000) in many areas. For instance farmers in many areas in Kenya grow landraces which differ in their morphological traits or characteristics leading to production challenges like variation in growth periods, poor quality seeds and low yields. In order for Mrenda to be increased in production to meet current high demand of these vegetables, purification, selection and breeding need be enhanced necessitating for characterization to provide current field accessions traits information for use in future breeding work or conservation strategies.

### **Characterization of Mrenda (Jew's mallow)**

Characterization and evaluation approaches are generally varied and depends on what is being worked on (IPGRI, 2001). At present most Germplasm breeders and conservationist believe that the larger the collection, the higher the degree of getting desirable characters to use in crop improvement (Brown, 1998). When doing characterization it's important to note that morphological traits such as stem, color, leaf size, petiole, flower color, fruit size, seed yield, plant height, branching pattern, days to flowering and tolerance to pests and diseases often have a high variability (Geleta, *et al.*, 2006), and are helpful as descriptors (Choudhury, *et al.*, 2007).

Generally, accurate characterization through phenotypic and genotypic methods is of interest both for the description, enhancement and protection of landrace materials and for the initiation of breeding programs (Akoroda, 1988, Guo, *et al.*, 2007). Also further knowledge of Germplasm diversity through genetic variation assessment has significant impact on the improvement of crop plant like Jute mallow (Drossou, *et al.*, 2004). In Kenya, the cultivated morphotypes types are highly variable. The rich genetic variation found in the many plant land races has so far hardly been exploited nor characterized, leaving ample room for development of improved varieties (Bhargava, *et al.*, 2007). When selections are made, characters considered useful include; better yields, rapid revenue earnings and high nutrition value (Romain, 2001). The most commonly selected characters are large leaf size, deep green and glossy leaf colors, late flowering, rapid early growth and profuse branching (Abu and Uguru, 2006). In some cases certain leaf types are associated with the nutritionally desirable 'draw' property of the leaves and plants with specific leaf shapes are selected (Bharttarai, *et al.*, 2010). The common practice, however, is to plant unselected and generally quite heterogeneous local germplasm and do selection or characterization process leading to morphotypes (Alvarez, *et al.*, 2006). Such will assist breeders in collection and conservation of local Germplasm and create a large enough base to be used for future crop improvement programs (Ronald, 2014). Despite increased importance of characterization in plant resources; there is scarce information about analysis of this type of data (Beebe, *et al.*, 2000). To fill such a gap of information, research like this being done on Jute mallow needs to be done. This will bring out the rationale behind relationship among accessions (Jakse, *et al.*, 2001) whether morphologically or genetically (within and between groups) and to identify morphotypes or accession (Krauss, 2000), and also discuss the parameters for specific plant (Drossou, *et al.*, 2004).

### **Materials and Methods**

#### **Experimental site and Design**

The research was carried out in a green house at Chepkoilel farm, University of Eldoret, Kenya which is situated at longitude 0°30'N and latitude 35°15'E and altitude of about 2140 m above sea level, and is 9 km North of Eldoret in Uasin Gishu county. Seed Germplasm was collected from five counties of Keiyo, Uasin Gishu, Nandi, Trans Nzoia and West Pokot in Kenya using stratified random sampling technique with a population sample of 500 at 100 per county.

### Morphological trait data collection

Collected seed sub-sample from each source (County) was planted in pots at green house and laid out using randomized complete block design with three replications and data scoring done. Non-destructive measurements was taken weekly commencing two weeks after planting and destructive measurements on leaf area and leaf yields was taken only twice just before onset of flowering, (eight weeks after sowing) and one week later. Five plants were selected per pot and tagged and thereafter their heights measured using a ruler from the soil surface to the apical bud. Number of emerged leaves, its average length and width, color, leaf lamina shape, leaf serration presence and leaf tip noted and number of branches per plant counted. Leaf petiole length was measured and average length determined. Flower shape, color, number of sepals its length and width noted. The number of pods per plant was counted in each pot and average determined. Fruits' shape was noted and its average length and width per fruit determined. Leaf yield per plant was determined by harvesting five plants per pot and cutting off the edible parts, including leaves, young branches and shoots and weighed on a balance. Seeds were harvested when mature but before drying up and shattering, and dried, threshed, winnowed and seed yield determined as well as germination percentage of the seed lot.

### Results and Discussion

A total of two morphotypes emerged based on stem color and two based plant height and named Green short (GS), Brown short (BS), Green tall (GT) and Brown tall (BT).

#### Characterization results of green and brown short (GS and BS) morphotypes

The plant height (Table 1), show early maturing plants were averagely dwarf (less than 50 cm) as indicated by Buddhadeb (2012). The GS (28.3 cm) and BS (29.0 cm) were same in height and only differentiated by color. The shortest plants were from West Pokot; GS and BS at (26 cm), while tall accession was from Nandi; GS (31 cm) and BS (33 cm).

Table 1: Plant parameters results in centimeters of GS and BS morphotypes at harvesting

Source of seed	Plant height (cm)		Pod count (numbers)		Leaf Petiole length (cm)	
	GS	BS	GS	BS	GS	BS
West Pokot	26±0.6	26±1.5	5±0.5	5±1	1.2±0.1	1.2±0.1
Simlaw seed	27±1.5	0*	14±2.1	0*	1.2±0.1	0*
Keiyo	27±2.5	27±0.6	5±0.6	5±0.5	1.3±0.1	1.2±0.1
Trans Nzoia	29±1.5	28±1	5±0.5	6±0.5	1.4±0.6	1.3±0.1
Uasin Gishu	30±2.5	31±2.9	6±0.5	6±0.5	1.3±0.1	1.2±0.1
Nandi	31±1	33±3.2	7±1	6±0.5	1.3±0.1	1.3±0.1
Mean	28.3	29.0	7	6	1.3	1.2

Nb. 0\* indicate absence of morphotypes in seed accessions from Simlaw Seed Company

The highest pod count per plant (Table 1) was GS at 14 pods from Simlaw seed selection while

lowest was 5 pods (West Pokot, Keiyo and Trans Nzoia). On BS pod count per plant, the highest was 6 pods (Most seed sources), except sources with 5 pods were West Pokot and Keiyo. On average, GS had 7 pods per plant while BS had 6 pods per plant. The petiole length analysis (Table 1) on average was GS (1.3 cm) and BS (1.2 cm). The leaf lamina shape (Table 2) showed GS and BS were lanceolate of measuring 6.5 cm length by 2.5cm width and in alternate positions. The leaf margin showed serration as present and facing leaf apex in both GS and BS morphotypes. The leaf tip shape was acute in both GS and BS. The GS leaf was green in color while the BS was brown.

*Table 2: Width and length measurement results in centimeters of GS and BS morphotypes*

Morphotype	Measurement	Leaf Lamina	flower	Fruit
GS	Width (cm)	2.5±0.1	1.2±0.2	1.2±0.1
	Length (cm)	6.5±0.4	1±0.1	3.6±0.5
BS	Width (cm)	2.5±0.1	1.2±0.1	1.3±0.2
	Length (cm)	6.5±0.4	1±0.1	3.8±0.6

Both GS and BS flowers were 1.2 cm in length and 1.0 cm width (Table 2), yellow in color, solitary in shape, positioned in opposite to leaves and 5 small narrow sepals. The fruit width and length results varied (table 2), where length for GS and BS were 3.6 cm and 3.8 cm respectively and width were 1.2 cm and 1.3 cm respectively. The fruit was cylindrical, 10 ridged; dehiscing by 5 with traverse septa between seeds averagely 100 seeds per capsule. All GS and BS seeds were pyramidal in shape, dark grey – blue in color and measurement of 1mm in length.

### **Characterization results of Green and Brown tall (GT and BT) morphotypes**

Plant height results (Table 3) showed that West Pokot had both the shortest Green Tall (GT) of 79 cm and Brown Tall (BT) of 77 cm while Nandi had the tallest of 93 cm (GT) and 84 cm (BT). The above results show that generally, Green types were taller than the Brown types of Jew’s mallow in the counties.

*Table 3: Plant parameters results in centimeter of GT and BT morphotypes at harvesting*

Source of seed	Plant height (cm)		Pods count (numbers)		Leaf petiole length (cm)	
	GT	BT	GT	BT	GT	BT
Morphotypes	GT	BT	GT	BT	GT	BT
Simlaw seed	0*	0*	0*	0*	0*	0*
West Pokot	79±3.2	77±3	16±0.6	16±1	1.7±0.1	1.8±0.1
Uasin Gishu	82±3.1	84±3.2	17±1	18±1.7	1.8±0.1	1.7±0.2
Keiyo	84±3.5	81±4.2	17±1.2	17±1.5	1.7±0.1	1.7±0.1
Trans Nzoia	85±4.1	84±5.1	18±1.8	17±1.2	1.8±0.2	1.7±0.1
Nandi	93±5.2	84±3.2	19±1.5	19±2	1.7±0.1	1.7±0.1
Mean	85	82	17	17	1.7	1.7

*Nb. 0\* indicate absence of morphotypes in seed accessions from Simlaw Seed Company*

Results (Table 3) on GT and BT pod count per plant showed Nandi having the highest (19 pods) and the lowest being 16 pods from West Pokot and on average the GT and BT varieties had same pods per plant of 17 pods and only colors could differentiate them. The leaf petiole length showed that on average, GT and BT were of 1.7 cm and 1.8 cm in length across the seed sources, and could only be differentiated by their colors. Both GT and BT leaf lamina shape was lanceolate, at 8.5 cm

length by 2.8 cm width (Table 4) respectively and in alternate positions.

Table 4: Width and length measurements of GT and BT Jute mallow parameters

Morphotypes	Measurement	Leaf lamina	Flower	Fruit size
GT	Width (cm)	2.8±0.1	1.2±0.1	1.4±0.3
	Length (cm)	8.5±1.1	1.0±0.1	3.9±0.5
BT	Width (cm)	2.8±0.1	1.2±0.1	1.4±0.4
	Length (cm)	8.5±0.2	1.0±0.1	3.9±0.6

Both GT and BT leaf had serration present, facing leaf apex and of acute shape. The GT leaves were green in color while BT was brown. The flower for both GT and BT were 1.2 cm length by 1.0 cm in width respectively, yellow in color, solitary in shape, positioned in opposite to leaves and having 5 small narrow sepals. The fruit length and width measurements of GT and BT were the same of 3.9 cm by 1.4 cm. respectively, were cylindrical, 10 ridged, dehiscing by 5 with traverse septa between the seeds. All GT and BT seeds were pyramidal in shape, dark grey-blue in color and 1mm in length.

### Conclusion

It is concluded that collected Germplasm seed accessions varied in morphological traits with two morphotypes outcome based on color and two morphotypes on height. This shows that there was variation or differences in characterized Mrenda accession from the five counties. To avail new varieties of Mrenda to farmers, it is envisaged further work by breeders be embarked urgently on breeding or purification to produce improved variety from the local identified or available landraces types.

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## **Evaluation for Resistance of some Maize Genotypes to the African bollworm, *Helicoverpa armigera* Hub in the Gezira and River Nile States, Sudan.**

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### **Abstract**

The African boll worm, *Helicoverpa armigera*, is the one of the most dangerous pests in Maize fields, the objectives of this study to screen for resistance of maize genotypes for this pest and to assess the damage in 2 locations in the Sudan. The study was carried to evaluate the performance of fifteen maize genotypes with two local checks against the infestation by the African bollworm, *Helicoverpa armigera*. Field experiments were carried out in the Gezira and Hudiba research stations. Seventeen maize genotypes were tested with. Four parameters, the incidence of leaves damage(%), ears infestation (%), number of larvae and grain yield were used as indicators for the susceptibility and tolerance or resistance. The results were significant different between the mean infestation incidence recorded for the leaves damage indicating maximum values 1.25,1.36,1.34 in Medani for YO63,YO64,VMH4102 and 1.3,1.41,1.41 in Hudiba for YO64,MO4,VMH2015, respectively. These values indicated the potential susceptibility of Maize genotypes., The leaf damage and the ear infestation showed more or less a similar trend. The grain yield showed significant differences between genotypes. From the obtained results genotypes MO4,YO63,YO64,VMH4102,VMH2015,PAC740,Hudiba-2 were highly susceptible, whereas, the genotypes VMH2000,VMH4040,PAC339,PAC999,PR89B5655 had potential tolerance or resistance to the infestation by the African boll worm and thus could be considered as promising maize genotypes and we recommend their cultivation in wider range for verification of their resistance.



## Effect of pulsing and wet cold storage on post-harvest quality and vase life of cut gladiolus (*Gladiolus grandiflorus*) l. cv. Fado

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### Abstract

Floriculture is among Kenya's top foreign exchange earners. *Gladiolus* is one of the four famous cut flowers in the world whose popularity in Kenya is attributed to its heat tolerance, many spike forms and color combinations. However, the perishable nature of the flower renders it vulnerable to huge post-harvest losses. This study aimed to evaluate effect of pulsing cut *Gladiolus grandiflorus* L. CV, Fado with 600 ppm 8-hydroxyquinoline sulphate plus 5 % sucrose prior to wet cold storage durations (0 – 5 days) on quality and vase life against the control (distilled water). The *Gladiolus* were grown in the open field from corms at the Horticulture Research and Teaching Field, in the department of Crops, Horticulture and Soils, Egerton University, Kenya, during two successive seasons. A two by six factorial experiment embedded in a completely randomized design with four replicates was adopted. Pro GLM model in two way Anova was used to determine mean differences. Means were separated using Tukey's test at 5 % level of significance. Pulsing and cold storage treatments had significantly affected the *Gladiolus* fresh weight ( $P = 0.0031$ ;  $82.214 \pm 0.7934$  grams) as compared to the control; dry weight ( $P = 0.0272$ ); interactive effect of the pulsing and cold storage duration treatments ( $P = 0.0004$ ); maximum vase life ( $11.5 \pm 0.287$  days) and opened florets ( $11 \pm 0.15$ ). The highest number of unopened buds ( $5.18 \pm 0.212$ ) were recorded in the control which also had least mean water uptake ( $23.87 \pm 0.26$  mls) as compared with the pulsed and cold stored spikes ( $31.98 \pm 0.193$  mls). This is the first time the significance on quality and vase life of cut *Gladiolus grandiflorus* L. cv. Fado due to pulsing with 600 ppm 8-hydroxyquinoline sulphate plus 5 % sucrose and cold storage treatments is reported.

**Key words:** pulsing; cold storage; *Gladiolus*, quality

## **Assessing constraints to enhanced agricultural productivity among maize-beans smallholders in Kisii County**

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### **Abstract**

Understanding socio-economics characteristics of farmers and assessing opportunity of enhanced agricultural production is one of the fundamental mechanisms in developing strategies of ensuring food security and increased income for smallholders in Kisii County. Farmers in Kitutu Chache South Sub-County were sampled to respond to a survey during the first-quarter of 2018. The objective of the study was to establish the socio-economics hindrance to enhanced maize-bean intercrop production. Most of the farmers were women accounting for 68% of the total population. On average farmers were 46 years old and had farming experience of 19 years. A large proportion on farmers (68%) had only achieved primary education. About 6 in every 10 farmers had no other source of income except peasantry farming on small parcels of land averaging approximately 1.4 ha. On average farming family has 6 members with maize-beans intercrop being the source of livelihood to 70 percent. High level of abject poverty prevails with on average per capita consumption per day averaging at KES 23 (US\$ 0.23). It was observed that constraints to maize-bean production included insufficiency in extension services (55%), inaccessibility to credit (97%), and poor development of supportive farmers' association (98%) among others. Other challenges hindering production of maize and beans include high cost of agricultural input, unpredictable weather conditions, small landholding, and low produce prices. Farmers in Kitutu Chache South Sub-county have a myriad of challenges that require concerted efforts by all development stakeholders including civil society, national government, county government and the population itself. Some of the intervention that goes beyond agricultural development includes population control, investment in education and expansion of formal and non-formal off-farm employment. However, addressing food security calls for enhanced extension provision, access to credit, accessibility and affordability of agricultural technologies.

## **Factors hindering Sweet Potato Production in Homa Bay County**

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### **Abstract**

Efforts to expand sweet potato farming as a food security and income generating interventions for smallholders' farmers in Homa Bay County in formerly Nyanza province are being hindered by information dearth on farmers' socio-economic characteristics and deterrence to adoption of agricultural technology. Consequently, a research was administered to smallholders in the county with specific objectives of understanding farmers' socio-economic characteristics and the factors that would constraint sweet potato expansion strategy by the agricultural development agents. A hundred and twenty (120) respondents to a pre-set and pre-tested questionnaire were stratified selected among farmers in two wards of Kabondo Kasipul sub-county. The choice of sub-county was influenced by sweet potato suitable agro-ecological conditions coupled with observed reduction in the quality and quantity of production. Farmers in Kabondo Kasipul were observed to be mostly women 55%. On average farmers were about 49 years old and had farming experience of 14 years. The major source of income was agriculture with 69% followed by business with 23% and finally 8% representing those who were employed. The average per-capita expenditure was KES 62 (US\$ 0.62). Education achievements by farmers were primary (48%), secondary (32%) and tertiary levels were (20%). Challenges to sweet potato production included high cost of production reported by 51% of respondents. Other major challenges were low prices of the produce (29%) as well as low returns (20%) and poor provision of extension services. The government should therefore intervene to enlighten the farmers by providing extension services and offering subsidies on farm inputs to lower the cost of production. In conclusion, based on the findings poor extension services and high cost of production are the key factors hindering sweet potato farming in the area.

## **The Economic, Health and Nutritional benefits of Chia (*Salvia hispanica* L.) Farming In Nyeri County, Kenya – Baseline survey analysis.**

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Chia (*Salvia hispanica* L.) is a member of the Lamiaceae, or mint, family. These herbaceous hardy annuals grow to 3 feet tall (91 cm.). They have thick, dark-green leaves that are wrinkled and deeply lobed. Tiny, soft, gray hairs cover the upper side of the leaves as well.

Chia seeds are a very high source of linolenic acid (LNA) and linoleic acid (LA). Both these essential fatty acids attract oxygen and help cell membranes to be flexible and fluid, plus strengthen our immune system to help protect our bodies from viruses, bacteria, and allergies. Most people's diets are dangerously low in essential fatty acids, which results in tired muscles, fatigue, and a range of health problems. Humans need to eat EFAs daily because the human body cannot manufacture them. EFAs, such as those found in Chia, can assist with weight loss and removal of toxins from the body. In order to investigate the economic, health and nutritional potential of Chia plant in Nyeri County, a baseline survey was conducted in three regions in the County. A sample size of 600 respondents was generated using the Chronbach's formula. Six hundred (600) questionnaires were distributed in the three selected regions namely: -Mathira, Kieni East and Kiaeni West. Out of the 600 questionnaires administered, 558 questionnaires were returned which was a 93% response rate. However, 43 questionnaires were spoilt leaving 510 questionnaires for analysis. The data was analyzed using the SPSS software. Results of the baseline survey indicate that 18% of the respondents have information on Chia while 81.9% have never heard about Chia plant. Out of the respondents who have information on Chia, 54.8% got it from friends, 29% from media, 5.4% from agricultural extension officers, while 6.5% got it from other sources. 88% of the respondents are willing to venture into Chia production. Majority are willing to venture into Chia production for economic and nutritional benefits of the plant. The baseline survey showed a great potential for Chia seed cultivation in Nyeri County for economic, nutritional and health benefits.

**Key Words:** Chia, Economic, Health, Nutrition

## **Response of selected cabbage varieties to *Alternariabrassicicola* under greenhouse conditions**

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### **Abstract**

Dark leaf spot (*Alternariabrassicicola*) is an important disease of cabbage crop. It is a major constraint in cabbage production in Kenya causing substantial losses if not managed properly. Hybridvarieties are now in the market but there exists little information on their resistance and tolerance to this disease. To undertake breeding for resistance and come up with improved varieties, there is need to identify cabbage genotypes for possible sources of resistant genes to the disease. This study was carried out to assess the response cabbage varieties to *Alternariabrassicicola* pathogen namely; Gloria F1, Queen F1, Pruktor F1, Copenhagen and Sugarloaf at theUniversity of Eldoret, School of Agriculture and Biotechnology Plant Pathology Laboratory and in the greenhouse. Isolation and purification of the pathogen was done in appropriate conditions in the laboratory and inoculated on to 10 days old transplanted seedlings. The experiment was laid under completely randomized design (CRD) with each variety replicated four times. Scores were made using a scale of 1-10 on nature of the leaf with leaf spots and percentage disease index per plant was calculated. Data collected was analyzed using Genstat software version 14.1. The study revealed no significant difference in percentage infection per plant between varieties. Using single link method three clusters were formed at 95% similarity coefficient axis. It was concluded that Gloria F1 and Copenhagen were susceptible; Queen F1 was tolerant while Pruktor F1 and Sugarloaf varieties were resistant. Breeding institutions and farmers are recommended to use resistant and tolerant varieties for breeding improvements and high yields.

Keywords: Varieties, Response, *Alternariabrassicicola*,Pathology,Resistance and Tolerance.

## **Moulds And Ochratoxin A Associated With Green Coffee Beans (*Coffea Arabica* L.) Processed By Dry And Wet Methods: A Case study Of Nyeri County.**

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### **Abstract**

Coffee when contaminated with moulds such as *Aspergillus* and *Penicillium* species due to poor processing and storage can produce mycotoxins such as Ochratoxin A (OTA) associated to many health hazards to consumers. The aim of this research was to determine the levels of moulds and Ochratoxin A in coffee processed by dry and wet methods. The coffee samples were collected from Estates and Factories located in the main coffee processing zone in Nyeri County, Kenya. The parameters determined in the green beans were; moisture content, levels of moulds and OTA contamination. The moisture content of coffee samples were determined by dry oven method, OTA levels by use of HPLC and moulds enumeration by serial dilution technique. The results showed no significant difference on the level of moisture content in the coffee samples from Estates and Factories. Ochratoxin A was not detected in all coffee samples. Mould counts of coffee samples from Factories and Estates were found to be between  $1 \times 10^3$  CFU/ml to  $6.0 \times 10^1$  CFU/ml. The highest mould contamination was observed in dry processed coffee as compared to wet processed coffee. Although few samples showed mould contamination, there were no OTA detected in the samples.

**Key words:** Factories and estates, Moulds, Ochratoxin A, Processing

### **1. Introduction**

Coffee plant belongs to the *Rubiaceae* family and genus *coffea* (Clarke, 2003). Coffee cherries are harvested when they are bright red, glossy and firm and processed either by dry, wet or semi-dry process methods. For dry processing, the coffee cherries are spread out in the sun in thin layers of about 5–8 cm thick on drying beds to dry to a moisture content of below 12% (Silva, *et al.*, 2008). In wet processing, the pulp is mechanically removed from ripe cherries, fermented and washed with plenty of water before drying (Masoud *et al.*, 2004). Poor processing and handling can lead to mould contamination and eventually production of OTA (Silva *et al.*, 2000). Ochratoxin A (OTA) is one of the most widespread mycotoxin that can be found in coffee beans and its beverage (Velmourougane *et al.*, 2010). This mycotoxin is produced mainly by two genera of microorganisms, *Penicillium* and *Aspergillus* (Fernández-Baldo *et al.*, 2011). Practices such as picking of fallen old cherries from the ground during harvesting, poor washing of coffee parchment, contamination of coffee by drying on the ground or dirty drying surfaces, storing partially dry coffee for long periods or rewetting during drying influences the growth of moulds on

coffee which affects the quality and safety of the final product due to production of mycotoxins (Edward *et al.*, 2005). The toxin is dangerous and often present noxious effect to eukaryotes, including humans, animals, and plants. It is considered nephrotoxic, cytotoxic, carcinogenic, teratogenic and immunosuppressive (Dachoupakan *et al.*, 2009). It has been classified by the International Agency for Research on Cancer (IARC) as a possible human carcinogen (IARC, 1993). The OTA is highly resistant to physical and chemical treatment and once in food it persists during the processing and storage conditions (Scott *et al.*, 1992). In Kenya the peak coffee harvesting and processing season coincides with the main rainy and cold seasons. Due to the cold weather conditions coupled with the wet season, coffee takes long period of time to dry and some may reabsorb moisture. These conditions encourage mould growth on the coffee beans which may lead to the production of mycotoxins (FAO, 2015). There are few reports on the level of mould and OTA contamination of coffee in Kenya. This study aimed at determining the level of mould and OTA contamination in green coffee beans processed by dry and wet methods. The information on the levels of moulds contamination and OTA in green coffee beans processed by dry and wet methods will be useful for extension services geared towards training of farmers and coffee handlers by relevant bodies, on effective ways of handling coffee to avoid mould contamination and OTA occurrence in coffee.

## **2. Materials and methods**

### **2.1 Study site and samples preparations**

Coffee samples processed by wet and dry methods were drawn from coffee factories and estates located in the main coffee processing zones in Nyeri County, Kenya. Nyeri County was selected as suitable site because of the cool and wet conditions which may favor growth of moulds and OTA production during harvesting and processing of coffee. The County is situated between longitudes 36°38' East and 37°20' East and between the equator and latitude 0°38' South. The coffee samples were collected from 5 different factories and 3 estates. From each factory and estate, a sample of 200g of coffee processed by wet and dry method was drawn randomly from different sites of the coffee heaps.

The control samples were prepared by taking a total of 100kg of ripe coffee cherries of mixed variety which were harvested from Dedan Kimathi University farm located in Nyeri County, Kenya. Ripe cherries were harvested by selective method sorted and pulped using a wet pulper machine. Parchment coffee obtained was then fermented for 72 hours in fermentation tanks using natural method of fermentation. It was then washed with plenty of water to remove mucilage and sun dried on raised beds for 12 days to attain a moisture content of approximately 9.0%. Another batch of coffee cherries amounting to 100kg was processed by dry method by exposing to the sun directly for 30days to attain a moisture content of approximately 9.0%. After drying, the samples were packaged in sealed polythene bags and stored at frozen temperatures of -18°C awaiting analysis.

## 2.2 Moisture content analysis

The moisture content of coffee samples was determined by dry oven method [(AOAC, 2005)] and the results expressed as percentage moisture content.

## 2.3 Mould enumeration

Moulds were enumerated by the serial dilution method. Samples of green coffee beans weighing 5g were transferred to a bottle containing 1800 ml of saline peptone diluent (0.1% of peptone, 0.5% of NaCl, 0.03%  $\text{Na}_2\text{H}_2\text{PO}_4$ ) and mixed for 15 minutes. Five-fold dilutions were prepared and appropriate dilutions spread on triplicate plates of Potato dextrose agar. The plates were incubated at 28°C for 5 days after which they were examined for colony growth visually and with the aid of a microscope. The colonies were then counted using a colony counter and expressed as CFU/ml (Silva et al., 2008).

## 2.4 Isolation and identification of *Aspergillus* and *Penicillium* species

The suspected colonies of *Aspergillus spp.* and *Penicillium spp.* were isolated by streaking on Malt Extract Agar and incubated at 25°C for 7 days. Morphological analysis of *Aspergillus* and *Penicillium* species was done by microscopic and macroscopic technique. *Aspergillus* species was identified by observing colony characters such as color and texture of the mycelium, characteristics of conidiophores such as shape of conidial heads and color of stipes (Samson et al., 2014). *Penicillium* species was identified by examining the texture of the colony, color of conidia, texture and color of mycelium, conidiophores with branching patterns (Visagie et al., 2014).

## 2.5 Screening of *Aspergillus* and *Penicillium* species for OTA production

Testing for OTA production of isolated *Aspergillus* and *Penicillium* was done by agar plate technique according to the method as described by (Bragulat, Abarca, & Cabanes, 2001) with some modification. One agar plug from each plate was cut out near the center of the mold colony and removed using a flame sterilized stainless steel scalpel. By means of a syringe, a drop of extraction solution (Chloroform and methanol in the ratio of 1:2) was placed directly on the mycelium. While still wet, the mycelium side of the plug was gently pressed against the application line on a thin-layer chromatography (TLC) plate and then removed immediately. After drying the application spot, the TLC plates (Silica gel on aluminium) were put in the development tank with the eluting solvent (Chloroform, Ethyl acetate and Formic acid in the ratio 6:3:1) and separation allowed until the solvent reached the solvent front. The plate was removed, allowed to dry and then viewed under infrared. The standard was compared with the samples for the presence of OTA.

## 2.6 Ochratoxin A analysis

Ochratoxin A was analyzed according to the method described by (Vukovic, Palvolic, & Ristic, 2009). One hundred milliliters of chloroform and 12.5 ml of phosphoric acid (0.1 M) were added to an Erlenmeyer flask containing 10g of ground coffee samples. The mixture was magnetically stirred for 30 minutes and filtered through Whatman no.100. The filtrate was transferred into a 500-ml separatory funnel, 50ml of the lower layer transferred to round-bottom flasks and evaporated to dryness on a rotary evaporator. The residue was dissolved in 5 ml of hexane and 5 ml of methanol/water mixture (1:1, v/v), filtered using Whatman paper no. 100 and the filtrate transferred to a 50-ml separatory funnel for separation. The lower layer was collected in a 25-ml Erlenmeyer flask and the upper phase extracted twice more with 5 ml of the methanol/water mixture (1:1, v/v)



used to rinse the round bottom flask containing the residue. All the lower layers were combined and 5ml of it loaded at a flow rate of 1 ml/min into a C18 SPE Cartridges previously conditioned with 5 ml of methanol and 5 ml of methanol/water mixture (1:1, v/v). The Cartridges were then washed with 5 ml of methanol/water mixture (3:1, v/v) and 3 ml of methanol at a flow rate of 2 ml/min. Ochratoxin A was then eluted with 10ml of methanol/formic acid mixture (98:2, v/v) at a flow rate of 2 ml/min and the solutions evaporated to dryness under nitrogen stream. The residue was dissolved in 500  $\mu$ l of the mobile phase (Acetonitrile: Glacial acetic acid: Distilled water, 5:1:4, v/v) and 50  $\mu$ l injected into the HPLC (Knauer, Japan) fitted with Nucleosil RP 18 C<sub>18</sub> column and a fluorescence detector (FLD).

## 2.7 Data analysis

The data obtained was analyzed using statistical package for social scientist (SPSS version 20) where variability among the different samples was done using ANOVA. The differences between group means was analyzed using Duncan and statistical significance established at  $p \leq 0.05$ .

## 3. Results and discussion

### 3.1 Moisture content of coffee samples

The results for percentage moisture content of coffee samples from estates and factories are shown in Table 1. The percentage moisture content of all coffee samples ranged between  $6.85 \pm 0.22$  to  $9.27 \pm 0.54$  which were slightly lower than what has been reported by other authors (Farah, 2012) who reported a range of 8.5% -12% in green coffee beans. This could be attributed to the variations in the prevailing drying conditions, method of drying and the method of monitoring the moisture content level of coffee parchment during drying by different processors. From the study, it was observed that the samples from the different estates and factories showed a significantly lower moisture content level than those of the control samples for both the wet processed and the dry processed samples. Similarly, the wet processed coffee samples from Estate A showed a significantly ( $p \leq 0.05$ ) higher levels of moisture content than those of Estate B and Estate C (Table 1).

The wet processed samples from the different Factories also showed significant variations with the coffee samples from Factory D showing a significantly higher level of moisture content than those of the other factories. Considering the dry processed coffee samples, there was no significant variations in the moisture content level for the coffee samples from the different Estates. However coffee samples from different Factories showed significant variations in the moisture content for the samples obtained by the dry method. The different variations observed in the level of moisture content from the different Estates and Factories could be attributed to common factors in processing factories which includes differences in prevailing weather conditions, lack of equipment to monitor the moisture content during drying, differences in storage conditions of dry coffee and the combination of coffee from different farms. Considering the lack of equipment in most of the Estates and Factories, as a common practice, the monitoring of moisture content in the coffee beans during drying is checked manually where the experts takes a dry coffee bean and bites with the teeth. From their experience, the personnel involved can know that a coffee bean is having correct level of moisture or not by the marks of their teeth on the bean tested. For a bean with correct level of moisture content (10-12%) the bean will be quite hard and will crack rather than form dents after biting but for the bean with higher moisture content above 12%, some dents will be seen on the surface of the bean (Gautz *et al.*, 2008). The storage conditions for the dry coffee may also vary

between the different Estates and Factories and this could contribute to the variations in the level of moisture content. In Kenya, the Estates used in the study represent big farms which produce and processed their coffee under one management. The Factories on the other hand represent the small scale farmers which produce their coffee separately and later combine them together under the cooperative management. Hence due to the nature of the different methods of handling coffee by the different Estates and Factories studied, the level of moisture content in the coffee beans they produce could also vary.

**Table 1: Moisture content of coffee samples from factories and Estates processed by wet and dry method (%)**

	Estates			Factories					Control sample
	A	B	C	D	E	F	G	H	
WP	8.47± 0.47 <sup>d</sup>	7.51± 0.29 <sup>bc</sup>	7.06± 0.30 <sup>ab</sup>	9.27± 0.54 <sup>e</sup>	8.48± 0.48 <sup>d</sup>	7.18± 0.02 <sup>ab</sup>	7.40± 0.09 <sup>abc</sup>	7.85± 0.34 <sup>c</sup>	9.00± 0.11 <sup>de</sup>
DP	7.43± 0.11 <sup>abc</sup>	7.20± 0.37 <sup>ab</sup>	7.17± 0.32 <sup>ab</sup>	7.16± 0.50 <sup>ab</sup>	7.65± 0.27 <sup>bc</sup>	6.85± 0.22 <sup>a</sup>	-	-	9.05± 0.72 <sup>e</sup>

(WP) Wet processed coffee (DP) Dry processed coffee (-) Sample not available.

Values within a row marked with different letters are significantly different ( $p \leq 0.05$ ).

### 3.2 Mould content of coffee samples

During different phases of harvesting, processing, transport and storage, coffee may be subjected to microbial contamination and subsequent colonization (Silva *et al.*, 2008). In this study, the mould content was not detected in the wet processed samples from Estates but for the dry processed samples only two Estates showed some presence of moulds in the samples. The level of mould content in the dry samples from Estates was  $3.13 \times 10^3$  and  $6.0 \times 10^1$  CFU/ml, for Estate A and Estate C, respectively. Considering the Factories, the mould counts for wet processed coffee samples were found to be between  $2.0 \times 10^1$  CFU/ml to  $2.5 \times 10^2$  CFU/ml while that of dry processed coffee samples ranged between  $1.46 \times 10^3$  CFU/ml to  $5.56 \times 10^3$  CFU/ml (Table 2). However the highest mould contamination was found in dry processed coffee as compared to wet processed coffee. The high mould contamination observed in dry processed coffee could be attributed to inefficient drying of the cherries since for dry processed coffee the whole coffee cherries are dried without separation of pulp from the beans. Hence depending on the weather

conditions, the coffee cherries may take long to dry. Similarly, it may take longer time to dry the whole coffee cherry as compared to the parchment coffee (Bucheli & Taniwaki, 2003). The different Estates and Factories used in the study dry their coffee cherries by exposing to direct sun and this may offer them challenges such as poor weather conditions leading to poor drying of coffees.

Generally, coffee samples from Factories had slightly higher level of mould contamination than the samples from Estates. This can be explained by the fact that the Factories are formed by small scale farmers mainly managed by cooperatives which are characterized by inadequate processing facilities than the Estates. Cooperative societies collect coffee from many small scale farmers and due to logistics of collecting coffee and storage, their coffee may stay long in the stores before being processed and marketed. Due to poor storage, the coffee in the stores may develop mould growth especially during wet and dump weather conditions where the coffee could reabsorb moisture (FAO, 2015).

**Table 2: Total counts of moulds of coffee beans from Estates and Factories processed by wet and dry methods (CFUs/ml)**

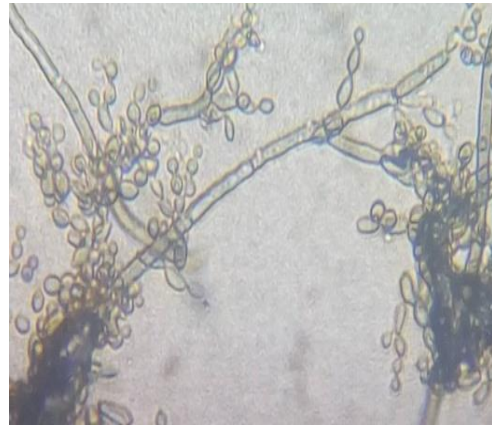
Estates			Factories					Control sample
A	B	C	D	E	F	G	H	
WP	ND	ND	ND	$2.5 \times 10^2$	ND	ND	$2.0 \times 10^1$	ND
DP	$3.13 \times 10^3$	ND	$6.0 \times 10^1$	$5.56 \times 10^3$	$2.18 \times 10^3$	$1.46 \times 10^3$	-	ND
WP– Wet processed coffee			DP– Dry processed coffee (-) Sample not available					ND- Not detected

### 3.3 Mould species in coffee samples

The mould species were identified in the coffee samples basing on the characteristics such as appearance of the colonies, color of the mycelium, degree of growth and the microscopic characteristics. The appearance of the moulds species as observed under a microscope (OPTIKA, Italy) are presented in Fig 1 and 2. The two species that were identified in the coffee samples are *Penicillium* and *Aspergillus* species. The same mould species have also been identified in green coffee bean samples as reported by (Couta et al., 2014). Their presence in food affects the quality and safety of the final product due to their ability to produce mycotoxins such as OTA, Aflatoxins B1 and B2 (Amézqueta *et al.*, 2012). Literature have shown that *Aspergillus* and *Penicillium* species are among the most important contaminants of coffee beans (Couta *et al.*, 2014), (Bucheli *et al.*, 2000).

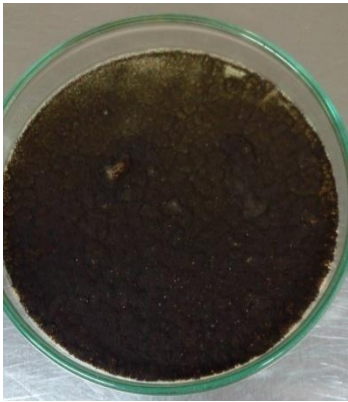


(a)



(b)

Figure 1: The photo of *Penicillium* species, (a) Colony on MEA, 25°C (5 days)  
(b) Conidiophores of *Penicillium* spp (×40)



(a)

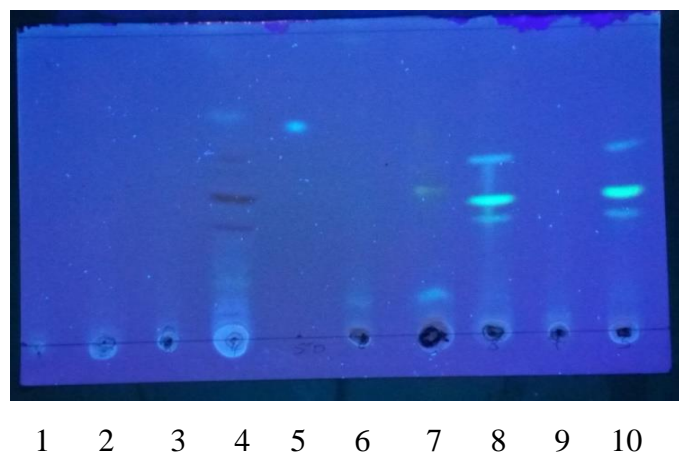


(b)

Figure 2: The photo of *Aspergillus* species, (a) *Aspergillus niger* group on MEA 25°C (5 days) (b) *Aspergillus* spp (×40)

### 3.4 Analysis of OTA

Isolates of *Aspergillus* and *Penicillium* species identified under a microscope (OPTIKA, Italy) (Fig 1 and 2) were screened for OTA production on Thin Layer Chromatography (TLC) plate. Sample from Estates and Factories with detection of mould contamination were used for OTA analysis. The results showed that the samples analyzed tested negative for the presence of OTA (Fig 3). Hence the dry and wet coffee samples from the Estates and Factories which indicated presence of moulds did not show any OTA contamination in the beans. This could be because the mould content level detected in the samples could have been too low or the coffee beans were not kept long enough to allow any OTA production (Suarez-Quiroz et al., 2004)



**Figure 3: TLC plate (silica gel on aluminium) representing OTA analysis after development in Chloroform: Ethyl acetate: Formic acid (6:3:1), as visualized under 366 nm UV light.**

**Key:** Tracks 1, 2, 3, 4, 5, 7, 8 and 6, 9 represents pure *Aspergillus* and *Penicillium* spp. isolates cultures respectively. Track 5 represents OTA standards. Estate C(m) 1, Estate C(m) 2, Estate C(m) 3, Factory F(m) 4, Estate C(m) 6, Factory F(m) 7, Estate A(m) 8, and Factory F(m) 9. The names and the number represent the estates and factories where the isolates were obtained from. (m) –Dry processed coffee.

Ochratoxin A is one of the most dangerous mycotoxin produced by certain filamentous fungi such as *Aspergillus ochraceus*, *Aspergillus carbonarius* with some isolates of *Aspergillus niger* and *Penicillium verrucosum* [24, 25, 26]. A study carried out by [26] showed that the toxicogenic micro flora that was associated to the coffee beans which was contaminated with OTA mainly comprised of *Aspergillus* species. According to Suarez-Quiroz *et al.*, (2004) the incidences of OTA in green coffee beans is attributed to the climate, the method used to process the coffee, how long the coffee is stored after processing and transportation as they influence contamination and growth of moulds.

**Table 3: Ochratoxin A content of coffee beans from Factories and Estates processed by dry and wet methods ( $\mu\text{g}/\text{kg}$ )**

	Estates			Factories					Control sample
	A	B	C	D	E	F	G	H	
Wet Processed	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dry processed	ND	ND	ND	ND	ND	ND	-	-	ND

ND - Not detected (-) Sample not available

#### 4. Conclusion

Research findings from this study indicated that there were significant differences in coffee samples in terms of moisture content of wet processed and dry processed coffee from the different Estates and Factories. Regarding mould contamination, dry processed coffee samples showed higher levels of mould contamination as compared to wet processed coffee. Ochratoxin A was not detected in wet and the dry processed coffee samples from the Estates and Factories. The information obtained from this paper is useful for extension services geared towards training of farmers and coffee handlers by relevant bodies, on effective ways of handling coffee to avoid mould contamination and OTA occurrence in coffee.

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## **Effects of various stabilisers including yam flour on the physico-chemical properties of goat's milk yoghurt**

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### **Abstract**

Goat milk is considered to be highly nutritious and can be processed into various fermented products. Many commercial stabilisers are used to increase the viscosity of all types yoghurt. However, evaluation of yam flour as a yoghurt stabiliser is limited in literature. The objective of this study was to evaluate effect of various stabiliser including yam flour on goat milk yoghurt physiochemical properties. Goat milk was obtained from an identified farmer in Meru County and transported to Food Science Laboratories in Meru University of Science and Technology. Milk was assessed for quality. Yoghurt was prepared with culture 0.0126% and sugar (5%). The various stabilisers; gelatine, yam flour and corn starch at 0.25 0.5 and 0.75% were used. The fermentation was carried out under controlled conditions in a cheese vat. After fermentation, yoghurt was analysed for the viscosity, water holding capacity, susceptibility to syneresis, titratable acidity and change in pH over six hours during fermentation and after 7, 14 and 21 days during storage under refrigeration. The viscosity increased with increasing concentration of all the stabilisers from 0-0.75% during fermentation. Comparing stabilisers at 0.75%, Yam flour and corn starch resulted in highest and similar viscosity ( $0.12\pm 0.01$  Pa.s) compared to gelatine ( $0.09\pm 0.01$  Pa.s). Among the stabilisers gelatine exhibited the highest water holding capacity. This study shows that it is possible to use yam flour in place of commercial stabilizers and achieve acceptable viscosity of goat milk yoghurt. This would provide market and commercial utilisation for yam flour.

*Key words: Goat milk yoghurt, yam flour, stabilisers, viscosity.*

## TTE

### **Integration of E-Learning into Education Sector; a Panacea for Growth and Sustainable Economic Development in Nigeria (A Case Study of Abia State, Nigeria)**

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#### **Abstract**

The percentage of students admitted in Nigerian universities over the years falls below 30% of the students seeking admission. This has resulted to high level of illiteracy, youths' restiveness, Boko Haram, militancy, Internet frauds etc. Hence, the researcher is advocating integration of e-learning in education sector; a panacea to economic development using Abia State of Nigeria as a case study. E-Learning is the teaching and learning activities over the Internet. E-learning platforms include; web base system, multi-media system, interactive videos, virtual class room and digital libraries. Nigeria as a developing economy has over the years depended majorly on the traditional education otherwise referred to as brick & mood class room. Nigeria has adopted many systems of education: 6-5-4 (primary, secondary and university) respectively, 6-3-3-4, and 9-3-4. Although Nigeria has not met the annual proposed education budget of 26% by UNESCO, but has spent billions of money in education sector without the desired result. This paper uses descriptive method. A total of 30 questionnaires were distributed to three out of five higher institutions in Abia State of Nigeria. A Cronbach alpha coefficient was used to test the reliability of the questionnaires at 0.8 while Analysis of Variance was used to analyze the data with the acceptance point of 0.03. It was discovered that integration of e-learning in Abia State school system in particular and indeed in Nigeria as well as other developing countries will increase high quality learning, and high students' intake in our higher institutions. It will also reduce high rate of illiteracy, crime rate (Boko Haram, militancy etc), over dependent on foreign aids, ensure good employment opportunity, and economy of large scale (eradicating poverty and recession). Notwithstanding the epileptic power system and cost of hardware, Nigeria and other developing countries will be transformed to developed economies.

**Key words:** *E-learning, Integration, Panacea, Descriptive method and Economic development.*

## **Dilemma of Integrating ICT into Pedagogy of Lower Primary: A Case of Tablets in Piloting Schools in Homa Bay County; Kenya**

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### **Abstract**

Over the last five years the government, KICD and Primary schools have made considerable investments in providing computer based instruction to support teaching and learning. ICT has strongly influenced education as it has become ubiquitous of instruction offering access to world of knowledge. Therefore, the purpose of this study is to shed light on issues on ICT integration into pedagogy. The objectives of the study were; to find out the role of teachers and pupils in integration of ICT in pedagogy, benefits of integrating ICT into pedagogy, attitudes of teachers and pupils on integration of ICT into pedagogy and challenges of integrating ICT into pedagogy. The study is founded on directed learning theory of Kohn which allows learners to explore the topics that interest them most. A qualitative case study approach was adopted. The sample size was 109 learners, 4 head teachers and 8 teachers. Data collection instruments were observation and questionnaire. Data were analyzed through inferential (spearman's correlation) and descriptive statistics such as standard deviation, means, frequencies and percentages. The results showed that; there was change in roles, teachers are mere facilitators as learners were in charge of their own learning, there is a gap between the proposed and the implemented curriculum for tablet technologies, teacher beliefs are a strong predictor of classroom instructional use, lack of time and access to technology was significant. The finding of the study may create awareness and need for integrating tablets into pedagogy for improved performance, it will save the pupils from carrying written assignment home. Hence the researcher recommends that; teacher capacity building should be part of integration of ICT in pedagogy. MoE should provide each and every child with his/her own tablet. KICD should digitize the content as per the classes.

**Keywords:** *Dilemma, ICT, Tablets, Pedagogy*

# **Influence of Antisocial Behavior Gender Different and Location on Academic Achievement Of Students Of School Of Technology, Kano State Polytechnic, Nigeria**

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## ***Abstract***

This study explores the Influence of Antisocial Behavior, Gender Differences, and location on Academic Achievement of Students of School of Technology, Kano State Polytechnic. The objective of the study was to identify the types of antisocial behavior exhibited by students of school of technology and to examine the most commonly exhibited antisocial behavior among the students. The study equally seeks to examine the link between students antisocial behavior and their academic achievement and to explore whether a statistically significant difference exist in antisocial behavior exhibition among the students due to gender, program and location of residence. In line with the objectives, four null hypotheses were forecasted to guide the study. A survey research design was employed to guide the study. The population of the study comprise of 7,800 students of school of technology 2015/2016 session comprising of male and female students out of which a sample of 365 was systematically selected. Data for the study was collected using an adapted instrument namely antisocial behavior scale with .836 alpha reliability coefficients. Collected data was statistically analyzed with the use of Statistical software (SPSS) using Pearson product correlation, t-test for independent samples and analysis of variance (ANOVA) at P= 0.05 level of significance. Findings of the study shows that school of technology students exhibits antisocial behavior with personality disorder was the most commonly exhibited. An inverse relationship was found between antisocial Behavior and academic achievement ( $r = -.107$ ,  $p = .041$ ), no statistically significant gender difference was found in antisocial behavior ( $t = .032$ ,  $p = .975$ ), location ( $t = -.349$ ,  $p = .727$ ) while a statistically significant difference was found in antisocial behavior due to program of study ( $f = 4.649$ ,  $p = .003$ ). Based on the findings, it was concluded that antisocial behaviors has a bearing on academic achievement and program of study while gender and place of residence does not influence the disposition of antisocial behavior.

## ***SIGNIFICANCE***

The importance of this research needs not to be overemphasized. It is essential to all educational stake holders especially the Polytechnic managements. To educational policy makers, to parents, and mass media, this will asst in decision making as well as guiding students towards abiding by rules and regulations of institutions of learning so as to face their academic studies without involving themselves in any act of anti-social behavior .

## ***DEFINATION OF TERMS***

1. Anti-social behaviors: are behaviors that do not conform to social standards and are acts that causes harm, physical or psychological harm to individuals, animals or properties or

lack of feeling for the right of others and may come in form of personality disorders, conduct disorder, hyper-activity disorder or attention deficit disorder.

2. Academic Achievement: the extent to which a student has achieved cumulative educational goals which is measured through examinations, continues assessment, projects etc.
3. Gender: gender is defined as the socially constructed sex roles of male and female, it is a connotation that sounds psychological background and use to refer to specific cultural pattern or behavior that are attributed to human sexes within different roles and responsibilities of men and women in a particular society.
4. Location: in this context, refers to a place of living where individual's lives can be influence by family, peers, school, climate and geographical reasons.

## **INTRODUCTION**

Higher institutions of learning all over the world comprises students of different sex, age, cultures and ethnic backgrounds to some other factors like emotional issues, aptitudes that are inborn, coming together in the same environment to receive some form of education. Such differences in back grounds may result in some differences in behaviors and attitudes including behavior that are anti social in nature, such behaviors may vary from hyperactivity personality disorder, conduct disorder, attention deficit disorder and other forms of anti-social behavior which are needed to be taking care of with a view to control, manage and produce students with necessary skills of livelihood and knowledge to compete in the world of technology and other related areas. Academic achievement are performances that are measured through different means under conducive learning atmosphere, where they become unachievable due to students involvement in anti-social behavior, learning becomes affected resulting into impede educational and social development and also long life impairment in social and personal life irrespective of gender.

Students behavior problem is a concern to many educators across the wall as Hossain (2013), mention that the current age of educational reforms from problem behavior (anti-social behavior) of student have become an imagine issues for educators, policy makers and school administrators. The case is not different in research findings which have shown that students are so much involved in different behaviors irrespective of gender for instance Dodd (2014) conducted a research on alcohol consumption among tertiary students, result have shown that 65% of the 124 students were involved in taking alcohol while 34% is the female figure for those involved in alcohol consumption.

## **STAEMENT OF THE PROLEM**

student with behavior problems (anti social behavior), family members are not left out in this concern, as no Students who are engaged in anti social behavior are punished accordingly, from verbal warning to written warning, rustication or even expulsion depending on the gravity of the offence. Not only the students suffer but the authority of such institutions are charged with extra responsibilities of managing family will appreciate their children causing problem to their institution through exhibiting anti social behaviors which as strictly against institution rules and regulations, the general society shares the same concern.

The consequences are that students become psychologically, physically and morally affected and it may become difficult to cope up with school life especially where they are expelled, if care is not taken the number of unemployed youths increased due to school dropouts and may be roaming the streets aimlessly as nuisance and economic burden. Parent also suffers in the same vein and more especially financially as their children school years may be extended. The institution may lose its reputation. The general public may also be affected culturally as youths who become school problems may become society problems as well.

### **OBJECTIVES OF THE REASERCH**

1. To find out if students of school of technology exhibit antisocial behaviors
2. To find out the common types of antisocial behavior (ABS) exhibited by students of School of Technology
3. To find out the relationship between antisocial behavior (ABS) and academic achievement of students from School of Technology.

### **SCOPE OF THE STUDY**

The scope of the study centered around the variables of antisocial behaviors, gender difference, academic achievement of students of School of Technology, Kano State Polytechnic. All the antisocial behaviors that are exhibited by the students of School of Technology such as personality disorder, conduct disorder, hyperactivity personality disorder and attention deficit disorder.

### **METHEDODOLOGY**

The study is a survey design which allows for collection of quantitative data using descriptive and inferential statistical methods for analysis. It has a sample of 365 students as respondents drawn by using table for determining sample size of Research Advisors (2006). The data collection instrument is the anti-social behavior scale adopted from Nasidi (2010).

### **CONCEPT OF ANTI-SOCIAL BEHAVIOR**

Anti-social behaviors are actions that harm or lack consideration for the well-being of others. Antisocial behavior (ABS) in childhood and adolescence are categorized to behavioral disorders, impulsiveness, stealing, vandalism, physical and psychological aggression, bullying, running away from home and truant. In this paper, antisocial behaviors refer to a set of behaviors which is against any established rules or norms (Farrington, 2005).

Anti-Social behavior exists where there is unwelcome activity that causes alarm and distress to individuals or families. Acts of antisocial behavior (ASB) can range from noise nuisance to violent behavior. Criminal behavior includes racial harassment and hate crime and the Council takes a zero tolerance approach to all criminal behavior. Antisocial behavior does not include behavior that would be deemed reasonable by most people (Hammersmith and Fulham Council, 2013). Studies have shown that in children between ages thirteen to fourteen years (13–14) who bully or show aggressive behavior towards others exhibits anti-social behaviors in their early adulthood (Renda, 2014). Antisocial behavior (ABS) are unacceptable and can disrupt the quality of both teaching and learning. Everyone has a right to leave in environment free from antisocial behavior.

## **CATEGORIES OF ANTISOCIAL BEHAVIOR**

There are three main categories for antisocial behavior, depending on how many people are affected:

Personal antisocial behavior (ABS)

Nuisance antisocial behavior (ABS)

Environmental antisocial behavior (ABS)

Antisocial behavior (ABS) is any act that imposes physical or psychological harm on other people or their property, lying, stealing, assaulting others, being cruel to others and being sexually promiscuous are all examples of antisocial behavior. Also, such behaviors may sometimes constitute a violation of legal codes and it is often accomplished by disturbances of thoughts of emotions (Jacob, 2002)

Anti-social behavior is seen as overall lack of adherence to social norms and the standard that allow members of a given society to peacefully co-exists, further more anti-social person may be referred to as a deviant personality, a sociopath personality, or a psychopathic personality (Eze, 2008). Anti-social persons are individuals who are characterized by truancy, lack of feelings for the right of others, reliance of violence or threat to solve their problems, tells lies, steals and assault on others, they perform poorly in schools, involved in substance abuse, argumentative, sexually promiscuous, (Health line, 2016). Antisocial behavior is exhibited in children which is characterized as conduct disorder, (CD) and or oppositional defiant disorder (ODD), in adult such behaviors are also exhibited and if not treated can manifest into metamorphoses of serious behavior disorder known as Antisocial Personality Disorder.

## DATA RESULTS AND RESULT PRESENTATION

Table 1-9 are results from anti-social behavior scales distributed to the samples

Table 1 Data Summary for Gender and Location.

<b>Gender</b>	Frequency	Percentage (%)
Male	243	67%
Female	122	33%
Total	365	100%
<b>Location</b>		
Urban	266	73%
Rural	99	27%
Total	365	100%

Table 1, provides the summary of the respondents' gender and location. From the table, 243 male students participated in the study which represents 67% of the sample with only 122 female students representing 33% of the study sample. The wide disparity in the number could be attributed to the school under study (School of Technology) where majority of the course are more inclined to male. Students' location was categorized as urban and rural. A total of 266 students that are urban residence participated in the study representing 73% of the study sample with only 99 students that are rural areas residents which represents 27% of the study sample. In all a total of 365 students participated in the study

Table 2. Data summary for Mean and Standard Deviation of Student Anti Social Behavior and GPA.

Variables	<i>N</i>	<i>M</i>	<i>SD</i>
Antisocial behavior	365	2.300	.4056
GPA	365	2.215	.755

Table 2 provides the mean and standard deviation of the study variables. From the table, antisocial behavior is having an overall score of ( $M= 2.300$ ,  $SD=.405$ ) while students GPA was having an overall score of ( $M=2.215$ ,  $SD=.755$ ) while the *N* represent the sample size.



Table 3 Types of Anti Social Behaviors Identified

<b>Antisocial behaviors</b>	<b>Frequency</b>	<b>Percentage (%)</b>
Conduct disorder	91	24.9%
Personality disorder	98	26.8%
Hyperactivity personality disorder	90	24.7%
Attention deficit disorder	86	23.6%
Total	365	100%

To assess the presence of anti-social behavior among School of Technology students, anti-social behavior inventory was administered to the sample students. Obtained responses shows that of all the various types of anti-social behaviors, school of technology were identified to have four anti-social behaviors namely conduct disorder, personality disorder, hyperactivity personality disorder and attention deficit disorder.

Table 4 Commonly Exhibited Anti-Social Behavior

<b>Variable (%)</b>	<b>Mean</b>	<b>Freq.</b>	<b>Std Deviation</b>	<b>Percentage</b>
Personality disorder	2.453	98	.417	26.8%
Conduct disorder	2.298	91	.364	24.9%
Hyperactivity personality disorder	2.301	90	.468	24.7%
Attention deficit disorder	2.171	86	.503	23.6%

In order to determine the commonly exhibited antisocial behavior among school of technology students, descriptive statistics was used. From table 4.4, the observed antisocial social behavior exhibited by school of technology students are conduct disorder, personality disorder, hyperactivity personality disorder and attention deficit disorder. Further analysis shows that personality disorder was the most commonly exhibited antisocial behavior among the students with a frequency of 98 representing 26.8% and a mean score of  $M=2.453$ ,  $SD=.417$ , followed by conduct disorder with a frequency of 91 representing 24.9% and  $M=2.298$ ,  $SD=.364$ , hyperactivity personality disorder with a frequency of 90 representing 24.7% of the study and  $M=2.301$ ,  $SD=.468$  and lastly attention deficit disorder with a frequency of 86 representing 23.6% of the study and  $M=2.171$ ,  $SD=.503$ . Based on the obtained results, out of the four antisocial behaviors were observed among students of school of technology, personality disorder was the most commonly exhibited antisocial behavior among school of technology students followed by conduct disorder, hyperactivity personality disorder and lastly attention deficit disorder.

Table 5 Relationship Between Antisocial Behavior and Academic Achievement

<b>Variable</b>	<b>Mean</b>	<b>Std Deviation</b>	<b>R</b>	<b>p-value</b>	<b>N</b>
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Academic Achievement	2.215	.755			
			-.107	.041	365
Anti-social Behavior	2.300	.405			

In order to test the stated null hypothesis that there is no significant relationship between anti-social behavior and academic achievement among students of school of technology, Pearson Product Moment correlation was performed. From table 4.5 the correlation value of  $r = -.107$  shows that a weak inverse correlation exist between antisocial behavior and academic achievement of school of technology students. The relationship is significant at  $p = .041$ ,  $p < .05$  level of significance. Based on the obtained result, a statistically significant inverse relationship exist between academic achievement and antisocial behavior of students. Therefore, the stated null hypotheses that there is no significant relationship between antisocial behavior and students' academic achievement was rejected. The finding revealed that a statistically significant relationship exist between antisocial behavior and students' academic achievement in school.

Table 6 Gender difference in antisocial behavior

Anti-social Behavior	N	Mean	S D	t-value	df	p-value
Male	243	2.354	.351	.032	363	.975
Female	122	2.353	.380			

In order to test the null hypothesis that there is no significant gender differences in exhibition of anti-social behavior among students of school of technology, an independent sample t-test was performed. From table 4.6, the mean score on anti-social behavior for each group was  $M = 2.354$  for male students and  $M = 2.353$  for female students. The results revealed that the mean score on anti-social behavior for male students of school of technology ( $M = 2.354$ ,  $SD = .351$ ) is not significantly different from that of the mean score on anti-social behavior for female students ( $M = 2.353$ ,  $SD = .380$ ) at t-value ( $t = -.032$ ,  $p = .975$ ,  $p > .05$ ). Thus, our P value .975 is  $> .05$ . Based on the obtained result, the stated null hypothesis that there is no significant gender differences in exhibition of anti-social behavior among students of school of technology was upheld. The result revealed that no statistically significant gender difference exist in the exhibition of anti-social behavior among students of school of technology.

Table 7a, Antisocial Behavior Based On Program of Study

<b>Department</b>	<b>N</b>	<b>Mean</b>	<b>Standard Deviation</b>
Fashion Textile Technology	48	2.232	.418
Computer science	191	2.416	.364
Mechanical Engineering	102	2.310	.320
Welding and Fabrication	24	2.289	.272

**Table 7b Analysis of Variance (ANOVA)**

Sum of Square	df	Mean	Scores	F	Sig
<b>Between Groups</b>	1.761	3	.587	4.649	.003
<b>Within Groups</b>	45.582	361	.126		
Total	47.343	364			

In order to test the null hypothesis that there is no significant difference in anti-social exhibition among students from different courses from school of technology, a one-way analysis of variance was performed. From table 4.6, the mean score on anti-social behavior for students from different course in school of technology were (M= 2.232, SD= .418) for fashion textile technology students, (M=2.416, SD= .364) for computer science students, (M=2.310, SD= .320) for mechanical engineering students and (M=2.289, SD= .272) for welding and fabrication students.

Result from the Analysis of Variance table (table 4.6.1) shows that a statistically significant difference exist across the mean scores of anti-social behavior among students of different courses in school of technology. This was based on the obtained F statistics value of 4.649 at  $p = .003$ ,  $p < .05$  level of significance. Based on the obtained p value of .003, a statistically significant difference exist in the exhibition of anti-social behavior among students of school of technology.

However, the ANOVA result does not indicates the groups which significantly differ from each other. Thus, post hoc analysis (see Appendix ii) was performed using Turkey's test to determine where the significance lays. Results from the Turkey test shows that the mean score on anti-social behavior of computer science students ( $p = .008$ ,  $p < .05$ ) significantly differs from that of the mean score of students from fashion textile technology ( $p = .573$ ,  $p > .05$ ), mechanical students ( $p = .589$ ,  $p > .05$ ) and welding and fabrication ( $p = .915$ ,  $p > .05$ ).

This shows that the anti-social behavior of computer science students significantly differ from that of mechanical engineering students, welding and fabrication and fashion textile technology. Based on the obtained result, the stated null hypothesis that there is no significant difference in anti-social exhibition among students from different courses from school of technology was rejected. The finding revealed that computer science students were having a higher level of anti-social behavior among students of school of technology.

Table 8 Differences in Antisocial Behavior Due to Location

<b>Anti-social Behavior</b>	<b>N</b>	<b>Mean</b>	<b>S D</b>	<b>t-value</b>	<b>df</b>	<b>p-value</b>
Urban students	266	2.350	.369	-.349	363	.727
Rural students	99	2.365	.337			

In order to test the null hypothesis that there is no significant difference in the level of anti-social behavior exhibition between urban and rural students of school of technology, an independent sample t-test was performed. From table 4.8, the mean score on anti-social behavior for each group was  $M= 2.350$  for urban students and  $M= 2.365$  for rural students. The result revealed that the mean score on anti-social behavior for urban students of school of technology ( $M=2.350$ ,  $SD=.369$ ) is not significantly different from that of the mean score on anti-social behavior for rural students ( $M= 2.365$ ,  $SD= .337$ ) at t-value ( $t=-.349$ ,  $p=.727$ ,  $p > .05$ ). Thus, our P value .727 is  $> .05$ . Based on the obtained result, the stated null hypothesis that there is no significant difference in the level of anti-social behavior exhibition between urban and rural students of school of technology was equally upheld. The finding revealed that no statistically significant difference exist in the mean score of anti-social behavior of students of school of technology from urban and rural areas.

## CONCLUSIONS

From the data above, t was found that

- School of Technology students exhibits antisocial behaviors.
- Four types of antisocial behavior were found to be exhibited by students of School of Technology.
- The most commonly exhibited anti social behavior was personality disorder followed by conduct disorder, hyperactivity personality disorder and lastly attention deficit disorder.
- Students from Computer science department exhibit high level of anti-social behavior among School of Technology students.
- Higher level of antisocial behavior disposition by a students would lead to low academic achievement.
- An inverse relationship exists between students antisocial behavior and their academic achievement, thus, the higher the level of students antisocial behavior disposition the lower will be their academic achievement and the lower the level of antisocial behavior disposition the higher will be their academic achievement.
- No statistically significant gender difference exists in the exhibition of antisocial behavior among students from School of Technology, this indicated that gender does not in any way influence antisocial behavior disposition of a person.

- Location is not an index in disposition of anti-social behavior among students of School of Technology because was no significant difference existing in antisocial behavior of students of School of Technology from rural and urban areas.

## RECOMMENDATIONS

1. The school and students unions should be organizing events which will facilitate students interaction with a view to minimize antisocial behavior related problems and as well incorporate students with such behavior problems with prosocial individuals.
3. Students should engage in prosocial act and avoid antisocial behavior due to their negative impact on their academic achievement. This is because prosocial behaviors have a positive bearing on students' academic achievement.
4. Parents and school authority should give equal emphasis to both sex in their campaign toward prosocial behaviors because gender does not have bearing with antisocial behavior.

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## **Challenges affecting successful implementation of blended learning in TVET institutions in Kenya**

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Blended learning has been used to integrate information and communication technologies with traditional classroom teaching to create a flexible, efficient, and personalized instructional methodology. Its continued use in institutions of higher learning has proven its sufficiency in achieving broader national education goals of improving social equity, economic development, and equitable access to education services. Despite the revolutionary and strategic role of blended learning in meeting demands and expectations of modern education system, its uptake in TVET institutions in Kenya is relatively low due to its relative complexity when balancing curriculum, learning, institutional, operational, and sectorial needs especially in resource constrained settings. The objective of this study is to determine the challenges faced by TVET institutions of Kenya when implementing and operationalizing blended learning, as well as propose a strategy that reduces their implications on learning outcomes. An exploratory methodology has been used to review secondary sources of data relating to the TVET sector. Results indicate that issues and challenges of blended learning can be classified into the following categories: instructor, technological aspects, content development, students, and institutions. A multifaceted strategy that coordinates the functions of TVET institutions, education agencies, and the government has been proposed to provide a holistic solution to the existing challenges. Whereby, institutions focus on curriculum development, leadership, technical capacity, and teacher training on requisite skills and competencies to teach with ICT successfully. Education agencies develop and enforce standards and guiding frameworks in line with broader government policies.

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## Evaluation Based Teaching as A Confidence Builder in Good Teaching Practice

Dr. Kipsang B. Rop

### Abstract

Every one requires confidence in order to perform any task. Similarly, students require confidence in their studies so as to pass examinations for the courses they undertake. I treat confidence as a psychological feeling that gives students courage to face challenges in a leaning environment with positive expectations. In fact, adequate confidence is most needed for attaining good results from practical assignments and for achieving best results in final examinations. Evaluation based teaching was considered as one of the practices that are good for confidence building. The practice can be applied in competency based curricula, to yield good examination results and eliminate examination cheating. It allows typical *summative evaluation* to be carried out in stages throughout the semester while the syllabus is being covered. I personally encourage those participating in harmonization of higher education programs for African universities to embrace this practice for the common good. The evaluation based teaching practice was applied to the course unit named Fundamentals in Engineering Geology. The course unit is offered to degree students pursuing Bachelor of Science in geology during first semester of third year in my institution. It is a core unit that provides an understanding of geological set up of construction sites so as to permit design of infrastructural structures. A set of past papers for end of semester examinations for previous eight semesters and a copy of model answers for one of the semesters were availed to the students, class size 14 for the students to; Appreciate complete coverage of the syllabus that is done during setting of final examinations, Differentiate levels of leaning that are tested as noted for questions that required a candidate to state, outline, explain, describe, solve etc.; the differences were explained to them, Refer later to the past papers when given assignments, individually or in groups collaboratively, Make solutions when each topic is covered as a provision of self-evaluation thereby capturing learner-centered requirement while contents for the entire syllabus are covered, To be able to predict questions that could be set based on probability techniques, Appreciate question answering style and depth of coverage as reflected in the model answer. The topic on geological maps was well represented with questions on geological cross sections that require drawing skills, covered for five semesters consecutively. End of semester examination question papers are open to public for use after the examinations have been done and are always available, although extra similar material can be issued while the semester is on. End of semester examination results for the class that was subjected to evaluation based teaching method were compared with results for pervious groups of similar class size that undertook the same course unit but had not been exposed to same method. Comparative statistical results for the performance were made from the comparison done and conclusions drawn forthwith. The practice, if applied, will make students to have an overview of the syllabus content up to evaluation level right from day one thereby triggering their eager to learn and pass final examinations. Repeated exposure to final past paper questions will increase students' skills in problem solving and decision making. However, the students will tent to avoid solving problems outside the syllabus, as a learner weakness, even if the problems are similar to the ones covered by the syllabus.



## **Introduction**

Teaching as a process of passing valuable information to a recipient is a noble career which has been respected in the society from time in memorial. In the past African societies, teaching used to be informal and undertaken by village elders and grandparents through verbal communication. Later on it became formal when education curricula were introduced for various programs parked up by teaching aids. This paper describes teaching practices that were applied to engineering geology as one of the course units in Bachelor of Science degree in applied geology. Special emphasis was focused on evaluation based teaching practice. The paper is intended to benefit participants of the symposium organized by the management committee of Tuning Africa Academy. It will encourage educationists who are involved in harmonization of higher education programs for African universities on the need of using practices that are effective in teaching, learning and evaluation processes.

Curriculum development is a tedious and a time consuming process which is done to satisfy needs of the industry as one of the stakeholders. Educational institutions empower the students, as workers to be, by imparting into the students, knowledge, practical skills and positive attitudes under classroom, laboratory, workshop and field situations. Capability of the students to deliver can only be confirmed by the employer thereby reflecting on the relevance and strengths or weakness of the curricula used, otherwise a review if not an overhaul of the curricula becomes necessary. Thus, the graduates produced at university level should be well equipped to face challenges of the industry. This aspect was a driving force in creation of the current program so as to make it relevant to construction industry as the main consumer of first degree holders of Bachelor of Science degree in applied geology. Furthermore, geology is one of geotechnical areas that design of building and civil engineering structures relies on for determination of suitability of proposed construction sites. Thus, a sound curriculum which emphasis on expectations of the workplace, particularly the construction industry has to be put in place.

This paper gives an overview on the creation of the current curriculum in applied geology as modeled by my department while capturing learning outcomes that have expectations of the industry. Various aspects of teaching that encompasses, classroom management, teaching methods, learning styles and assessment methods are discussed. It exposes the experience I gained, for first time, when teaching the course unit named engineering geology to a class to which I had subjected a new teaching practice. The outcome harvested was impressive as witnessed by statistical results obtained and reflection on the teaching administered as described in this paper.

## **(a) Program Design**

### **(i) Entities involved in the process of course design**

My department has a curriculum development committee which is charged with the responsibility of developing and reviewing education curricula. The committee used the current curricula for Bachelor of Science degree in geology from various universities to overhaul both regulations and syllabus contents therein while focusing on the performance of current graduates in the construction industry. This action was taken based on the consensus that construction units were to be introduced so as to widen employability of the graduates and enable them deliver more competently. The following were resourceful in providing criticisms and guidance at stake holders' forums held that saw final development of the new curriculum a success:

- Academic staff members,
- Practicing geologists in private sector,
- Practicing building and civil engineers in the construction industry,
- Experts in environmental based non-governmental organizations engaged in geological and construction concerns.

### **(ii) Design of learning outcomes for the program**

Sectors that absorb graduates, particularly mining, hydro-geological, construction and research based organizations were captured as major focus for development of work place learning outcomes. They are the main anticipated employers of our graduates. The learning outcomes provided in the curriculum will enable the graduates to perform specified tasks in the industry and hence indirectly captured subject specific competencies.

Learning outcomes under classroom laboratory/workshop or field environments were also addressed. The outcomes involving correct demonstration of understanding knowledge in specified areas and effective communication, among others. In this case, the outcomes represented indirectly the envisaged generic competencies.

### **(iii) Other design considerations**

#### **Categorization of course units**

- 1) Basic physical sciences and Mathematics including information technology,
- 2) Complementary units-common to other programs,
- 3) Core units for Applied Geology

#### **Sequencing of the course units capturing pre-requisites**

There are study areas for which contents fit in more than one unit. For such areas, the contents were spread into two or more units in order of increasing level of learning. It was also ensured that the units were sequences in the same order when time tabled. Thus, units of lower learning level were treated as pre-requisites and were time tabled earlier.

**Examples of learning outcomes that fall under generic/subject specific competencies which were provided in form of objectives**

<b>Course unit name</b>	<b>Course unit objective</b>	<b>Competency categorization</b>	
<b>Communication skills</b>	To use effective communication methods when reporting results for assignments in various course units.	Generic competency	Ability to communicate effectively when executing business tasks at work place. For- prompt and effective report writing when assigned duties.
<b>Entrepreneurship education, Business plan</b>	To demonstrate understanding of correct and effective managerial skills that applies to entrepreneurial investments.		Ability to demonstrate leadership skills. For- management of projects at work place.
<b>Environmental impact assessment</b>	To demonstrate understanding of stages applied in environmental impact assessment.		Ability to demonstrate Environmental awareness. For- applying remedial measures to negative impact to be caused by activities at work place such as mining, quarrying etc.
<b>Computer applications</b>	To use softwares such Excel and MATLAB in solving problems involving statistics and numerical methods	Subject-specific competency	Ability to use and/or develop modern analytical and numerical techniques in solving geological problems
<b>Mapping sedimentary terrain, Mapping igneous terrain Mapping metamorphic terrain</b>	To identify and collect rock samples from different geological terrains, To distinguish rock samples from different terrains using petrological studies, To produce standard geological maps for different terrains using geological measurements and petrological as well as structural results.		Ability to collect, analyze and interpret geological data using various Geoscientific techniques for different infrastructural projects.
<b>Construction materials I, Construction materials II</b>	To identify and select suitable construction material based on geotechnical properties		Ability to identify the genesis, types and uses of geological Materials.

### Allocation of contact time

Contact time for degree course units in our institution is 3hrs per unit for 15 weeks per semester thereby giving total of 45hrs for each unit. Therefore, the applied geology program had to conform to this time allocation which in practice includes the duration for end of semester examinations.

### Course description

Contents to be covered for each course unit were arranged systematically in increasing order of strength. Thus, for each sub-topic, concepts were put first followed by application and then problem solving where applicable.

### Teaching methodology

Teaching methodologies will consist of the following delivery methods:

- 1) Lectures and tutorials by institution lecturers,
- 2) Talks by selected professionals,
- 3) Assigned reading of relevant materials
- 4) Audio-visual presentation
- 5) Laboratory/workshop practice and preparation of reports
- 6) Field work demonstration, practice and Visits to relevant industries

### Instruction materials and equipment

- 1) Classroom lectures using white board
- 2) Hand outs: soft and hard copies
- 3) Power point presentation on screens
- 4) Overhead projector presentations
- 5) Audio-visual presentation on screens and speakers
- 6) Library books, e-books and linkages

### Course Assessment

Assignments, continuous assessment tests and practical work to be examined are to constitute a total of 30% while end of semester examinations will carry 70%. Marks distribution is as follows:

Item	Mark (%)	
Assignments (at least 2)	5	30
Continuous Assessment Tests (at least 2)	10	
Laboratory/workshop Practices and Reports(at least 3)	15	
Semester Examination	70	
<b>Total</b>	<b>100</b>	

### **Industrial attachment**

Industrial attachment was introduced to be administered at the end of 3<sup>rd</sup> year for a duration of 14 weeks. Students are expected to participate in various geological and/or construction activities in the industry and be supervised as per stipulated regulations.

### **Reference material**

Relevant textbooks and journals were identified for each course unit and listed as appropriate.

### **Program Regulations**

Regulation to govern mounting of the program was death with in details. Covered under the regulations are; mission and vision of the university, goals, justification of the program, job opportunities for graduates to be produced, entry requirements for applicants and examination regulations for candidates.

### **(b) Classroom Management**

**(i) My first day in class:** First encounter with learners is crucial in a number of ways, particularly on the basis of good human relations. Cordial interaction should be witnessed on first encounter so as to result into learners liking both the resource person and the new subject being introduced. If learners develop a negative attitude towards the resource person then they could end up disliking the subject as well. According to Wolk (2003), teachers must "win their students' hearts while getting inside their students' heads". Furthermore, developing good relationships with students results into fewer classroom behavioral problems and better academic performance (Deckeret et al, 2007). Class BSCE/Jan 2015/S-EV of 14 students was one the four classes I was time tabled in January 2016. I taught students of this class the course unit Engineering Geology. Activities during my day one encounter with the class were as follows:

**Filling of class attendance register:** I introduced myself to the students then provided a blank class register for each student to fill student number, name and sign accordingly. The filled register was then handed back to me for custody.

**Overview of syllabus content:** I introduced the course unit coupled with basic definitions then outlined the key aspects of the topics as shown in the syllabus contents using white board and coloured markers. Emphasis was focused on relevance of physical sciences, computer science as information technology and entrepreneurial education as well as environmental impact assessment as complementary units for the program. I then used overhead projector and PowerPoint slides to show typical application areas where applied geology plays a crucial role. Slides on landslides as geodisasters affecting highly weathered and saturated physiographical landscapes, and provision of retaining walls as mitigation measures were exiting to the students. The message delivered also proved that there exist a link between applied geology

and construction engineering. For instance, figure 1 shows that despite applying engineered benched mining technique to mitigate slope failure as shown in (b), geodisasters involving land sliding can still occur just as the case in (a). Thus, disaster preparedness measures should be in place all the time.



**Fig.1: Typical geodisasters involving slope movement**

**Overview of past papers and model solution:** I distributed past papers for previous eight semesters to the students and a model answer for one of the examinations. The students noted that each question paper contained; examination instructions as provided on the rubric, Five questions out of which three questions were to be answered including question one that is compulsory, maximum time allowed of 2 hours and maximum marks for each question being 20 marks each. The levels of leaning examined were explained to them to distinguish comprehension questions from questions that covered analysis and synthesis. Differences in depth of answering for questions that required a candidate to state, explain, describe, solve etc including their corresponding solutions as contained in one of the model answers provided were explained satisfactorily. The past papers were to be referred to, by the student, when given assignments and for revision whenever each topic is covered. It was expected that at the end of the semester, revision of the syllabus contents, would have been done on continuous basis.

**Issuance of lecture notes:** I issued a bounded hard copy of lecture notes for the entire course unit to the class representative for each student to make a copy later. I also uploaded a soft copy of the notes to the e-mail address of the class representative. The class representative was to forward the same to the classmates after the lesson. The lecture notes contained references of other publications that they could refer to at the hour of need.

**What I shared with students:** I counselled the students on the need for seriousness in their studies, self-discipline as adults and self-motivation for them to realise success at the end of the program. I explained

to them that copies of the past examination questions papers issued to them on day one were to act as a

confidence builder. They were to appreciate a satisfactory coverage of the syllabus that was always embraced when setting end of semester examinations. I urged them to aim at highest best grade and consult for clarification and when in difficulty. I advised them to contact me in case they missed any lesson for remedial measures to be taken. The students were, warned on examination cheating since the system expected them to be honest and truthful all the time. They were also expected to have attained class attendance of at least 75% as contained in the program admission booklet covering examination regulations, to which I referred them for details. I further alerted the students to expect at least two assignments and two continuous assessment tests as a course requirement for continuous assessment purposes. A student who enters a classroom late normally disrupts an ongoing lesson. To this, I advised students to observe punctuality for all lessons and that a student who is late for more than 15 minutes was to stay out of class and report to me, when the lesson is over, for further direction and guidance. Unsatisfactory explanation for perpetual lateness and absenteeism were to be reported to head of department for necessary action. We then unanimously agreed that all cell phones shall be in vibration mode or shall be put off during lesson time for convenience to everyone. In that way, I had timely established classroom rules for positive behaviour I was to expect from the learners.

**(ii) Engineering geology and world of work:** University education prepares students to be able to contribute to nation building at the end of their studies. I informed the students that they are expected to be equipped with knowledge, practical skills and positive attitudes that will give them the ability to perform competently at their place of work. I explained to the students, significance of applied geology to infrastructural development in which construction engineering is the main player. Furthermore, all construction projects are located on sites of which geotechnical aspects of applied geology, among other considerations, have to be invoked when ascertaining suitability of proposed sites. I enlightened the students on Career opportunities that await them on successful completion of their studies. The opportunities at hand were;

- 1) Energy resource firms particularly for Oil and gas drilling as well as Coal mining activities,
- 2) Hydropower generation and Geothermal power companies,
- 3) Ground water resources exploration and drilling firms,
- 4) Ore and industrial minerals mining companies,
- 5) Construction industry as ground investigation consultants,
- 6) Academic institutions of higher learning,
- 7) Governmental and non-governmental Research institutions as International organizations.



## (c) Teaching Methods

### (i) Classroom methods used

Teaching as an art and a skill of transferring knowledge from an expert to a learner requires use of different methods so as to reach both weak and gifted learners. I used the following methods to deliver the knowledge in styles that engaged the students in a learner-centered process:

- **Lecture method:** Lecture lessons involved verbal communication of geological information on concepts and specific knowledge for respective topics. The lecturing took about 1 hours and was aided by power point slides and an overhead projector. When writing on the white board I strategically positioned myself so as to allow all students a clear view of the writings made. The strategic position taken also guaranteed effective eye to eye contact while lecturing progressed thereby engaging students well.

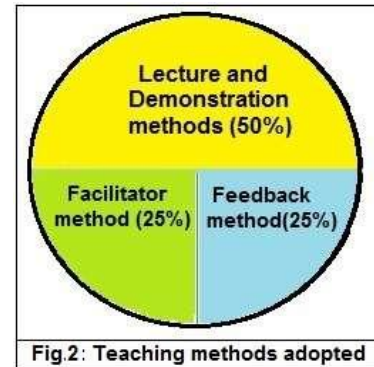


Fig.2: Teaching methods adopted

- **Demonstration method:** This method, also referred to as coach style, was applied for topics that required application of theory to practice. Thus, during lecture time, it was slotted in so as to aid the teaching and learning process. A typical example used was 'determination of correct direction of engineered quarry excavation to produce benched slopes'. It was done by drawing sketches on white board after slide viewing. Demonstrations were mainly done during 3hour practical lessons to cover areas such as interpretation of engineering geological maps and orientation of discontinuities in rocks.

- **Facilitator method:** This interactive method also known as activity style was applied in answering questions from students at the end of the lecture time. The question answering session took about 45 minutes. It promoted self-learning and helped students develop critical thinking skills and question answering techniques as well as increased knowledge retention.

- **Feedback method:** This method involved returning marked scripts for students' homework for previous lesson and assignment that involved website/library work. The method provided a mode of communicating that focused on constructive criticism to students regarding their performance with recognition being done for best performers. The method was undertaken for 45 minutes after facilitator time and thereafter similar assignment given out for following week's feedback.

**(ii) Strategies for engaging students:** I moved around the classroom to ensure teacher-learner eye to eye contact was effected adequately and that no student was involved in a different activity. Stretching and body shaking activities were applied when concentration got diminished in order to put learners back on the track. I also did reinforce positive behavior for outstanding performers by using words of praises and a

hand clap, popularly referred to as ‘thunder clap’. When returning the scripts during feedback time, I made an overview on performance for each student so as to point out weaknesses and strengths. In that way, I engaged each student to learn skills for making correct answers. Also, during practical sessions, I ensured that each student carried out at least one of the steps involved in experiments and use of the data obtained in interpretation stage.

**(iii) Problem based learning:** Adequate problem solving enables a learner to master acquired concepts, particularly if the concepts are applied to real world. Therefore, I prepared open ended geotechnical problems for the students to solve. They utilized library and website facilities in their search for solutions. Occasionally I gave group work assignments, for which each group leader, for the three groups, reported findings for the group, during feedback times. The group work given allowed interaction and collaborative efforts to mature up for the group members.

**(iv) Use of technology in class;** Laboratory analysis, for the course unit Engineering Geology, involves studies of different rock or mineral samples from the field using various apparatus and equipment. I used slides to show operation procedures for different equipment under classroom environment. At times I displayed coloured pictures and photographs for key equipment, processes and samples to act as an aid in the descriptions. Later on, actual use of the equipments was done under laboratory/workshop conditions.

**(v) Positive effects and impact of teaching strategies**

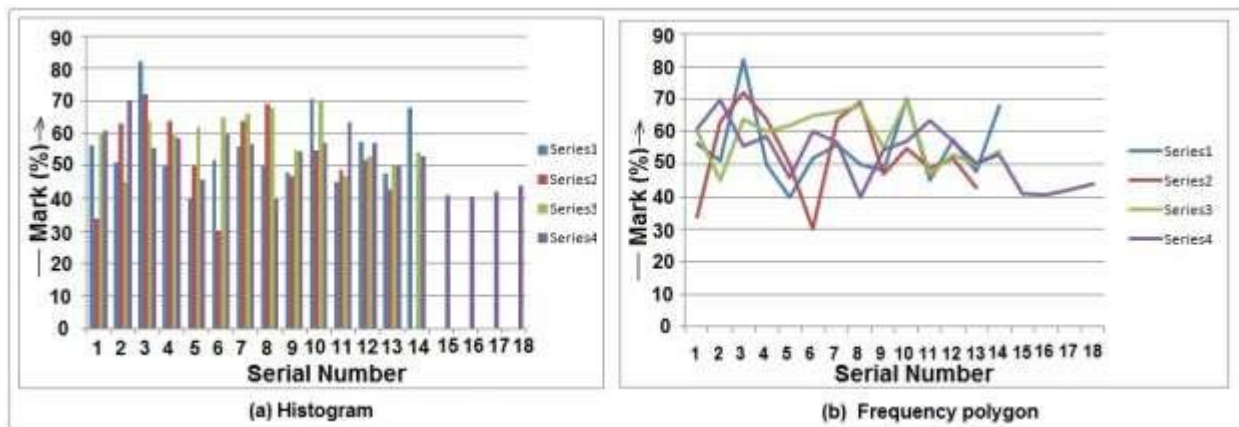
- ***Issuance of class rules on day one:*** Timely awareness of discipline behaviour in class contributed to effective class control. It made students to be attentive during lesson time and avoid attempting to engage in wrong activities.
- ***Past paper examination questions:*** Provision of past examination question papers was fruitful. Questions for each topic were well answered before moving to the following topic and at the end of syllabus content coverage, revision had been done. Furthermore, students were well aware of the expectations for depth of coverage expected for each type of question set and levels of learning tested when examination setting is done.
- ***Group work assignments:*** Group work assignments, being learner-centric and collaborative, enabled gifted learners to share knowledge and problem solving skills with weak learners, as classmates. It also contributed to bonding amongst the students, thereby overriding cultural and religious barriers that normally exist. Thus, overall academic strength for the class increased leading to good performance. Leadership and presentation skills as noted in group leaders, during feedback time, were impressive and satisfactory.
- ***Issuance of full lecture notes on day one:*** Notes are summary of lectures. In this case, the time I would have spent writing during lesson time was utilized on a different item.

- Statistical analysis for semester performance:** Performance for the class that was subjected to evaluation based teaching method, as a new stimulus, was compared against performance for other similar classes that had not been subjected to the same new stimulus. The results used for four classes are as shown in appendix B. Thus, evaluation results for continuous assessment and end of semester examinations were analyzed statistically in Microsoft excel environment and results obtained were as follows:

**Table 1: Statistical results**

Item	Class			
	BCE/Jan2015/ S-EV	BSCE/Jan2013/ S-PT	BSCE/May2013/ S-EV	BSCE/Sept 2012/ S-PT
Mean score	55.00	53.23	58.50	53.00
Standard deviation	11.23	12.96	7.93	8.86
Range	42	42	25	30
Representation in fig.3	Series 1	Series 2	Series 3	Series 4

Some positive correlation was realized from Pearson correlation coefficient of about 0.10 between continuous assessment evaluation and final semester evaluation for class BCE/Jan2015/S-EV, thereby suggesting a possible contribution from evaluation based teaching method that had been applied, among other factors. Correlation check was relevant since continuous assessment is expected to have contributed to performance in final evaluation.



**Fig.3: Graphical representation**

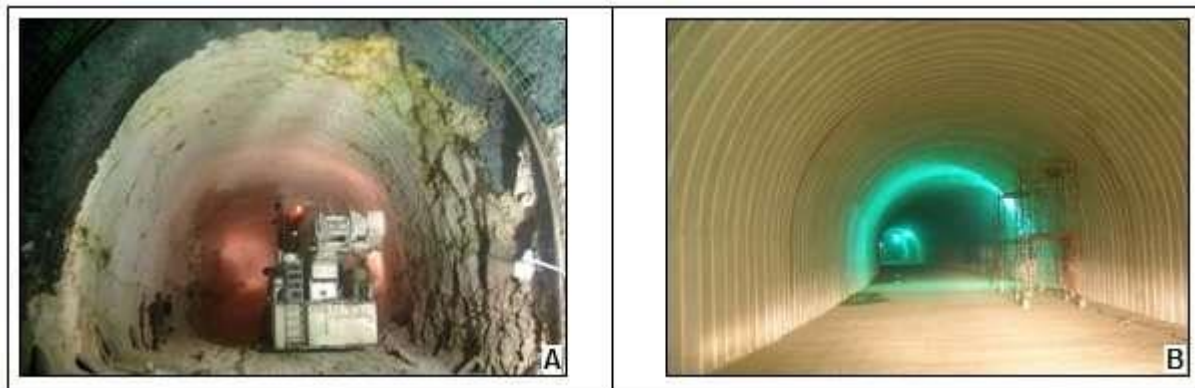
**Test of hypothesis:** Testing of hypothesis, at 5% level of significance, was done on the proposition that ‘evaluation based teaching method had contributed to good performance in end of semester examination for the course unit named engineering geology’. Continuous assessment was out of 30% while end of semesters marks were out of 70%. Each mark was converted to 100% as appropriate and Student ‘t’ distribution used in computation since population sizes were less than 30. Results obtained as shown in appendix C is that the proposition was accepted at the level of significance considered.

#### (d) Learning Styles

Learners take in and process information by seeing, hearing, reasoning logically, analyzing data, etc. from a source that depends on the teaching method in operation. It is preferred that teaching methods be varied in order to capture preferred learning style for each student. Furthermore, each teaching method, particularly for technical courses, needs to be aided so as to arouse students' curiosity and anxiety as to what lies ahead whenever a lesson is in progress. Apparently, when a mismatch between teaching and learning occurs, then the students easily lose concentration thereby resulting into a state whereby teaching goes on while learning is not taking place. As for me, I applied the following learning styles to achieve best results:

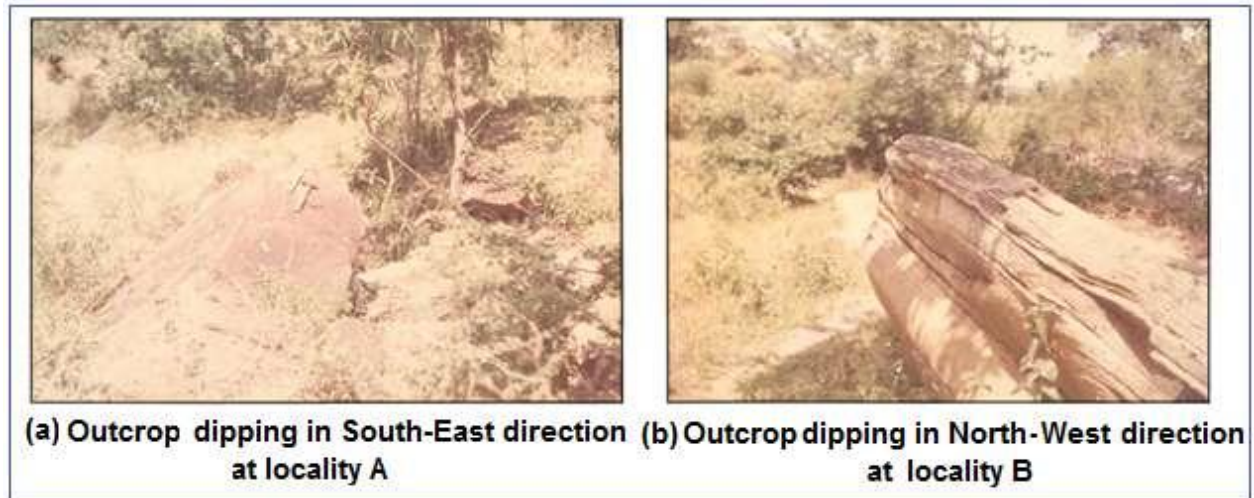
(i) **Solitary style:** This style allows students to work alone. Giving individual practical assignments were found to be suitable for this style. It was an opportunity for active learning and engaged students in practical learning activities. For instance, carrying out five (5) laboratory tests on same geomaterial in order to determine the criteria for suitability or otherwise, if the material is proposed for roadwork yielded different results from the students.

(ii) **Visual style:** In this style, also known as spatial, I used power point slides to display photographs, sketches and drawings. Use of audio-visual aids of the web-site also proved exemplary, particularly the tunnel boring machine which fixes concrete segments for support while excavation progresses and robotic shotcreting technique of tunnel support as shown in figure 4.



**Fig.4: Construction of Kent Tunnel in U.K; Robotic shotcreting (A), Completed tunnel(B)**

(iii) **Logical:** Logical reasoning is needed when applying concepts to obtain an acceptable outcome. This is the case when interpreting the occurrence of geological structures. For instance, use of geological maps to note change in direction of dip for folded rock strata which can be confirmed from rock outcrops in the actual field (e.g. in fig.5). The intensity of deformation, as reflected by the amount of dip, can also be determined by measuring the angles of dip on the maps or geological cross section provided.



**Fig.5: Rock outcrops for folded meta-sediments South-East of Murang'a, Kenya**

**(iv) Problem-based learning:** This style also referred to as 'social style' enabled students to learn in groups and also to learn from each other through questioning and determining answers collaboratively. Thus, group assignments were given to the students to search for specific solutions. Such assignments included; investigative determination of geotechnical considerations that were adopted for approval of site suitability e.g. for the site on which Marine Engineering block was constructed.

**(v) E-learning:** Website facility offers an opportunity for fast written communication in digital form. In this case, students learned use of on-line spaces for communication purposes of which they can apply at their own work places. They then practiced up-loading of information, scanned illustrations and images of geological features, and sending the same to my e-mail, as solutions for assignments done.

**(vi) Project-based Learning:** This style enabled students to individually solve problems that require wide knowledge while focusing on the needs of the industry. Thus, my students undertook projects such as studies to determine environmental impact caused by geological/construction activities of selected companies in Kenya.

**(vii) Experiential learning:** Experiential learning refers to applying knowledge to experience in order to develop skills or new ways of thinking. The learners may identify the knowledge they require and then acquire it themselves, reflecting on their learning styles as they progress Moon (2004). Thus, learning takes place by doing according to Lewis and Williams (1994). Experiential learning can be field-based e.g. during internship or classroom-based such as through group work, case studies etc. I allowed students who are employed to be in different groups for them to share workplace experience, as background knowledge, with other group members. For the learning to be effective I factored in the following:

- Cultural diversity of the students as it would contribute to their cordial interaction,
- Pre-requisite course content that should have been covered when composing assignments,

- Significance of activities to be involved to course objectives and institutional goals,
- Comparison of experiential activities to be involved with documented course content,
- Link between problem or questions to be solved and activities so as to stimulate critical thinking,
- Provided clear expectations in form of assessment criteria used and references of completed projects.

**(e) Assessment Methods**

In assessment of learners' performance, the primary goal is to choose a method which most effectively assesses objectives of the unit of study while capturing overall aims of the program and addressing abilities at envisaged work place.

**(i) Development of competency-based assessment and methods used:** In developing competency based assessment, I considered broad categories of learning outcomes as proposed by Nightingale et al (1996). The competency based learning outcomes considered, which would empower the students to deliver effectively at work place were;

- Written communication,
- Critical thinking and sound judgment,
- Problem solving and planning techniques,
- Performing procedures and demonstrating techniques
- Demonstrating knowledge and understanding

**Assessment methods used were;**

- ***Assessment of individual assignments:*** For assignments involving geological or construction applications, I checked for constructive flow of information as portrayed by solutions for every problem, critical reasoning and sound judgement for problems that involved synthesis and analysis, concept mastery and problem solving skills and demonstration of knowledge understanding for comprehension problems that required memory recall.
- ***Assessment of Collaborative/group assignments:*** The assessment was similar as for individual student. In addition, I considered constructive verbal communication based on presentation form the group leader.
- ***Assessment of practicals:*** Ability to perform laboratory tests, by students after demonstration being done as contained in codes of practice for the tests was assessed by observing performing procedures of which the students used. That was followed by assessing knowing of relevant concepts that apply to the tests by oral questioning. The verbal answers given were subjected to constructive communication checks.

### **(ii) Peer assessment strategy in class**

Two of the assignments given to the groups were for peer assessment purpose. The assignment was in project format and the students sort for solutions to the assignment collaboratively. However, each student presented a section of the project and was assessed. The presentations done were given same weighting.

### **(iii) Examples of formative assessment**

In general, models of assessments are categorized under formative (continuous) and summative (final).

Formative category is either formal or informal. I applied informal methods as follows:

- **Checks for Understanding:** I posed after a few minutes of lecturing so as to check whether the students had understood the knowledge already delivered or not. I also stopped after a few minutes of lecturing to reinforce the learning by using power point slides. By oral questioning and assessment of the responses received, I was able to identify gaps in comprehension and take corrective measures. Similarly, when demonstrating a practice in the laboratory, I posed at end of each step to conform if the students had understood the process before proceeding to the next step and that they had not deviated to other activities out of curiosity.
- **Class Deliverables.** This is an assessment for team-base learning where acquisition of knowledge takes place collaboratively in groups. Thus, I assessed the group assignments as outlined in e (i).

### **(iv) Feedback to students on assessment tasks**

Answer scripts for all assignments were returned to students. Performance for each assignment was discussed and areas that had been performed below average or were not well answered were identified and revisited. That feedback to students on their assignments was effected during feedback session as factored in lesson plan.

### **(f) Reflection on Teaching and Conclusion**

In most institutions questionnaire feedback is recognized as a major source of information for review exercises and for regular monitoring. However, it should be used in combination with other forms of feedback. Evaluation of teacher performance by students is a common practice in the USA although less common in the UK. However, in some institutions elsewhere, module questionnaires are used. As for my case, I developed a *course unit* questionnaire to be filled by students at end of the semester for analysis to be done thereafter. A copy of the questionnaire is shown in appendix A. Aspects covered in the questionnaire focused on both effectiveness of resource person and competencies of the course unit.

Educating a learner from pre-unit to university level, for the learner to be able to deliver competently afterwards in the industry, is amazingly very costly. Thus, it is a challenge for teachers and other players



involved in molding learners to be committed and ‘play to the rules of the game’ if positive results have to be realized at the end of the day. Challenges involved can be overcome if various teaching methods adopted are tuned in favour of learning styles since it is the learners who are recipients of stimuli. However, factors that contribute to excellent performance in examinations are several. In fact, it is also a challenge to isolate and celebrate any one of them as being the major cause for excellent performance.

When the teaching and learning activities are over at the end of the semester, efforts should also be made, to reflect on the teaching that had been done. In that way, strength and weaknesses of the resource persons involved can be diagnosed, identified and corrective measures mitigated accordingly. That effort is in the right direction and should continue to be emulated by all of us who are in the teaching profession.

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*<http://www.edutopia.org/blog/student-feedback-improves-your-teaching-vicki-davis>*

## Appendix A: Teaching and Learning Questionnaire

Course unit name: \_\_\_\_\_

Semester: \_\_\_\_\_

Academic year: \_\_\_\_\_

Date: \_\_\_\_\_

The University continually seeks to review and improve the quality of its teaching and learning. The purpose of this questionnaire is to enable staff to use student opinion in their review of this course unit. Each response will be aggregated with others and held in confidence. The questionnaire focuses on aspects such as subject matter and teaching styles. Kindly, let your contribution be constructive and truthful in this endeavour.

Please answer the following by ticking in the appropriate box:

S/N	Question	Response				
		A	B	C	D	E
1	The aims, objectives and learning outcomes of the teaching were clearly stated and followed					
2	The teaching was well organized and delivered in a logical sequence					
3	The lecturer displayed interest and enthusiasm for the subject					
4	The lecturer made the sessions interesting and informative					
5	Assessment methods were appropriate and fair					
6	The lecturer had a comprehensive knowledge of the subject matter					
7	Comments on the assessment feedback were helpful					
8	Group discussions/tutorials were valuable					
9	The course unit enhanced my understanding of the program					
10	The course unit generated intellectual and analytical skills					
11	The course unit utilized relevant industrial examples					
12	The course unit is supported by adequate library resources					
13	I attended lectures regularly					
14	I participated actively in practicals, Group tutorials/ discussions					
15	I spent sufficient time reading/researching in order to fulfill the course unit's academic requirements					
16	The course unit is relevant for the program					
		A = Strongly agree    B = Agree    C = Not sure    D = Disagree    E = Strongly disagree				

Please comment on the following aspects:

17	Three aspects you LIKED about the course unit	1 <sup>st</sup> Comment
		2 <sup>nd</sup> Comment
		3 <sup>rd</sup> Comment
18	Three aspects you DISLIKED about the course unit	1 <sup>st</sup> Comment
		2 <sup>nd</sup> Comment
		3 <sup>rd</sup> Comment

**Appendix B: Examinations Results for Four Classes**

BCE/Jan2015/S-EV (Class A)	S/N	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	CAT (%)	18	20	25	22	20	24	24	21	21	19	18	19	21	20
	EXAM (%)	38	31	57	28	20	18	32	29	21	51	27	39	27	48
	TOTAL (%)	56	51	82	50	40	42	56	50	42	70	45	58	48	68

BSCE/Jan2013/S-PT (Class B)	S/N	1	2	3	4	5	6	7	8	9	10	11	12	13
	CAT +EXAM (%)	34	63	72	64	50	30	64	69	47	55	49	52	43

BSCE/May2013/S-EV (Class C)	S/N	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	CAT +EXAM (%)	60	45	64	60	62	65	66	68	55	70	47	53	50	54

BSCE/Sept 2012/S-PT (Class D)	S/N	1	2	3	4	5	6	7	8	9
	CAT +EXAM (%)	61	70	56	59	46	60	57	40	55
	S/N	10	11	12	13	14	15	16	17	18
	CAT +EXAM (%)	57	64	57	50	53	41	41	42	44

### Appendix C: Computation for Test of Hypothesis

Continuous assessment (CAT) marks semester examination marks were converted to 100% and tabulated as follows:

S/N	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CAT mark - out of 30%	18	20	25	22	20	24	24	21	21	19	18	19	21	20
CAT mark - out of 100%	60	67	83	73	67	80	80	70	70	63	60	63	70	67
EXAM mark -out of 70%	38	31	57	28	20	28	32	29	27	51	27	39	27	48
EXAM mark -out of 100%	54	44	81	40	29	40	46	41	39	73	39	56	39	69

Mean mark and standard deviations were determined and tabulated as;

	Size(N)	Mean ( )	Standard deviation ( )
Continuous Assessment Results (A)	14	69.50	7.33
End of semester exam Results (B)	14	49.29	15.27

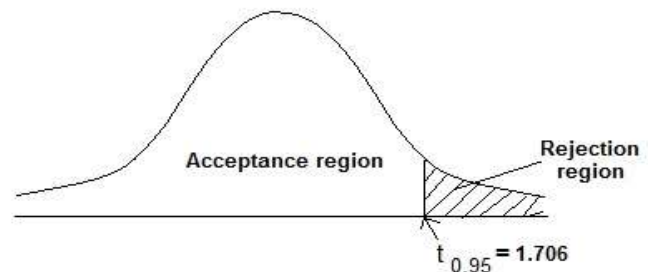
For Continuous assessment results A:  $n = 14$   $\bar{x} = 69.50$   $s = 7.33$

For End of semester exam results B:  $n = 14$   $\bar{x} = 49.29$   $s = 15.27$

**Let:** Null hypothesis;  $H_0$  : =

Alternative hypothesis;  $H_1$  : >

This is a single tailed test  $\Rightarrow$



**Decision:** Reject  $H_0$  if calculated value for  $t$  falls in rejection region thereby accepting that introduction of evaluation based teaching contributed to good performance,  
 Accept  $H_0$  otherwise i.e. that no contribution was realized. —

**Computation:** Using expression;  $t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} = \frac{69.50 - 49.29}{\sqrt{\frac{7.33^2}{14} + \frac{15.27^2}{14}}} = 4.464$

At 5% level  $\alpha = 0.05$  and  $\nu = 14 + 14 - 2 = 26 \Rightarrow$  percentile value = 1.706

**Conclusion:** Since calculated  $t = 4.464 > 1.706 \Rightarrow H_0$  is rejected and  $H_1$  is accepted indicating that the new stimulus i.e. introduction of evaluation based teaching method, contributed to good academic performance in final examination. This is true at 5% level of significance.

# SMI

## Understanding terrorist groups

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### Abstract

Terror is driven by networks in the modern world and understanding these networks is fundamental in fighting threats that these groups pose. These are networks determined to inflict maximum civilian deaths, social and economic damage. With modern technology, terrorists have access to most parts of the globe and an array of weapons including domestic items that can be easily weaponized to cause deaths and damage. The evolution of the Salafi Islam is the ideology behind Al-Qaeeda the fore runner of many terrorist groups. Many Muslim share the Salafi belief but fall far short of violence, and any heinous acts that are propagated by these groups. However, law enforcement and the none Muslim normally are not able to distinguish the difference between peaceful Islam preaching the "*dawa*" and the terror groups like Al-Shabab, Al-Qaeeda and others terrorist networks. The ideology behind violence against none Muslim foreign government and civilians evolved after the Soviet Union invaded Afghanistan in December 1979 and led to the formation of Al Qaeeda which recruited foreign volunteers to fight against the Soviet Army in Afghanistan. The Salafi Jihad is a new concept in terrorism combining enthusiasm, eagerness to die and kill for the cause or '*shahada*' testimony of faith or martyrdom. There is a stereo-typing of terrorists that they are naïve, poor, uneducated, unsophisticated and single in their outlook, but quite on the contrary that we also tend to blame level of education as key to radicalization and becoming terrorist. Empirical data demonstrates that terrorists are more educated than the average person. It also shows that they are global citizens well-travelled and familiar with many countries in the Middle East. Kenya is doing many things right in the fight against terror, dismantling of the hubs have weakened the networks and reduced them to small scale operations. However because of the small world network concept small, scale operation are difficult to eradicate. Policy changes on immigration, education, integration of individuals into communities must be streamlined. Lack of equal opportunities must be addressed. The random arrest of low level individual in the network is not enough as it only displaces the terror threat and does not eliminate it. Surveillance be increased, changes in their life style should be closely monitored. Request for new passport, loss of passport or frequent travel arrangements should sound alarm to the intelligence community. Friend and relative should be persuaded and put under surveillance Salafi mosques, congregations, phone conversation, email, and social media need to be monitored. All this should be done with utmost care not to jeopardize the human rights and civil liberties. Penetration of the networks using those trained but not joining the jihad should be used. The trained should not be prosecuted but used to further penetrate the network. De-radicalazation programs must be enhanced. Imams of fundamental mosques who refuse violent Jihad should be used and encouraged; they are excellent source of information about their respective congregation. Special case officers' with knowledge about language and Islam need to be increased. Working with media, non-governmental organizations the criminal justice system to control and condemn violence should be enhanced. Show of tolerance by governmental

agencies to certain good program is good. We need to remember that the networks are robust and self-growing; precautions must be taken to ensure the networks are disrupted and not allowed to grow back. The local Somalis must be made to participate in their local politics and destiny back home. The rebuilding of Somali must be done with minimal outside interference if we don't then our KDF will always be considered an infidel army in Dar Islam. Somali is a great opportunity and danger depending on how we handle it. We must invest in fully understanding our neighbors the Somalis and the Islamic faith and avoid stereo-typing .We must also understanding the local Somali landscape in religious, political, economic and social arena from human security as the pillar

**EXTREMIST VIOLENCE:** Is the beliefs and actions of people who support or use violence to achieve ideological, religious or political goals.

**EXTERMISTS:** The holding of extreme political or religious views that do not tolerate other viewpoints

**RELIGION FUNDAMENTALIST:** Is the belief of an individual or a group of individuals in the absolute authority of a sacred religious text or teachings of a particular religious leader, prophet, and/ or God.

**TERRORISM:** The unlawful use of violence and intimidation, especially against civilians, in the pursuit of political aims.

**ISLAMIC FUNDAMENTALISM:** Movement of believers who want to return to the fundamentals of Islam

## INTRODUCTION

Terror is driven by networks unlike in the past. Understanding this networks is fundamental to help fight the current threats that this groups pose. This network or groups are determined to inflict maximum civilian deaths and economic damage. Without peace and security there can be no Sustainable Development and growth. With modern technology the terrorist have access to most parts of the globe and an array of weapons including domestic items that can be easily weaponized to cause the deaths and damage.

The decades of Islamic decadence gave rise to people trying to cleanse the faith. They believed Islamic decadence was as a result straying from the right path. A return to the authentic ancient faith jihad is needed. A rebirth of Islam through *Dawa* was necessary. *Dawa* is simply a call to Islam they believed *dawa* would lead to *umma* the authentic is Islamic faith.

## METHODS

In this section, a detailed description of the materials, methods and tools used in the work should be given. The components may include samples, study area, experimental design, protocols, data collection and analysis. Authors may include other subsections that are relevant in their respective research areas.

## **Data collection and challenges**

It should be noted that the author did not have access to government agencies data and Jihadist who are very secretive. This of course slants the study to certain degree. Groups such as Al shabab put out into the public domain well-orchestrated media propaganda with poor documentary value. Captured terrorist also do not talk freely for

Jeopardizing their criminal case

Fear of betraying their cause

Fear of retaliation from former comrades

They also reject any social science project that diminish the validity of their mission (Jihad in the path of God).

## **DISCUSSION**

### **Religious Extremism and Violence**

Religious fundamentalism is a term that refers to strict adherence to a set of basic beliefs in principles (Ashok 2006) very often religious in nature. For religious fundamentalist holy writings are considered authentic and authoritative word of God and cannot be fallible and final. The holy writings are word of God the fundamentalist believe that no human being has the right to change or disagree with it. Various religious groups have different set of belief but there is one common thread of the sacred writings is final and not open to interpretations. Religion fundamentalist aim to reform society by changing laws, morals, social norms and political configurations in accordance with their religious tenets.

There are however some organized groups who perpetrate violence and tend to hide behind religion. It is important to note that this are normally treated as normal organized criminal Gangs by law enforcement and should not be mistaken for terrorist e.g. the Bagdad boy in Kisumu, Chikororo in Kisii, Angola Msumbiji in Western Kenya. This is because they do not have strong ideological outlook in their belief fabric or even the belief of using violence to change the society, they simply use violence as a means for earning their lively hoods. When this happen locally, law enforcement tend to treat this as acts of crime and not extremist violence or terrorism. The differences terrorist networks and organized criminal gangs are the sole belief in God and ideology. However they all tend to operate in networks. In such scenario sustainable development cannot be easily realized.

### **ROOT CAUSES OF TERRORISM**

The negative effects are when religious fundamentalism leads to violence. When these groups feel excluded from the society and feel justified to use violence to achieve their means. Then religious fundamentalism takes the form that it is widely known for in the current world stage. This is simply termed as terrorism by most criminal justice systems around the world.

### World Power & Inclusion/ Exclusion Dichotomy

The US has played role in global system (Modelski 1987). The US uses its power to further its own position. During the rise of the US, They set up a system of free trading while dismantling empires and replacing them with sovereign self-determining nation states. Britain and France Empire was taken apart. Even in Europe countries were dismantled and reconfigured into newly independent countries and included the global system of the United Nations. The emergence of the USSR challenging this dichotomy was dismantled and diminished. Currently China is actively opposing this “business as usual” arrangement. The US Then hand the sole discretion of setting up norms. The fundamentalist in any given geographic location who do not agree with the US are usually excluded from affairs of the State affairs. However their religious teaching and beliefs make them see this exclusion as evil since all men are equal before God leading to weaponisation and violence.

Well this could be exclusion from particular political arena such as participating in government (Crenshaw 1981) (Hoffman 1998). Or the disorientation caused by change of globalization and frustration of missing out on its benefits as perceived by the terrorist.

### Actors, their Motivation

We need to understand why terrorism occurs and why certain individuals chose this kind of violence, how to deter and even prevent it. Some scholars say desperation, poverty and access to resources cause radicalization as the push and pull factors. However the main reason is belief in God and knowing that when people engage in this kind of violence they believe that they are serving God. Religion and nationalism contribute to feelings of alleviation and why some groups or individual feel less violent approach to unsatisfactory for addressing grievances. Alienation, humiliation, demographics, history, and territory (Stern 2004) is what make people use this kind of violence.

Technological development that has led to industrialization and modernization has left many people with a feeling of loss rather than achievement. By undermining “traditional” value systems and allocating opportunities in highly unequal ways within and among nations. Modernization can produce a deep sense of alienation and stimulate a search for an identity that will give life some purpose and meaning.

Birth of Al Qaeda the front runner of terrorism is a blow back of unintended consequence of CIA training Afghan Arabs during the Soviet Afghan war. The CIA funded and trained their allies who later turned against them. The Jihad is a new concept in terrorism combining enthusiasm, eagerness to die and kill for the cause or *shahada* testimony of faith or martyrdom. This removes terrorist groups and insurgent terror groups in various countries which is social, economic and political war and are secular like the ones fighting for oil in the delta region of Nigeria, Palestine and Algeria.



Religion is one of the main factors that contribute to radicalizations into violence and extremism though there are other factors like poverty, identity and Ideology (Chacha 2011). Though there has been a decline terrorist activities in major cities in Kenya. The threat has been displaced to Lamu and North Eastern parts of the country as Kenyan security forces still come under attack, greatly undermining sustainable development programs.

### Education

Education is partly the transmission of the accumulated knowledge of society. That knowledge must entail a justified true belief. According to Aristotle children are born without culture, they grow up in one, molding their behavior and belief towards their eventual role in their society. It is the subjective process of learning to be self-reliant, as noted by K.Odhiambo (2010, p. 114). Self-reliance in this definition and study refers to the ability of individuals to be creative enough to solve their own and societal problems.

Point of interest in this paper is the comprehensive hierarchy of the Islamic faith in education starting with the Imam as a leader. The Imam is the final authority in the Islamic faith and even in the Islamic republic states the secular leaders are compelled to consult the Imam when there is any key decision to be made in the society. This is normally followed by the sheikh who is a well-educated and respected individual in the community. The sheik is also a teacher with vast knowledge in the Islamic teaching and way of life. The Maalim who is the teacher of the madras is next in this hierarch. They are known to have good memory and have memorized huge swaths of the Quran that they help the student to recite. Finally there are the Ulamaa Islamic scholars who are vast in both secular education and Islamic education.

The rule of law can be invoked by the state in countering violent extremism in Kenya. The militarized counter-terror approaches are inadequate and sometime fall below in addressing the threat posed by extremists. There are times when reliance on force exacerbates the root causes terrorism and entrenches social exclusion, alienation and state insensitivity to community rights, as seen in what was the so called Northern Frontier district of currently North Eastern of Kenya with a homogeneous Somali population. This area of Kenya is also predominantly Muslim. Moreover, extremist exploit local discourse of land grievances like in Lamu and the wider Coastal counties. The inequities associated with identity politics, and state curtailment of civil liberties and political rights to recruit youth like currently in Kenya where the indigenous Kenyan Somalis are given an identity card that is different in color from the rest of Kenyans.

The collective punishment of communities by the State alienates the victims and erodes state legitimacy in the face of local populace and lends credence to why God who sees all men as equal should be used to away with such evil systems. The absence of meaningful alternative narratives shared through appropriate channels has left a vacuum that is easily filled by religious

extremists. Their narratives are about the fundamental restructuring of the *status quo* in a manner that provides fertile ground for the growth of violent extremism

### Holy Writings

The Sacred writings of the Muslims the Quran, also have at least 109 instances of war with non-believers

[Quran \(4:95\)](#) - "Not equal are those of the believers who sit (at home), except those who are disabled (by injury or are blind or lame, etc.), and those who strive hard and fight in the Cause of Allah with their wealth and their lives. Allah has preferred in grades those who strive hard and fight with their wealth and their lives above those who sit (at home). Unto each, Allah has promised good (Paradise), but Allah has preferred those who strive hard and fight, above those who sit (at home) by a huge reward "

Some text in the Quran talk about very graphic violence as mentioned below:

[Quran \(5:33\)](#) - "The punishment of those who wage war against Allah and His messenger and strive to make mischief in the land is only this, that they should be murdered or crucified or their hands and their feet should be cut off on

The common bond of Muslim victimization also plays a role, people will not seek significant change in association unless there disruption social networks. Ideology is a social phenomenal intensification of faith and belief. This stage is characterized by active personal learning about faith. Pages 117 of the book talks of joining Jihad as having a high personal price and an upfront cost the individual joining. This cost include rejection by friend, family employer etc. Salafi behavior is highly visible for all to see. Growing of beard, wearing the Islamic garb, giving up some form pleasure. All this distances the new devotee from the social network but draws them closer to other Salafis who's only opinion become source of reference. Only most devoted will dedicate to this life of personal loss of economic and social level.

Joining is not a random process. This is because Al-Qaida totally failed to recruit people from its headquarters, training camps in Pakistan and Sudan. The devout Al Qaeda would look down on the host community in Afghanistan and Sudan as being not so good Muslim. The host community responded and there was a blow back effect on the group. Therefore the bond of terror does not form spontaneously by mere exposure as in the Mass ideological appeal theory of Marxist of religion being the opiate of the people.

The terror groups operate a small world concept. This small world networks are joined by hubs and nodes. This type of group is difficult to dismantle. The South East Asia group had a hierarchical topology which is easy to dismantle once you decapitate the head. But once hubs are eliminated then the network can be alienated and their capacity to carry out an operation is highly compromised. The danger is the networks can still grow even after eliminating the human hub.

Terrorisms is resilient to random arrest of its members but fragile in targeted attacks on the hubs. Many hubs are linked to each other and to defeat them taking down 5% to 15% of the hub at once is necessary otherwise they will grow back and take role the destroyed network. The small world network topology is a spontaneous process of self-organization rather than international organization.

Embeddedness

This is rich nexus of social and economic linkage between members of terrorist networks and its environment. Lack of embeddedness made people join the Jihad. Malimoud from Iraq, Osama Bin Laden are example of people who were never fully embedded into the local host community. Groups and cliques tend to respond to current affairs around them e.g. in the war in Yemen, Chad and uprising in Mozambique. They also lump together events like presence of AMISOM forces in Somali. This bring to the fore theories like game theory or the rational choice theory of why the terrorist groups form.

Outsiders of the groups see terrorist willingness to kill and insiders see willingness to die to become jihadist not killers. The groups become subculture or counter culture leading to intense cohesion of the group.

### Communication

New technological advancement like email, computers satellite phone cellphones networks are used by terror networks. But the surveillance of this networks have also made intelligence gathering on groups simpler leading to arrest and severely jeopardizing their missions. Laptops captured in Manila Philippines helped law enforcement to round up and arrest sever terrorist and know the location of sever safe house around the world. Use of modern technology is both a boon and bane to both terrorist and the law enforcement. Example of lack of use of communication is when terrorist on their way to a bombing mission lost their way and did not reach the target in Casablanca morocco. Data from confiscated computers helped in conviction of the East Africa bombing.

### Internet

Internet has universal chat rooms, social platforms like twitter Face book Instagram. These platforms are egalitarian and the terrorist use this platforms. These platforms allow people to join the virtual society, messages can be delivered and instantaneously. The unanimity of this platform have been used by terrorist to claim and spread propaganda with hidden identities. There is no evidence is internet is persuasive enough in recruiting terrorist because they prefer face to face which the internet does not have someone to vouch for you. Good information sharing allowed large scale terror attacks like Bali bombing, September 11<sup>th</sup> the East Africa embassy bombings. Good and frequent communication helped the terrorist overcome planning challenge and solve unforeseen obstacles.

Challenges

## CONCLUSION

Many Muslim share the Salafi belief but fall far short of violence, however law enforcement are usually not able distinguish the difference between peaceful Islamic preaching the *dawa* and jihadists. Imams of fundamental mosques who refuse violent Jihad should be used and encouraged, they are excellent source of information about their respective congregation. Special case officers with knowledge about language and Islam need to be increased. Look out for any discouragement and hate speech should be implemented. Working with press, non-governmental organizations the criminal justice system to control and condemn violence should be enhanced.

Show of tolerance by governmental agencies to certain good program is key. Anti-west propaganda and information should be strongly countered in press magazines and the education systems. We need to remember that the networks are robust and self-growing so all precautions must be taken.

The Constitution of Kenya provides an important framework for addressing the contextual, political, economic, and social factors that feed violent extremist ideology. If well implemented, devolution will. Decentralize political power and give communities more decision making power in choosing leaders, determining developmental priorities, and demanding accountability and the transparent use of public resources. The impacts of economic, social, cultural, and political marginalization, which accumulated prior to 2010 when the new Constitution was promulgated, can be reversed through the empowerment of county governments and implementation of other constitutional provisions related to inclusion.

The involvement Somali must be reviewed critically and the local Somalis made to participate in their local politics and destiny. The rebuilding of Somali must be done with minimal outside interference if we don't our army will always be considered an infidel army in Dar Islam. Somali is a great opportunity and danger depending on how we handle it. We must also understanding the local Somali landscape in religious political economic and social arena using human security as the pillar.

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## **Innovative Approaches to terrorism and security: implications in educational system and regional development**

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### **Abstract**

The paper focuses how terrorism paralyzes the operation of teaching and learning because of insecurity in schools for counties of Mandera, Wajir and Garissa. Recently the terrorists act of assassinating civil servants in a mayhem when travelling from Mandera, compelled the teachers working in those counties reject returning to their station in fear of being butchered the similar way their colleagues was done. The problem is that Teachers Service Commission is forcing the teachers to go back and the teachers vowed not go back, leading pupils in North Eastern suffering. The objective is to study the best approach or strategy to curb terrorism and instill security and sustainability of teaching and learning. And to study whether there is correlation of terrorism and religious status of teachers in North Eastern. The study employs analytical survey method and data would be collected empirically from teachers working in North Eastern and refused to go back. The results are, teachers refused to go back and paralyzed the operation of educational system. It is concluded terrorism has affects teaching and learning the educational sector in North Eastern, leading to future retardation of county development. It is therefore recommended to train large numbers of teachers who would persevere working from their own environment.

**Key words:** County development, Educational system, Security, Terrorism

## **ADH**

### **The plight of the aged in traditional systems and sustainable African development**

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#### **Abstract**

The research focuses the emerging concern about the plight of the elderly which has been neglected despite the many years that organizations in solidarity with them have advocated for their recognition and helping them. The problem is many African governments have failed to recognize in their policy formulation concerns of the elderly, and therefore contributing to their isolation in the society, as they are neglected by the members of the family and the community at large. The objective is to study the best strategy to approach or applied for policy initiatives and programmes to have adequate appreciation of the rights and needs of the older people. The research employs the descriptive research design method. The key results indicates that today, the society has undergone tremendous changes in social and cultural transformation which weaken the strength of traditional systems that held the elderly in high esteem and recognition in the society. The attitude towards the aged people who have lived their lives and have become irrelevant. In some hospitals they don't get proper medical attention as the medics consider them as not important in sustainable development in the community. It concluded that the younger who despite and down look upon the elderly should take note that ageing is a process and that they too will become old sometime later in progressively. The paper thus, recommends that the old people should be assisted financial by the national and county governments so that to cater for their basic needs especially food, clothes, shelter and medical security.

**Key words:** Aged, Traditional, National, County, Sustainable, Health.

## **INTRODUCTION**

As people grow older, they pass through various stages in life, childhood, youth, adulthood, middle age, and old age are terms commonly used to describe these stages of passage till death, and the term “life cycle” is often used to describe this process (Fulcher and Scott,2011;437) The research focuses the emerging concern about the plight of the elderly which has been neglected despite the many yeas that organizations in solidarity with them have advocated for their recognition and helping them. Old age refers to the later years of adulthood and the final stage of life-begins around sixties (Macionis, 2013; 77). Activist groups have started tofight against ageism-discrimination against people on the basis of their age-seeking to encourage a positive view of later life and older people (Giddens, 2011:317).

Bytheway (1995) argues that the categories we use to describe ageing-such as “elderly” and “the old”,-are themselves ageist. They are socially constructed in order to legitimize the separation and management of people on the basis of their chronological age by dominant groups with something to gain from the inequalities associated with ageism. There are two main ways in which people become classified as old.first,is based on chronological divisions-old age is taken to mean the age at which people become entitled to the state pension, which is past meant that men become old at 65 years and women at 60 years. The second is the way that they look; grey hair and wrinkles are examples commonly taken to indicate that people are old. Once people are classified as old, they get treated as dependent, and as physically and mentally incapacitated, irrespective, of their characteristics as individuals. This stereotyping of old age has led to those who would conventially be considered old rejecting the term as inappropriate for them (Fulcher and Scott,2011;445-46).accordingly people who look old frequently state that they do not feel old. There is, as Pilcher (1995) points out, a tension between eternal appearance and sense of identity.

### **The statement of the problem**

The problem is many African governments have failed to recognize in their policy formulation concerns of the elderly, and therefore contributing to their isolation in the society, as they are neglected by the members of the family and the community at large. This means that the policy makers are to blame for the increasing abuse of rights of Africa’s elderly people, because policy initiatives and development programmes have not adequately appreciated the rights and needs of the older people of this segment in the society.

### **The objective of the study**

The objective is to study the best strategy to approach or applied for policy initiatives and programmes to have adequate appreciation of the rights and needs of the older people.

Question what could have happened to those values Africans so fervently held onto, and which elaborately took care of the elderly?

### **Assumptions of the study**

1. Old age is a must process for every human being and those who treat the old people contemptuously

2. Old age is not one's own choice but God's choice and blessings, therefore, people who are young should treat the old with respect to receive the blessings.

### **Theoretical framework**

In the direct practice level, the professional function as defined by life model is to improve the level fit between people's (individuals, family, group, community) perceived needs, capacities and aspirations and their environmental supports and resources. Through processes of mutual assessment, worker and service recipient(s) determine practice focus, choosing to: 1. improve a person's (collectivity's) ability to manage stressors through more effective personal and situational appraisals and behavioral skills; 2. influence the social and physical environments to be more responsive to person's (collectivity's) needs; and 3. improve the quality of person; environment exchanges (Gitterman, 1996; 395).

### **Literature review**

In the first World Assembly of United Nations convened in Vienna Austria, in 1982 on Ageing addressed issues of older persons and their implications on national development. The Second World Assembly on Ageing was held in Madrid, Spain in April 2002, which reviewed and reformulated the International Plan of Action on Ageing. The same year African Union, in July 2002 formulated and adopted its Policy Framework and Plan of Action on Ageing and focused on Older Persons on the continent. Kenya being a member of both the United Nations and African Union, took on account of utilizing these international and regional instruments. Parliament in February 2009 enacted the National Policy on Older Persons and Ageing to provide a comprehensive framework for guiding issues of older persons and ageing in development processes, programmes and also to inform other sectorial policies. It underscores the Government commitment in addressing the rights, and protection of this segment of population. The Government through the Constitution (2010) it is commitment in addressing the rights, and protection of this segment of population. This means the overall goal of this policy is to provide an environment that recognizes, empowers, and facilitates Older Persons to participate in the society and enjoy their rights, freedoms and live in dignity. Some of the specific objectives are to: a) Facilitate the provision of reasonable care and assistance to Older Persons by family and the state; b) Promote collaboration and partnerships among key stakeholders for the effective implementation of this policy; c) Promote the participation of Older Persons in development processes; d) Enhance and facilitate Older Persons to pursue their personal development; e) Create a favorable environment that enables Older Persons to live in dignity; f) Protect the Older Persons from abuse.

### **Definition of terminologies**

The term "life cycle" has biological origins and implies that a process of biological ageing shapes the stages of life. It concludes the idea that there is a fixed sequence of stages that everyone passes through as the age. In this aspect of old age in contrast with the active, up-beat presentation of the third age, images of fourth age tend to be negative, treating the old age as a period of dependence, disability and decline. Countries vary widely in what they are doing to cope with the growing numbers of older people (Giddens, 2011; 319). In Africa, it is a reverse where the numbers of older people is decreasing due to a number of factors related to HIV/Aids, poverty, accidents and the like. Countries like United Kingdom, relies primarily on the state pension and the National Health Service to provide safety net to serve the financial and health needs of older people. According to Giddens (2011; 319), a number of national laws in Japan

support the employment and training of older workers, and private businesses also support retraining. But in Kenya, there are as many false stereotypes of the older people as there are in other areas. For example people believed that older workers are less competent than younger ones, that most people over 65 are in hospitals or homes for the elderly, and that a high proportion are senile(Giddens,2011:318).The productivity and attendance records of workers over 60 years are superior on average to those of younger age groups. In United Kingdom, the government has put forward proposals to ban age discrimination, which could cover recruitment, training (including entry to higher education), promotion, pay, job-retention and importantly-retirement.

Old people continue to be excluded from mainline educational settings (Hamil-Luker and Uhlenberg, 2002).When efforts are made to involve older people in educational activities, they often operate from an age-segregationist principle, with separate programmes for old people. Many older people report that participating in church or other religious activity is their most significant social activity outside the family (Neman and O'brien, 2011:322). Fulcher and Scott (2011:436) argues that people of different ages are often described as belonging to different generation. In these sense two different usages of the term generation is given as follows: one, those born during a particular period, or a particular event unique in historical epoch for instance war or famine or drought. Two, kinship groups defined by parent-child relationships, examples children and their cousins; parents, aunts and uncles; their grandparents, great aunts, and great uncles and so on, each of this constitute a generation.

## **METHODS**

The research employs the descriptive research design method. Kombo and Tromp (2006), noted, concerning descriptive design, that such studies are not only restricted to fact finding, but may often result in the formulation of important principles of knowledge and providing solutions to significant problems.

## **RESULTS AND DISCUSSION**

The key results indicates that today, the society has undergone tremendous changes in social and cultural transformation which weaken the strength of traditional systems that held the elderly in high esteem and recognition in the society. The attitudes of people towards the aged people who have lived long enough and have become irrelevant in the society. And in some hospitals they don't get proper medical attention as the medics consider them as not important in sustainable development in the community. People have the attitude the aged people have lived their lives and have become irrelevant. Today's society has undergone through social and cultural transformation and the socio-economic changes have been the ground for weakening the strength of traditional systems that held the elderly in high esteem. In countries which have had conflicts and natural disasters in the form of floods and drought, the older people are the ones who suffer most and are victims of disasters given that they are neglected and their frail bodies prevent them from escaping disasters.

In the African traditional set up, elderly people were viewed as the wise and give advice to the young in the society, therefore were viewed as significant and as integral part of the family and were accorded great respect in all aspects in the society.

In the past, it was usual for the elderly to receive various forms of assistance from the relatives. This is contrary in the modern society and yet the help to the aged needed now than before in very many aspects and issues affecting the society. The family is still the most important institution for older people and that the older people were in the past, given much recognition for their roles in areas of conflict resolution, cultural and health education, but the changing structure of the family, migration and new cultures through intermarriages have eroded the values of recognizing the old in the society.

Basing the overall results, the government of Kenya, though, the National policy on older persons and ageing is based on key guiding principles which are derived from the Kenya Constitution, Vision 2030, and other sectorial policies, legislation, international and regional instruments. The Ministry of Labour, Social Security and Services, is mandated by the Government to plan, implement programmes and address issues of older persons. It is also mandated to oversee that all policy documents are reviewed and aligned with the Constitution of Kenya. The Ministry reviewed and aligned the policy with the Constitution Kenya (2010) in January 2014. The need for a National Policy on Older Persons and Ageing arose from the Government's realization that without a coherent and comprehensive framework for guiding the different sectors and agencies involved in development issues pertaining to Older Persons, substantial resources and efforts may continue to be wasted. The available international, regional, legal, policy, and institutional frameworks on Older Persons have guided the development and review of this policy adequately.

#### **Policy on Education, Training, and ICT for the older**

The current education, training and ICT policies and programmes do not comprehensively address the potentials and needs of Older Persons. In this aspect, the Government shall in collaboration with relevant stakeholders:

- i. Promote the lifelong education and technology that enhances the positive self-esteem and self-reliance amongst Older Persons.
- ii. Provide equal opportunity to persons of all ages, Older Persons in particular, with respect to continuing education and training.
- iii. Adapt vocational training and ICT programmes to meet the needs of Older Persons.
- iv. Strengthen and/or review functional literacy programmes to ensure that they are responsive to the needs of Older Persons.
- v. Support public education campaigns to utilize appropriate communication, media, and languages to meet the needs of Older Persons.
- vi. Provide opportunities within educational programmes and community institutions to enable Older Persons act as mentors, mediators', advisors, and teachers of cultural studies for the exchange of knowledge and experience with Older Persons as resource persons.
- vii. Provide training and education for the media to increase understanding, coverage and positive reporting of issues regarding Older Persons and Ageing.

- viii. Identify and create awareness of the negative socio-cultural attitudes towards Older Persons and engender positive change.
- ix. Promote education on eradication of gender bias in performance of roles in the family and community for children, carry out sociological and geriatrics studies at university level.
- x. Identify and develop an inventory of skilled Older Persons.

#### **Policy on Infrastructure for the older**

To review existing infrastructural policies and legislation to ensure they accommodate the rights and needs of Older Persons. Therefore, the Government shall in collaboration with relevant stakeholders:

- i. Involve professional Older Persons during infrastructural development.
- ii. Review the transport policy to address the needs of Older Persons and Ageing.
- iii. Promote investment in housing with universal design from an early age.
- iv. Ascertain that architectural training curricula, designs and institutional facilities take cognizance of the special needs of Older Persons.
- v. Review and update infrastructural policies, legal frameworks and programs to ensure they address the needs of Older Persons in the rural and urban set up.
- vi. Make consideration to vulnerable older persons in public housing schemes.
- vii. Modify existing public buildings during periods of refurbishment and renovation to ensure access for Older Persons.
- viii. Promote accessible, adequate, affordable, and reasonable standards of sanitation and decent living housing conditions for Older Persons.
- ix. Ensure that public recreational facilities take into consideration the needs of Older Persons.

### **Policy on Social Protection and Services for the older**

The objective is: i. to strengthen the existing social and health insurance schemes to cover all workers in formal and informal sectors. i To upscale social assistance programmes to cover all vulnerable Older Persons. In this aspect, the Government shall in collaboration with relevant stakeholders: i. Ensure progressive realization of social assistance for needy Older Persons with special needs. ii. Promote and strengthen comprehensive social security schemes in all sectors. iii. Facilitate the creation of community-based structures that encourage membership of Older Persons to social and health insurance schemes. iv. Develop and implement programmes of leadership, volunteerism, community service, and self-reliance, for Older Persons. v. Intensify awareness creation to workers on saving and investing for old age.

### **CONCLUSION**

It is concluded that the younger who despite and down look upon the elderly should take note that ageing is a process and that they too will become old sometime later in progressively. This idea is supported by Macionis (2013; 80), connotes that “life course points to two major conclusions”. First, although each stage of life reflects the biological process of aging, the life course is largely a social construction. For this reason, people in different societies may experience a stage of life quite differently or not at all. Second, in any society, the stages of life course present certain problems and transitions that involve learning something new, and in many cases, unlearning familiar routines. Therefore in some countries, societies organize the life course according to age, but other forces, such as class, race, ethnicity, and gender also shape people’s lives. so people’s life experiences also vary depending on when, in the history of the society, they are born.

### **Recommendation**

The paper thus, recommends that the old people should be assisted financial by the national and county governments so that to cater for their basic needs especially food, clothes, shelter and medical security.

The young people should be sensitized to change attitude and know that olderness is a process in life and therefore, even themselves they will become old and need the kind of assistance which they offer the older in the society.

The older should be given special dignity and respect because “Whatever they do for the older persons today is what they expect to obtain from the younger generation tomorrow” in all societies in the world.

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