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TRACK 1: DESIGN, MANUFACTURING, AUTOMATION AND ICT

TWO-DEGREE-OF-FREEDOM CONTROL OF SELEMION CMV-BASED IPMC ACTUATORS IN EXTREMELY LOW HUMIDITY ENVIRONMENT.

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Abstract

Selemion CMV-based IPMC (Ionic Polymer Metal Composite) actuators have numerous promising applications in designing electroactive soft motion robots. This research work presents feedforward, feedback and two-degree-of-freedom control analysis applied to the Selemion CMV-based IPMC actuators. The time dependent charge behaviours obtained by employing the circuit model successfully resulted in the prediction of bending behaviour of the IPMC. A circuit model had been proposed for deriving the time-dependent behaviour of charge, which was caused by both Faradaic and non-Faradaic currents, passing through the IPMC. The time dependent charge behaviour's obtained by employing the circuit model successfully resulted in the prediction of bending behaviour of the IPMC. In previous research, using Simulink – Matlab, an open loop model was built, based on the circuit model and the stability analysis of the Selemion CMV-based IPMC bending behaviour was carried out. In this study, using the actuators dynamics and transfer functions, self-sensing controllers, using feedforward, feedback and two-degree-of-freedom control techniques, were implemented. The controllers performed well with the Selemion CMV-based IPMC actuator. The highly dehydrated Selemion CMV-based IPMC bending behaviour exhibited a fairly linear relationship of curvature vs. charge in extremely low absolute humidity environment.

Keywords: IPMC; Selemion-CMV; control; system identification; Simulink-MATLAB

INTRODUCTION

The Ionic Polymer-Metal Composite (IPMC) is a bending mode electroactive polymer actuator. Its supple motion and soft body and electroactive nature make it strikingly similar to animal muscle [1–4]. Researchers consider IPMC a promising candidate for creating artificial muscle, miniature robots and biomedical devices. Selemion CMV-based IPMC is a well-known and investigated IPMC material. Attempts to design and fabricate practical Selemion CMV-based IPMC actuators have been ongoing for the last two decades or so [1–4]. The progress has, however, been unsuccessful. The major hurdle lies in the electrical control of the Selemion CMV-based IPMC bending curvature. The Selemion CMV-based IPMC exhibits large bending in

response to the applied voltage. However, the bending is largely uncontrollable, especially under high humidity environments.

The Silver-coated Selemion CMV-based IPMC (hereafter called Selemion IPMC) is usually activated in a highly hydrated state even in an aqueous solution. Even under such conditions, the Selemion IPMC exhibits large bending in response to an applied voltage. Its bending controllability, which is poor, could be improved greatly by dehydration treatment [5–8]. Furthermore, the bending curvature of the dehydrated Selemion IPMC is proportional to the total charge imposed on it. Owing to such a proportional relationship between the curvature and charge, successful experimental test carried out on the bending controllability of Selemion IPMC by controlling the charge imposed on it, the input current [9].

In this research work, we fabricated a silver-coated Selemion CMV-based IPMC (CMV IPMC) and investigated its bending controllability in the dehydrated state. Under normal environmental conditions, we observed only a slight improvement in bending controllability in the dehydrated state. On carrying out further investigation, we found that the bending controllability of CMV IPMC improved in the extremely low absolute humidity environment. In this case, we observed the linear relationship between the CMV IPMC bending curvature and the quantity of charge imposed on it.

This experimental result indicated that the bending controllability of CMV IPMC could be significantly improved in the extremely low humidity environment. Thereafter, we made a successful attempt to control the bending of CMV IPMC through feedback, feedforward and two-degree-of-freedom control techniques [10,11].

1. THE SELEMION CMV-BASED IPMC ACTUATOR

The Selemion CMV-based IPMC actuator is fabricated from a piece of Selemion coated with silver layers on both sides. The fabrication requires several steps. First, the surfaces of a Selemion sheet are first crazed and sandblasted to improve silver adhesion [12–13]. Silver is then deposited through the silver mirror reaction [14]. The silver coated Selemion sheet, measuring 0.2 mm thick, is then cut into strips 20 mm long by 2 mm wide.

Due to the deterioration in bending controllability of CMV IPMC in high hydrated state, as a result from being submerged in an aqueous solution [5–9], the strips were stored in a vacuum with a desiccant to remove almost all moisture. Since water is essential for electrical conductivity (bending action of the CMV IPMC), we allowed the CMV IPMCs to reabsorb minute amount of water by exposing them to the ambient air for 30 min prior to any experiment.

Hence, the results in this research work were obtained using CMV IPMCs that were very slightly hydrated. Hereafter we refer “a very slightly hydrated Selemion CMV-based IPMC” as “a dehydrated CMV IPMC”.

The CMV IPMC Actuator Bending Model

In the course of this research, the relationship between CMV IPMC bending behavior and the absolute environmental humidity was ascertained. To achieve this, the following experiment was carried.

A dehydrated CMV IPMC was clamped at one end to a pair of electrodes connected to a power supply as shown in Figure 1. When voltage was applied, the CMV IPMC bent toward the anode (see Figure 1). A pulsated wave ($1.5V_P$, 16.667 Hz) was applied as the input to the system (the strip) while monitoring the position of a point on the strip 10 mm away from the clamp point with a laser displacement sensor (LK-085, precision $3\mu m$, KEYENCE, Osaka, Japan). At the same time, the environmental relative humidity and temperature were measured and recorded using a Z2000 (HIOKI, Nagano, Japan) humidity sensor and a K type thermocouple respectively. From the recordings, the absolute humidity was determined. The measured tip displacement of the CMV IPMC was then converted to bending curvature C .

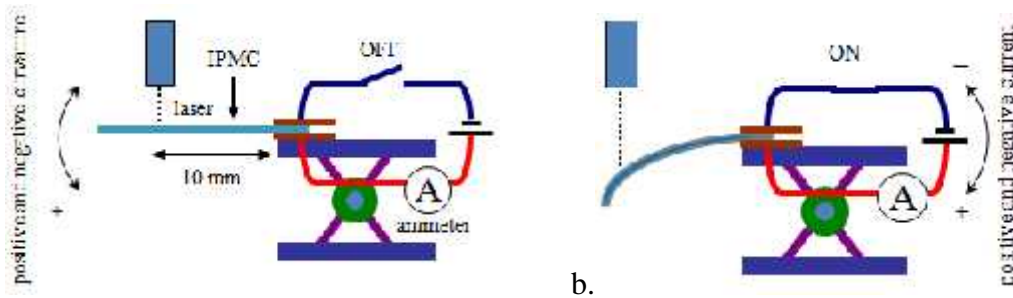


Figure 1. Experimental setup for measuring the tip displacement of Selemion CMV based-IPMC (It indicates the effects on the shape of CMV IPMC in:(a)the OFF and (b) the ON stages).

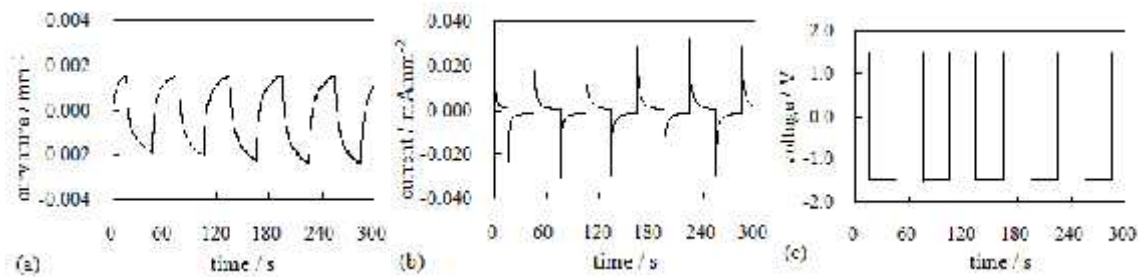


Figure 2. Experimentally obtained data of: (a) Bending curvature, (b) the Output current, (c) the oscillating rectangular voltage ($1.5V_P$, 16.667 Hz) used as input with respect to time of the CMV IPMC at the absolute humidity is 4.5 gm^{-3} .

As described in the introduction part of this research work, the bending curvature of dehydrated Selemion IPMC is proportional to the charge imposed on it. Thus, the bending curvature of CMV IPMC is also proportional to the input current imposed on it, in its dehydrated state.

Figure 2a,b shows the Bending curvature and the Output current of the CMV IPMC with respect to time duration when a pulsated wave ($1.5V_P$, 16.667 Hz) was imposed on the CMV IPMC per unit surface area in Low absolute humidity environment. A linear relationship between the curvature and charge imposed on Selemion IPMC in the extremely low humidity environment was observed, and the CMV IPMC exhibited regular triangular form of curvature as a function of time under the oscillating rectangular voltage ($1.5V_P$, 16.667 Hz) as shown in Figure 2a. A highly hydrated CMV IPMC exhibits a well-controllable bending behavior [15,16], however, it doesn't last that long. Soon, the bending controllability reduces gradually with time.

CMV IPMC Actuator Modelling using SIMULINK-Matlab.

In an extremely low humidity environment, Selemion CMV IPMC bending curvature exhibit well-ordered characteristics as in Figure 2a,b. This is due to bending controllability of CMV IPMC in the extremely low humidity environment.

Using the experimental data shown in Figure 2b, we derived a transfer function Equation (2) for the Selemion CMV IPMC which associates an output parameter (output current), Equation (1) to the input signal I(electrical signal imposed) via the equation $L[O] = G(s) L[I]$ where L, represents the Laplace transform. The derivation was achieved through the SIMULINK-Matlab software. Procedure for solving the circuit equations is given in the ref. [14]

$$I(t) = V(t) \left[\frac{1}{r_2} e^{\left(\frac{-t}{r_2 C_2}\right)} + \frac{R}{r_2(r_2+R)} e^{\left(\frac{-(r_2+R)t}{r_2 R C_2}\right)} + \frac{1}{r_2+R} \right] \quad (1)$$

$$I(s) = [V(s)] * 10^{-3} \left[\frac{25.065s^2 + 37.835s + 1}{2.3985s^2 + 7.4645s + 1.714} \right] \quad (2)$$

In this study, we built a model using the Control Toolbox in MATLAB. The data set used for the input to the system was a rectangular voltage wave shown in Figure 2(C) as the input and the corresponding bending curvature and output current of the Selemion CMV IPMC strip piece shown in Figure 2a,b as the output. The derived transfer function is shown in Equation (2).

We found that the transfer function of dehydrated Selemion CMV IPMC is fairly stable at extremely low absolute humidity environment, but that change with increase in absolute humidity levels.

To validate the transfer function Equation (1) of the Selemion CMV IPMC, we compared the simulated results to the experimental ones. The two curves match closely after an initial period, indicating that the transfer function Equation (2) is a reasonable one.

Figure 7. Time-dependent bending curvature of Selemion CMV IPMC obtained experimentally and computationally.

Control Strategy of the Actuator.

We successfully attempted to control the bending of highly dehydrated Selemion CMV IPMC using feedforward, feedback and two-degree-of-freedom techniques. Feedforward control requires an inverse control system using the transfer function of the Nafion IPMC. Thus, we performed a system identification to obtain it. All three control systems were tested in turn by implementing them in Simulink (within Matlab). All the bending control tests were carried out at the absolute environmental humidity around 7 gm⁻³

Feedforward Control.

The diagram of the feedforward control that was implemented to control the bending of the Selemion CMV IPMC specimen appears in Figure 8a. The input was the same rectangular wave as before (1.5V_p, 16.667 Hz). Figure 2b shows the output current of the specimen over time. The thick line represents the ideal curvature, while the fine line shows the experimentally obtained curvature. The two lines almost coincide.

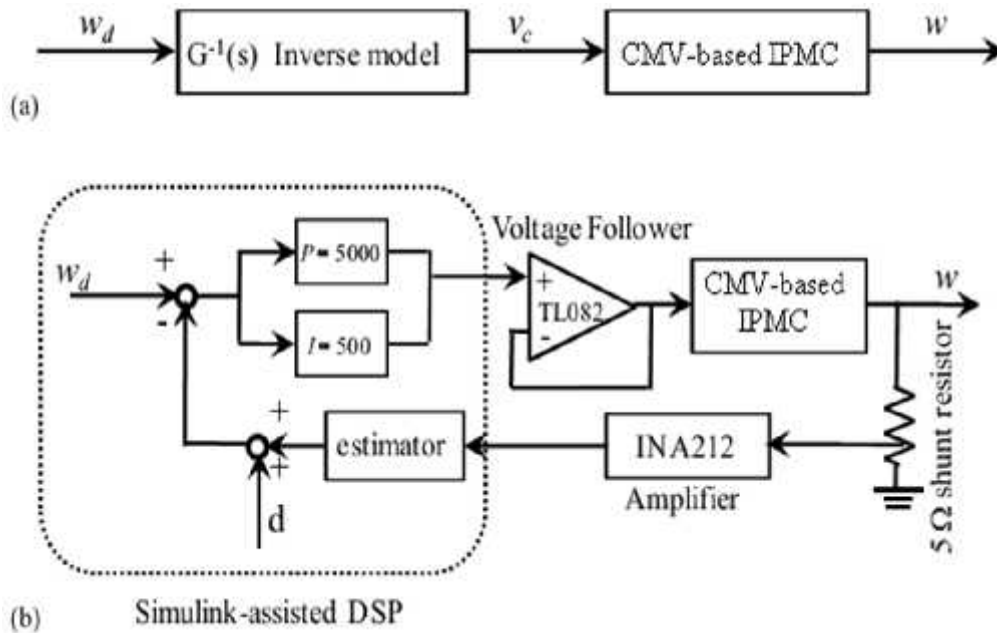


Figure 3 (a) Feedforward control system (b) Feedback control system.

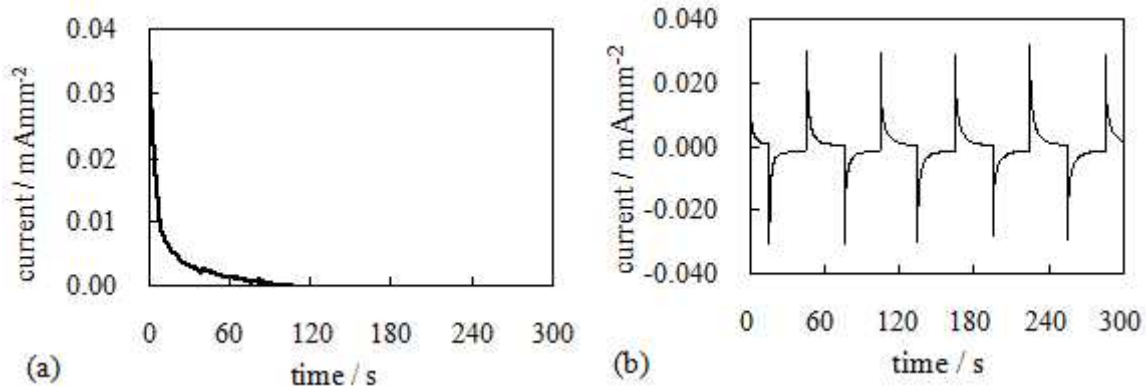


Figure 4. The Selemion CMV IPMC response vs. time at $AH = 4.5 \text{ gm}^{-3}$ under; (a) step input and (b) square waveform ($1.5V_p$, 16.667 Hz).

Feedback Control.

We implemented the feedback control system in Figure 3b, where P and I were determined by trial and error. The input signals were the step and oscillating rectangular waveforms. The inverse system ($G^{-1}(s) = \text{inv}(I(s))$) given by equation (3) was implemented in the control system.

$$I(s) = [V(s)] \left[\frac{2.3985s^2 + 7.4645s + 1.714}{0.025065s^2 + 0.037835s + 0.001} \right] \quad (3)$$

Two-Degree-of-Freedom Control.

Figure 3b shows the block diagram of a two-degree-of-freedom control system where P and I were determined by trial and error. The input signals used were the same step and oscillating rectangular input waveforms as applied earlier.

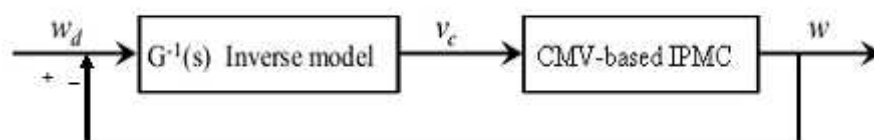


Figure 5. Two-degree-of-freedom control system.

Since the experimentally measured data quantitatively agrees well with the simulated data for both the step and square waveform inputs, the resulting controllability was not much different than that of the feedback

Exploiting the linear relationship exhibited by the Selemion CMV IPMC, a feedforward, feedback and two-degree-of-freedom controls for output currents were successfully implemented. Thus, under conditions of extremely low humidity, all three control techniques worked well.

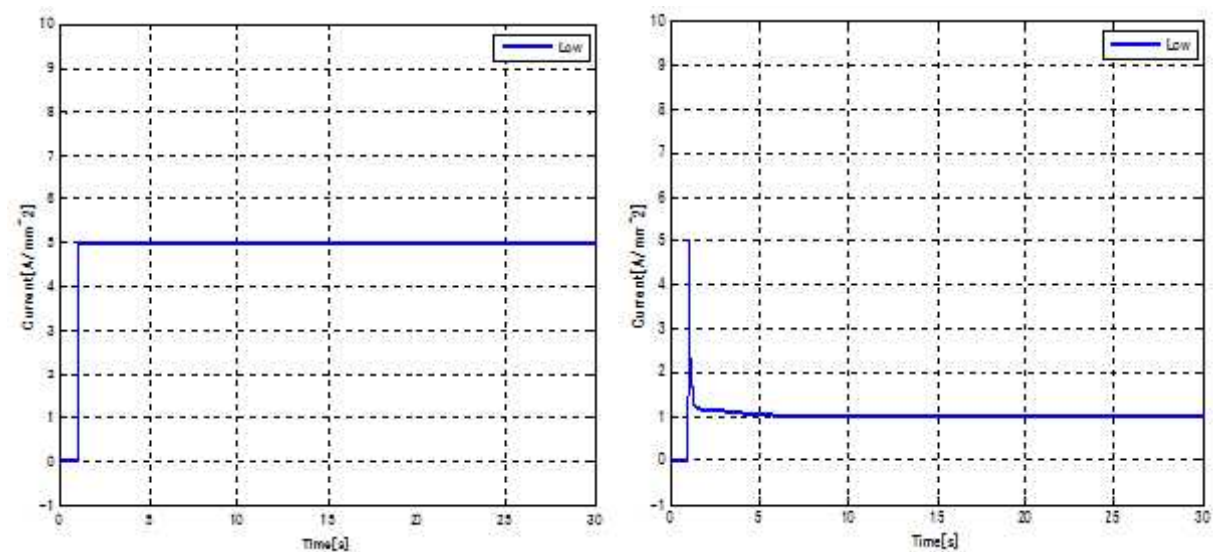
In this research work, we would like to emphasize the fact that, the dehydration treatment gives rise to the simple linear relationship of “bending curvature vs. total charge” and such a simple relationship enables us to control the Selemion CMV IPMC bending using the presented control techniques such as feedforward, feedback and two-degree-of-freedom controls. Also, at extremely low humidity environments, there exists a linear relationship between the output current and the charge responsible for the bending of the Selemion CMC-based IPMC. Thus, controlling the response of the input voltage, step or square, effectively controls the bending curvature.

Furthermore, we would like to emphasize that the dehydration treatment enable us to achieve a longer duration time of Selemion CMV IPMC bending control. The data for such a long bending control is not shown in this paper, due to its enormous volume.

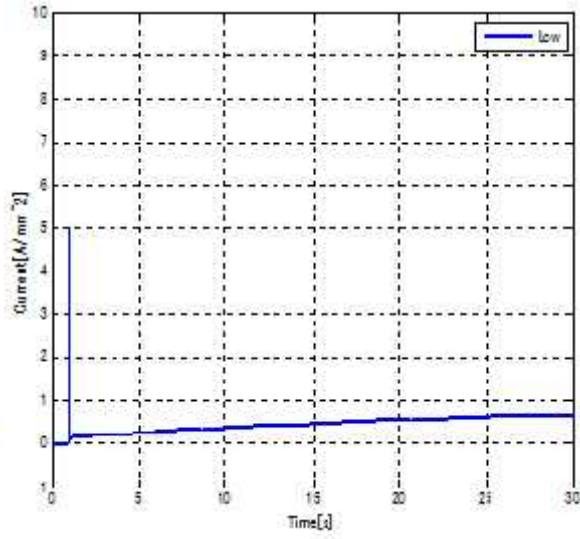
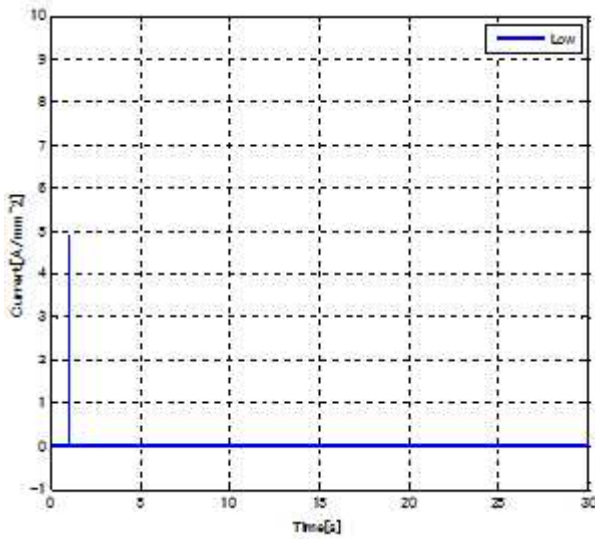
2. RESULTS AND ANALYSIS

Linear Quadratic (LQ) is an optimal multivariable feedback control approach that minimizes the excursion in state trajectories of a system while requiring minimum controller effort. The behavior of a LQ controller was determined by two parameters; R_{aug} (Gain) and Q_{aug} (Error weighting matrix), whose tuning method used, was trial and error.

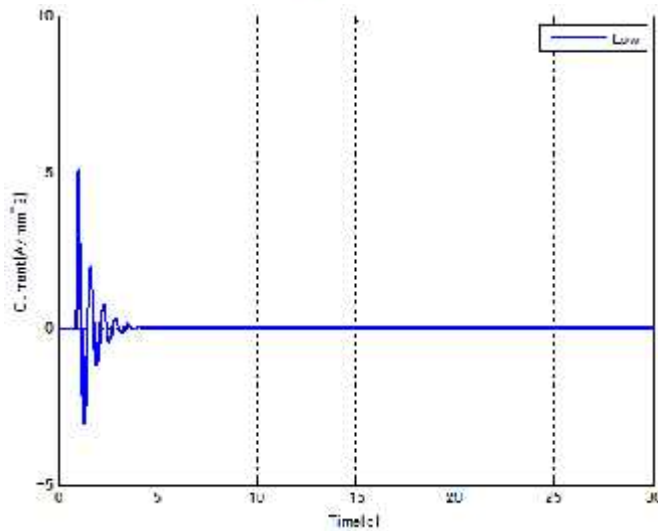
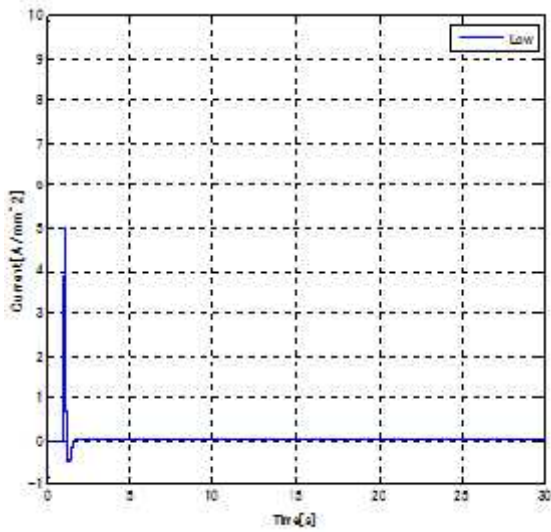
The results of the two-degree-of-freedom control using the inverse system transfer function of the LQ control step input as well as the square waveform input are illustrated and discussed below.



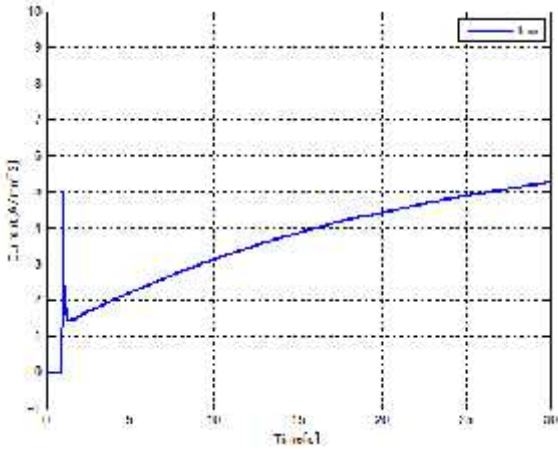
Raug=1000, Qaug = [1000 0 0; 0 1 0; 0 0 100] b. Raug = 0.025, Qaug= [10 0 0; 0 1 0; 0 0 100]



c. Raug=0.000001, Qaug = [1000 0 0; 0 1 0; 0 0 100] d. Raug = 0.025 Qaug = [1000 0 0; 0 1 0; 0 0 100]



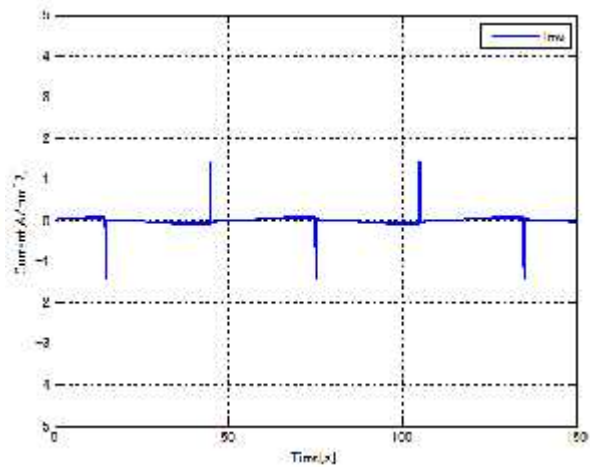
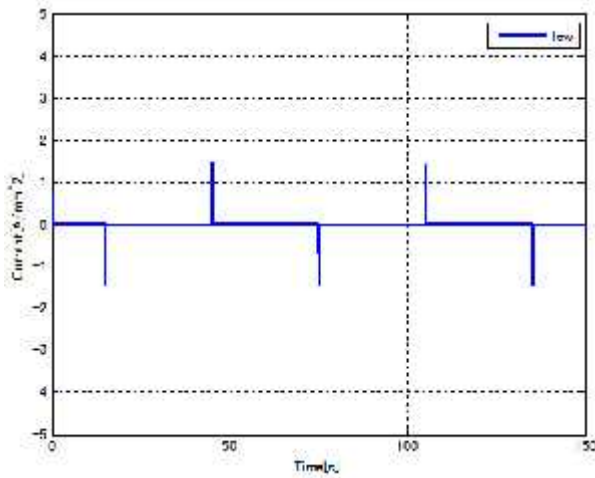
e. Raug=0.025 Qaug=[10 0 0 ; 0 1000 0 ; 0 0 100] f. Raug = 0.025 Qaug = [- 10 0 0; 0 1 0; 0 0 100]



g. $R_{aug}=0.025$ $Q_{aug}=[10 \ 0 \ 0 \ ;0 \ -0.01 \ 0 \ ;0 \ 0 \ 100]$

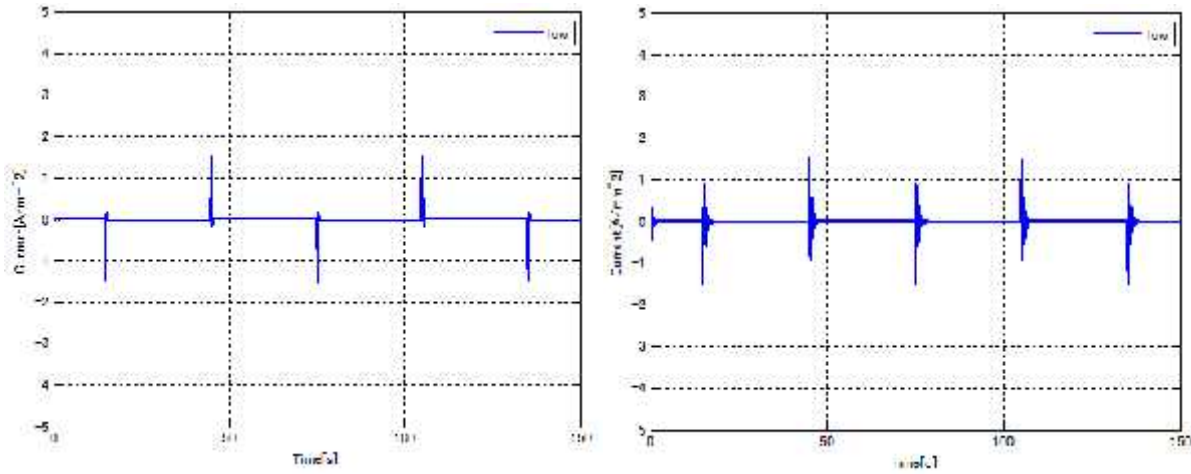
Figure 6. The Selemion CMV IPMC response vs. time at $AH = 4.5 \text{ gm}^{-3}$ under the 2DoF control with different gain and error weight values for a step input.

The results indicate a highly damped system. A low gain value (R_{aug}) causes the graph to reduce to “spikes” and shows a rise corresponding to the rectangular wave. Also, the graph indicates a fast and rapid rise and a consequent fall. The pulses were reduced to almost a spike, when the value of R_{aug} was extremely small. The varying of the error weight value (Q_{aug}), causes different variations but after rising sharply at the initial stage, the current decreases rapidly and starts to rise gradually. A value of 5 was attained in the initial rise.

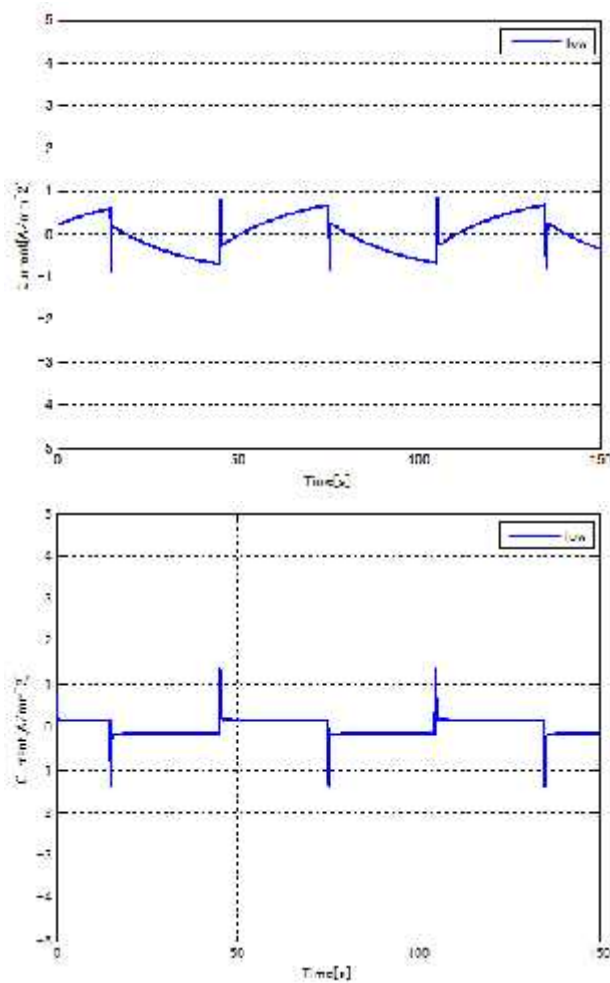


a. $R_{aug}=0.000001$, $Q_{aug}=[10 \ 0 \ 0 \ ;0 \ 1 \ 0 \ ;0 \ 0 \ 100]$

b. $R_{aug}=0.025$, $Q_{aug}=[1000 \ 0 \ 0 \ ;0 \ 1 \ 0 \ ;0 \ 0 \ 100]$



c. $R_{aug}=0.025$ $Q_{aug}=[10 \ 0 \ 0 \ ; 0 \ 1000 \ 0 \ ; 0 \ 0 \ 100]$ d. $R_{aug}=0.025$ $Q_{aug}=[-10 \ 0 \ 0 \ ; 0 \ 1000 \ 0 \ ; 0 \ 0 \ 100]$



e. $R_{aug}=0.025$ $Q_{aug}=[10 \ 0 \ 0 \ ; 0 \ -0.01 \ 0 \ ; 0 \ 0 \ 100]$ f. $R_{aug}=1000$ $Q_{aug}=[10 \ 0 \ 0 \ ; 0 \ 1 \ 0 \ ; 0 \ 0 \ 100]$

Figure 7. The Selemion CMV IPMC response vs. time at $AH = 4.5 \text{ gm}^{-3}$ under the 2DoF control with different gain and error weight values for a square waveform ($1.5V_P$, 16.667 Hz) input.

The response tends to rise gradually afterwards, a sharp fall rapidly after rising in response to the square wave. i.e. the response increases gradually toward the positive peak value ($+1A/mm^2$) and then decreases gradually toward the negative peak value ($-1A/mm^2$). A spike occurs at

the transition. It is assumed that, the characteristics match the number of negative second term, the convergence.

The output in two-degree-of-freedom control was derived through the inverse function of the transfer function and the plant (LQ control (square wave)) input.

3. CONCLUSION

It was found that the dehydrated Selemion CMV IPMC exhibits linear relationship of curvature vs. charge in the extremely low absolute humidity environment. The simple linear relationship of curvature vs. charge enables us to control the Selemion CMV IPMC bending actuator.

We successfully achieved the bending control of the Selemion CMV IPMC using feedforward, feedback and two-degree-of-freedom controls. The experimentally measured output current quantitatively agrees well with the desired ideal bending curvature.

By analyzing the electrical properties of the IPMC actuator dynamics, a modified control circuit model of the polymer actuator was derived and implemented.

Using the circuit model derived to determine the parameters, and by comparing the simulated results with the experimental results, the feasibility, usefulness of the circuit model was tested and verified.

An attempt to control for the circuit model by varying parameters such as weight gain was made and the results indicated.

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STRATEGIC APPROACH IN CRITICAL ASSET MAINTENANCE

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Abstract

In today's industries, asset maintenance plays a strategic role in sustaining the organization's competitiveness through enhancing equipment availability, reliability and productivity. In recent years, considerable research work on asset management (AM) has been undertaken. This stems from the fact that AM considers the assets life cycle where the operational and maintenance phase is important. Core to asset maintenance is the proposed use of various risk assessment techniques/tools. These tools propose a structured approach through which critical failure modes are identified, analyzed and mitigated. Commonly applied risk assessment tools in AM include the failure mode and effect analysis (FMEA), static/dynamic fault tree analysis (FTA) and static/dynamic Bayesian networks (BN). Despite considerable effort directed towards developing individual risk assessment (RA) tools, few papers propose a structured framework that allows selection of tools best suited for the organization, considering the often varying business or operational context. Thus, this paper proposes a conceptual risk assessment tool selection model. Based on an extensive literature review, the model enumerates generic selection criteria accounting for the well-known 'factors of production', i.e. manpower (personnel), machines (assets complexity), methods (procedures), and materials (tools and aids). Next, the selection criteria are assigned priority weights based on the analytic network process (ANP) methodology that accounts for the type of RA tool and business context. Finally, applicability of the conceptual model as an audit tool where the organization assesses its suitability against the varied RA tools is demonstrated.

Keywords: Maintenance, Asset management, Risk assessment,

1. INTRODUCTION

In the last few decades, the business environment organizations has undergone considerable changes. As such, organizations are nowadays confronted by challenges such as changing market dynamics and shifting consumer preferences. Moreover, operational and maintenance (O&M) costs are increasingly becoming an important aspect that cannot be ignored. Indeed research shows that the O&M cost constitutes as much as 70% of the asset's total cost of ownership [Koronios et al., 2007]. As such, the maintenance function is no longer perceived as "necessary evil", but an important contributor to the organizations competitiveness [Van Horenbeek, 2014].

Thus to remain competitive, organizations are increasingly adopting asset management strategies where all phases in the asset's life cycle are considered, i.e. right from inception to disposal. In literature, several definitions for AM are discussed. One such definition is the PAS-55:2008. Here, AM is defined as "*the systematic and coordinated practices through which the organization optimally and sustainably manages its assets and asset systems, their associated performance, risks and expenditures over the asset's life-cycle for the purpose of achieving the*

organization strategic plan.” This definition clearly situates risk management in the context of management of technical assets.

In risk management, a wide range of risk assessment (RA) techniques/tools have been developed and applied for in diverse sectors such as finance, insurance, and more recently, asset management [IEC, 2009]. In asset management, such techniques present a structured approach where asset failures are systematically identified, analyzed, evaluated and mitigated. Often, mitigation is achieved through implementing appropriate maintenance policy(s), e.g. condition based maintenance (CBM). In AM, commonly applied risk assessment techniques include the failure mode and effect analysis (FMEA), fault tree analysis (FTA) and Bayesian network (BN) [Khan, 2004; Langseth and Portinale, 2007; Moubray, 2001].

Whilst numerous RA tools are discussed in literature, current research effort is largely directed towards enhancing the capabilities of individual tools. However, such improvements seldom take into account the practical use of these tools in maintenance decision making. For instance, Liu et al. [2013] reviews research focused on FMEA where the conventional risk priority number (RPN) is enhanced. Here, some enhancements include adapting linear programming and fuzzy rule base approaches. However, such enhancements often increase the complexity of the FMEA, thus inhibiting its use in maintenance decision making. Moreover, the maintenance decision makers are often confronted by numerous RA tools and selecting an appropriate tool can be quite a daunting task. This is attributed to the lack of a clear selection framework. Thus, in absence of such a selection framework, the decision maker may opt for an ad-hoc selection or not use a specific RA tool at all. Yet, these tools play a vital role in structured maintenance decision making where failure risks are identified, prioritized and mitigated [Pintelon, 2006].

What is your reaction when you drive on a highly dilapidated road or drive in a poorly maintained vehicle or inhabit a house that is a shabby state? The first reaction is that of neglect, run-down, with all clear indications that the asset in question is not well taken care of,..... or technically speaking, “*poorly maintained*”. So, we may start by asking ‘What is Maintenance? Why is Maintenance important? And which policy approach can we employ to ensure the assets are well maintained?’

2. MAINTENANCE FUNCTION

Maintenance is defined as the “combination of all technical and associated activities required to keep equipment, installations and other physical assets in the desired operating condition or restore them to this condition”. The role of maintenance could be well defined by the four objectives it seeks to accomplish (see Figure 1); (a) ensuring asset functionality, (b) increasing asset life, (c) ensuring asset shine, (d) ensuring safety.

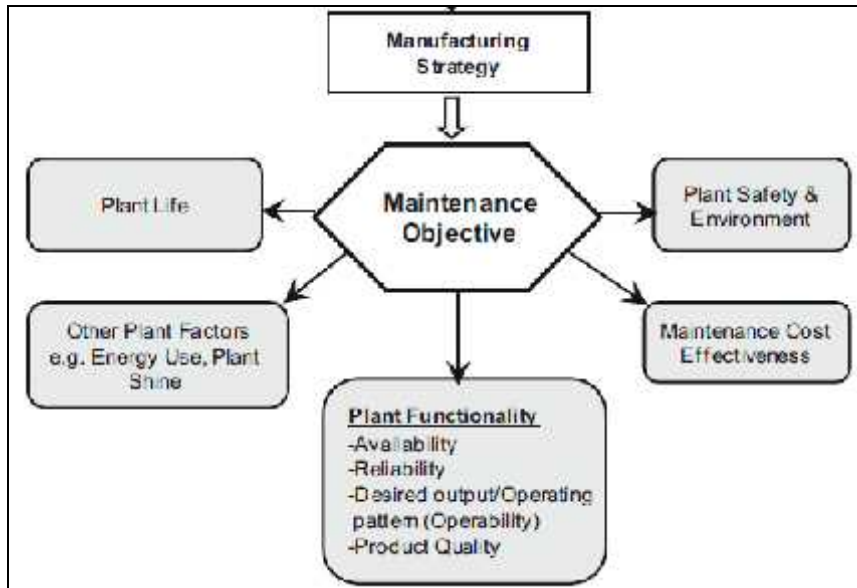


Figure 1: Summary of Maintenance objectives for a Maintenance department

For most assets, ensuring functionality is the prime objective of maintenance function. Here, maintenance has to provide the right reliability, availability, efficiency and capability to function in accordance to the need for these characteristics. Ensuring system life refers to keeping assets in proper working condition, reduce chance of condition deterioration, and thereby increase its life. Maintenance for ensuring equipment shine has no direct economical or technical necessity but primarily a psychological one of ensuring the equipment or asset look good. A good example is painting for aesthetic reasons. The last, but very important objective of maintenance is to ensure safety of all assets. Here, maintenance has to prevent significant deterioration or deviation in asset operation, which can threaten not only the functionality but also safety and to return the asset to full functioning after breakdown or disturbance.

3. METHODOLOGICAL APPROACH TO ASSET RISK ASSESSMENT

It is worth noting that the deterioration of assets' condition begins to take place as soon as the asset is commissioned. In addition to normal wear and deterioration, other failures may occur especially when the equipments are pushed beyond their design limits or due to operational errors. As a result, equipment downtime, quality problems, speed losses, safety hazards or environmental pollution become the obvious outcomes. All these outcomes have the potential to impact negatively the operating cost, profitability, customers' demand satisfaction, and productivity among other important performance requirements.

To ensure the assets operates at the required condition while meeting its productivity targets at an optimal cost, maintenance management has to make conscious decisions regarding the maintenance objectives and strategies that need to be pursued. In this paper, we propose a methodological approach of identifying, quantifying and mitigating the risks associated with asset deterioration and failure. Once the risks are identified and quantified, the methodology proposes an approach of mitigating the asset risk through a maintenance policy as shown in figure 2.

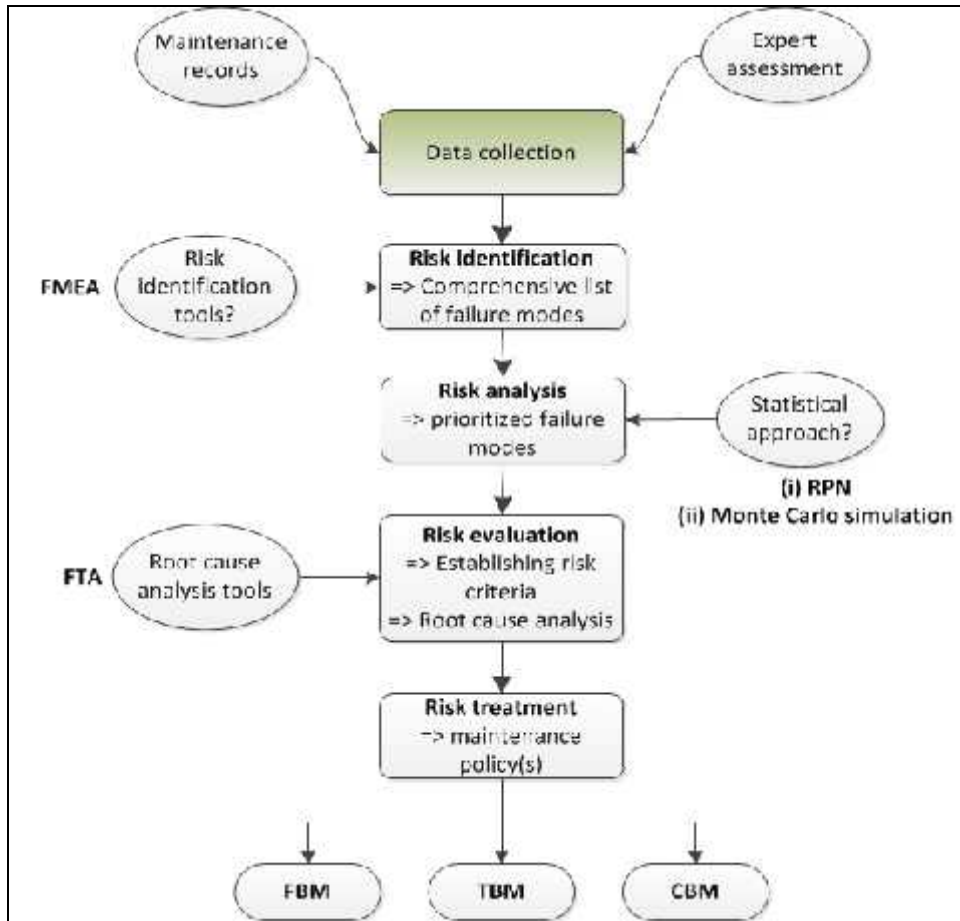


Figure 2: Methodological approach of Maintenance risk identification and mitigation

In the proposed methodology, we start with the *data collection* of the different types of failure a system or plant experiences. Data availability is one of the key challenges of many organizations since failure data is rarely kept. Where secondary data from the maintenance records is not availability, then primary data can be collected. The second step involves the *risk identification* where a comprehensive list of failure modes and failure impact is generated, relating to all the risks identified in the asset or plant. Here, we propose the use of risk analysis tools like failure mode and effect analysis (FMEA) for risk identification.

The third step is the *risk analysis* stage, where the risks are quantified with the use of failure frequencies and failure effect. The failure effect can be quantified in terms of failure cost, production losses, safety impact among other factors. Here, we propose the use of risk priority numbering (RPN), where the failure modes are ranked based on the RPN numbers. The higher the RPN Number, the higher the risk or the criticality of the failure mode.

$$\text{Risk} = \text{Likelihood} \times \text{Consequences} \times \text{Detectability}$$

In the fourth step, the *Risk evaluation* stage entails establishing acceptance criteria, which filters the failures that are acceptable and unacceptable. E.g. if the failure repair cost exceeds a certain threshold, the failure is not acceptable and should be prioritized for improvement (e.g. selecting the best maintenance policy that mitigates the failure). The risk evaluation will identify which failures are most important and the next stage would be to establish the root causes of the critical failures. Tools like Fault tree analysis can be applied at this stage. Finally after establishing the root causes of critical failures, a *mitigation strategy* is adapted, where the most appropriate maintenance strategy (policy) for the asset is selected. This is an important part of maintenance management and is discussed below.

4. MAINTENANCE POLICY APPROACH.

Maintenance policies outline the rules or set of rules for triggering maintenance actions. These maintenance actions may be corrective, when the failure has already occurred, or precautionary actions, which are carried out to deter failure. Different types of maintenance policies can be employed based on the criticality of the asset.

We can classify maintenance policies in the following five general categories: *passive* policy, *reactive* policy, *preventive* policy, *predictive* policy or *proactive* policy. Further, several types of maintenance policies can be considered to trigger, in one way or another, either precautionary or corrective maintenance interventions. These policies are mainly Failure-based maintenance (FBM), Time/Used-based maintenance (TBM/UBM), Condition-based maintenance (CBM), Design-out maintenance (DOM) and Opportunity-based maintenance (OBM), as shown in figure 3. The kind of policies adopted for an asset or for specific equipment has great impact on maintenance activities, productivity, and safety. Let us briefly look at what each policy represents;

Opportunity-based maintenance (OBM) is policy where maintenance action is only carried out if an chance arises. This is a ***passive policy***, since no maintenance plan is developed. Maintenance only happens when an opportunity arises because there is a maintenance intervention for another component of that machine and can be applied when the asset risk is negligible.

Failure-based maintenance (FBM) is a purely ***reactive policy*** where maintenance is carried out only after breakdown has happened. This policy may be appropriate where failure risk is low e.g. bulb replacement. However, it may be very risky for other systems due to the potential of secondary damage and safety hazards. For example, a car tyre failure may lead to rim damage or a serious accident. Reactive maintenance is also a recipe for safety hazards since little time is taken to plan due to urgency of the failure and thus some things are likely to be done in an inappropriate manner.



Figure 3: Policy levels in Asset Maintenance

Time/Used-based maintenance (TBM/UBM) is a ***preventive policy*** where maintenance is carried out at specified time intervals. For UBM, intervals are measured in working hours while in TBM intervals are in calendar days. In between PM actions, CM actions can be carried out when needed. The preventive approach is applied if the failure cost is higher than preventive cost, or if it is necessary because of criticality due to the existence of bottleneck installation or safety hazards issues. Also in case of increasing failure behaviour, like for example wear-out phenomena, preventive policies are appropriate. However, preventive policies are not able to

foresee failure and are therefore not able to reduce the failure probability or potential safety hazards.

Condition-based maintenance (CBM) is a **predictive policy** where maintenance is carried when a measurable condition, which can signal the probability of a failure, is sighted. This is comparable to ‘intelligence’ gathering on the condition of the system and is highly recommended for critical failure modes with high failure risk. Foreexample, vibration measurement can clearly indicate the start of a failure mode in rotating components like bearing. Other technologies used in predictive maintenance are; oil analysis; Thermographic analysis, ultra sound analsis among others. Moreover, the use of fairly low-level technics such as checklists, together with human senses (visual inspections, detection of “strange” noises in rotating equipment, etc) can help detect potential problems and initiate preventive actions before the situation deteriorates to a breakdown. These helps in mitigating failures, long before they occur and give maintenance staff some adequate time to prepare precautionary actions.

Design-out maintenance (DOM):- While FBM, TBM, UBM and CBM are used to maintain the physical assets, there may be a need to look for the possible design changes that may avoid maintenance in the first place. This **proactive policy** is referred as design-out maintenance (DOM). This policy implies that maintenance engineering is proactively involved at design stage of the equipment to solve potential problems in relation to maintenance and safety. Ideally, DOM policies intend to completely avoid maintenance throughout the operating life of installations, for example the design of airless tyres for aircrafts to ensure there is no tyre burst during landing. As a consequence, equipment modifications are geared either at increasing reliability (by rising the mean-time-between-failures) or at increasing the maintainability (by decreasing the mean-time-to-repair when the equipment fails) or increasing equipment safety.

5. CONCLUSION

Maintenance management is a very critical function in any organization. For manufacturing assets, maintenance can determine the level of productivity, safety, profitability or the competativeness of a company. However, most organizations lacks a clear maintenance policy approach for their assets. This paper proposes a failure risk evaluation methodology that can support managers to prioritize failure modes and develop a maintenance strategy to mitigate failure. The methodology is highly recommended for critical assets whose failures is likely to result to huge financial losses.

In conclusion, we see that various maintenace policy approaches demand for different level of planning, preparedness, investment, expertise and technology among other managerial factors. We also see an increasing level of sophistication in planning for the various levels of policies (see figure 3), from the passive policy, which has basically no maintenance plan, to proactive policy, where asset performance results are derived from careful and thorough analysis, design and implementation.

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APPLICATION TRENDS AND TECHNOLOGY UPDATE IN LASER MATERIALS PROCESSING TECHNOLOGY

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Abstract

In laser material processing, fibre lasers continue to displace CO₂ gas and lamp-pumped Nd: YAG lasers in a broad range of applications and other technologies, especially direct diode and disc lasers are taking an increasingly larger share of the laser market as new applications and new processes such laser additive manufacturing, LAM, continue to emerge . This paper looks at the application trends of laser material processing technology in recent years

Keywords: excimer, diode laser, DPLSS, laser additive manufacturing, stereolithography, hybrid laser welding

INTRODUCTION

Laser material processing for a long time has become a well established technology in a broad range of industries and is predominant in automotive, aerospace, medical equipment manufacturing ... for different industrial processes, primarily in cutting, but also in drilling, welding, marking, heat treatment just to name a few. In previous papers (Niyibizi, Ikua, &Kioni, 2013; Niyibizi, Ikua, Kioni, &Kihato, 2012; Niyibizi, 2011), authors presented elaborate reviews on how fibre lasers and other technologies such as disc and high-power direct diode continue to displace CO₂ gas and lamp-pumped Nd: YAG in applications they once dominated unchallenged. The landscape of laser manufacturing industry is changing very fast not only in terms of new laser sources but also in terms of materials, manufacturing processes and applications.

In the same perspective as the previous papers, here we discuss ultraviolet lasers and their industrial applications and also new industrial processes including laser additive manufacturing, LAM.

We base our research on a series of classical books, authoritative scientific and professional periodicals and journals with updated information on different research aspects and technological state-of-the art findings in photonics, optoelectronics and manufacturing industries worldwide over more than 10 years. Information on technological and industrial

innovations are based on industry periodicals such as Laser Focus World, Industrial Laser Solutions for Manufacturing and proceedings of conferences and events in the laser material processing industry, worldwide

I. UV LASERS

On the electromagnetic spectrum, ultraviolet (UV) light is [electromagnetic radiation](#) with a [wavelength](#) shorter than that of [visible light](#) but longer than [X-rays](#), that is, in the range between approximately 400 [nm](#) and 10 nm, corresponding to [photon](#) energies from around 3.1 [eV](#) to 124 eV. UV laser light offers significant advantages for materials processing, because its short wavelength can be focused to a smaller spot size than visible or infrared light. It produces finer features in microstructuring and marking applications than can sources with longer wavelengths (Lou, 2002). The minimum imaged feature size achievable by an optical system is limited by diffraction, which increases linearly with wavelength. Another advantage of UV lasers derives from the nature of the physical interaction between high-energy UV photons and many solid materials, particularly organics. In this interaction, termed "photoablation," UV photons directly break the molecular bonds holding the material together. Surrounding unilluminated material is virtually unaffected by this nonthermal ("cold") process, resulting in sharply defined features and a minimal heat-affected zone. This is very evident for example in electronic board printing. In contrast, visible and infrared lasers process material by heating it until it is boiled off or vaporized, which results in peripheral thermal damage (Paetzel, 2006). Any disadvantages of UV processing are application specific. For example, a given material might not absorb well at certain UV wavelengths, and therefore would be difficult to process with UV lasers. For the shortest UV wavelengths (<200 nm), the limited number of transmissive optical materials available can make it difficult or expensive to produce focusing lens systems. The typical solution is to go to all-reflective optics, which may be more bulky. For industrial applications the most valuable type of high-power UV laser is the excimer laser. Excimers are the most powerful ultraviolet lasers, delivering the highest pulse energy and the highest average power available. This has made excimers the tool of choice for a number of demanding applications. The largest commercially available excimer lasers generate up to 1200 W of average power and up to 2J pulse energy (Coherent, 2013). Another UV laser is the frequency-multiplied UV Nd:YAG, in which a nonlinear crystal is used to transform the 1.06 μm output to its third (355 nm), fourth (266 nm), or fifth (216 nm) harmonics. When diode lasers are used as the pump source, these lasers are all solid-state and thus mechanically rugged. However, because of the critical lifetime of the nonlinear crystals and the limited conversion efficiency of this process, this type of laser is still restricted to low power but still can be very useful especially in micromachining.

I.1. Excimer Lasers

Table 1 gives a short overview of excimer lasers (Niyibizi, 2008).

TABLE I. SOME CHARACTERISTICS OF EXCIMER LASERS

Gas	XeF	XeCl	ArF	KrF	F ₂
Wavelength (nm)	351	308	248	193	157

Applications	Semiconductor industry: UV photolithography, fabrication of fibre Bragg gratings, fabrication of inkjet nozzles, metal processing, flat-panel displays, FPDs, polysilicon annealing, GTI cylinder liners
	Medical: ArF: eye surgery.
	Photochemistry
Trends	Shorter and shorter wavelengths for narrower IC features, more compact, wall-pluggable, portable, air-cooled, plug-and-play designs
Competition	Frequency-converted DPSSLs, GaN diode and fibre UV lasers
Average price (\$US)	\$US 380,082, one of most expensive lasers in cost and maintenance

Excimer lasers are presently the most powerful UV lasers. Their design is very similar to that of CO₂ lasers. They use high pressure with active gas constituting only 1% of the total and buffer gases, notably He and Ne, taking the rest. An excimer laser operates only in pulsed regime and can produce pulses with energies ranging from mJ to 2J with peak power in hundreds of MW (Coherent, 2013).

The most widespread industrial application of excimer lasers has been in deep-ultraviolet [photolithography](#), a critical technology used in the manufacturing of [microelectronic](#) integrated circuits. With phenomenal advances made in equipment technology in the last two decades, and today microelectronic devices fabricated using excimer laser lithography totaling \$400 billion in annual production, it is the semiconductor industry view that excimer laser lithography has been a crucial factor in the continued advance of Moore's law, enabling minimum features sizes in chip manufacturing to shrink from 800nm in 1990 to 22nm in 2012. This trend is expected to continue into this decade for even denser chips, with minimum features approaching 10nm (Wikipedia, 2014). From an even broader scientific and technological perspective, since the invention of the laser in 1960, the development of excimer laser lithography has been highlighted as one of the major milestones in the 50-year history of the laser (U.K. Engineering & Physical Sciences Research Council, 2010).

Another important application of excimers is excimer-enabled low temperature polysilicon (LTPS) annealing that is critical to the performance of several types of high-resolution, high-brightness flat panel displays (FPDs). For both excimer laser annealing (ELA) and two-shot sequential lateral solidification (SLS) excimer lasers are used by all leading FPD manufacturers. A third very important application of excimer lasers is drilling the array of tiny nozzles that form the ink pattern of inkjet printers (Coherent, 2013). Low cost of ownership and superior laser reliability are essential in such a high-volume application.

Automanufacturers use excimer lasers to create low-friction cylinder liners that reduce the emissions from high-performance diesel engines. Rugged laser reliability has enabled to implement this technology in the production of turbo direct injection (TDI) engines for many popular models (Nagel, 2012). Traditionally, the most important disadvantages of excimer lasers are: their very high price, massive size, poor stability, and short lifetime of the tubes and electrodes. In addition their maintenance is very costly and they are not user-friendly, because they contain halides. However, design enhancements over the past few years have reduced the

cost and complexity of excimer lasers while increasing their reliability. The most advanced excimer lasers use corrosion-resistant ceramics and carbon- and silicon-free alloys for their tube components. These materials reduce the tube corrosion that results from exposure to halogen gases, thereby extending tube lifetime and decreasing cost of ownership. Other improvements in excimer laser design address noxious gas storage and handling. By introducing a sealed module inside the laser casing that generates halogen gas (on an as-needed basis) from all-solid, inert materials, excimer laser designers have been able to eliminate the problems associated with halogen gas storage and transport (Basting, 2013; Delmdahl, 2009). The new designs are compact and some are air-cooled

1.2. UV DPSSLs

Another class of UV lasers used in micromachining are frequency-multiplied or high-harmonic diode-pumped solid-state (DPSSL) lasers.

1.2.1. Diode Pumped Lasers

Table 2 shows the types of Nd: YAG lasers, that include diode-pumped Nd: YAG usually referred to as DPSSLs

Table 2. Overview of Nd: YAG lasers (Niyibizi, 2008)

Type	Lamp-pumped	Diode pumped
Wavelength (nm)	1064 nm	1064
		532
		355
		266
Applications	The most versatile laser in terms of applications: metal processing, semiconductor industry, medical, pointers, range finders, direct-to-plate printing, image recording, photolithography, basic research...	
Competition	Fibre , disc, high-power diode lasers	
Average price (\$US)	40,850	16,000

There are two pump systems for Nd-doped lasers: lamp- and diode-laser pumping. Lamp pumping is the oldest and presently it is used only for high-power systems, but it presents many inconveniences, including the need of high voltage, high temperatures, short-life time of the lamp and a complicated firing circuitry and most importantly very low efficiency.(<1%).

The advent of high power semiconductor lasers, which can be tuned by altering temperature and drive current to emit at wavelengths that correspond closely to the absorption bands of the

lasing medium, has allowed the development of very efficient compact solid-state lasers (Hawkes, 1995). With flashtube pumping, most of the energy is wasted, not only by poor spectral overlap but also by poor spatial overlap of the pump light and the lasing mode thus heating the rod more than necessary. Because of this, the efficiency of lamp-pumped solid-state lasers can rarely surpass 5% (Koechner, 2008). For Nd:YAG, which constitute the majority of DPSSLs, diode laser pumping takes advantage of the fortuitous match of the emission line of the GaAlAs diode laser with a strong absorption peak of neodymium ion at 808 nm. Such high-power reliable diode lasers based on GaAlAs were developed in the 1980's. Pumping Nd:YAG crystal rod and discs with diode lasers has allowed more compact, even battery-powered devices. To produce very high pumping powers (10W to several kW) many diode pump lasers are required. Optical fibres can be used to couple light from a bank of laser diodes into the crystal, generally cut in the form of a slab in which pump light propagates in zigzag by total internal reflection. The same technique is used to pumped fibre and disc lasers. These are in reality DPSSLs

For DPSSLs, Nd:YAG is a crystal of choice; it is inexpensive, it can be grown in large sizes of high quality. DPSSLs have high wall-plug efficiency up to 40% which enormous for laser standards. Low-powered DPSSLs are air-cooled and battery-powered. Nd:YLF and Nd:YVO4 lasers are growing in popularity. They present a high gain, a lower threshold, for example those used in low-powered hand-held pointers (Maini, 2013)

In recent developments, high-power InGaAs diode-laser stacks and arrays at 940 nm have led to the use of ytterbium (Yb) ion instead of Nd-ion. Yb³⁺ based laser materials: Yb: glass, Yb:YAG can be efficiently diode-laser pumped in the 900-980 nm range. The broad emission band of the Yb ion allows the production of femtosecond pulses by mode-locking. [Thin-disk lasers](#), which most often work with Yb:YAG crystals, can also generate well above 1 kW diffraction-limited output with high beam quality (Paschotta). The emission is usually at 1030 and 1050 nm in Yb-YAG. The development of AlGaInP red diode underlies research into pumping of Cr³⁺-doped crystals (alexandrite, LiCaF and Ti:sapphire) lasers (Schriber, 2014; Lupei, 2010) Gallium nitride technology should provide high-power UV diode lasers to pump DPSSLs in the visible without the need of frequency conversion (Harkonen, 2008)

1.2.2. High Optical Harmonic Generation

The most preferable field of DPSSLs is in harmonic generation: SHG, THG and FHG (second, third and fourth harmonic generation) with possibility of modular design (Table 2) at prices competitive with ion lasers in the visible and with excimer lasers in UV applications (Niyibizi, 2008)

Optical high harmonic generation is very similar to the familiar frequency multiplication used in radiotransmitters at radio and microwave frequencies. In [electronics](#), a frequency multiplier is based on a nonlinear component and generates an output signal whose output frequency is a harmonic (multiple) of its input frequency. Optical second harmonic generation, SHG, also called frequency doubling is a nonlinear optical process, in which photons with the same frequency interacting with a nonlinear material are effectively "combined" to generate new photons with twice the energy, and therefore twice the frequency and half the wavelength of the initial photons. Second harmonic generation was first demonstrated by [Peter Franken](#) et al at the [University of Michigan](#), Ann Arbor, in 1961 (Franken, 1961).

Frequency tripling is a process of nonlinear frequency conversion where the resulting optical frequency is three times that of the input laser beam. In principle, this can be achieved with a

⁽³⁾ nonlinearity for direct third-harmonic generation but this is difficult due to the small ⁽³⁾ nonlinearity of optical media and phase-matching constraints. Therefore, frequency tripling is usually realized as a cascaded process, beginning with frequency doubling of the input beam and subsequent sum frequency generation of both waves, with both processes being based on nonlinear crystal materials with a ⁽²⁾ nonlinearity (RP Photonics, 2014).

The main application of frequency tripling is the generation of ultraviolet light. Most common is the generation of 355-nm light by frequency tripling of a laser beam with 1064 nm, as obtained from an Nd: YAG or Nd: YVO₄ laser. A common approach is to use two LBO (lithium triborate) crystals, or an LBO and an BBO crystal, the first being phase-matched for second-harmonic generation and the second for sum frequency generation. The process is made more efficient by using pulses from a Q-switched or mode-locked laser, but also possible in continuous-wave operation e.g. with intracavity frequency doubling and resonant sum frequency generation. It is also possible to generate blue light by frequency tripling the output of a 1.3- μ m neodymium laser. Overall conversion efficiencies from infrared to ultraviolet can then be of the order of 30 to 40%.

II. EMERGING APPLICATIONS AND PROCESSES

II.1. Laser Additive Manufacturing, LAM

The most important and noticeable new processes for laser application is the LAM, laser additive manufacturing. 3D additive manufacturing is defined as “process of joining materials to make objects from model data, usually layer upon layer, as opposed to subtractive manufacturing technologies (Jun, 2013). 3D printers make parts and assemblies in similar fashion to a standard inkjet printer. It spreads layers of plaster or resin powder then binds them together. It can produce different mechanical and physical properties in a single build process. Laser sintering uses a high-power laser to fuse plastic, metal, ceramic or glass powders in cross section and a new layer of powder is added. Some plastic laser-sintering systems feature 50 W CO₂ lasers and direct metal laser-sintering [DMLS] systems may have a single, 200 W ytterbium-fiber laser with an option of 400 W for faster processing (Niesler, 2014). Emerging uses of laser additive processes include the development of nickel superalloys for jet engine parts, direct laser sintering of titanium for aerospace components, repair of heat-treated steel and components (Gu, 2012). Though this paper mainly focus on the laser process-related technology research trends, it is important to recognize that the laser processes are a small part of the overall additive manufacturing (AM) equation (Byiringiro, 2013, 1). Since the commercialization of the first stereolithography apparatus in the mid 1980s, more than a dozen types of processes have been developed. They range from simple, inexpensive devices to complex systems that utilize lasers to transform materials from liquid state into complex 3D objects. This diversity of processes is further complicated by the fact that some of them have only recently been developed and commercialized, whereas other processes have more than 20 years of research and commercialization history (Byiringiro, 2013, 2). Despite the diversity of stereolithography technologies, a number of key barriers still exist across many AM processes. They include:

Part fabrication times which are significantly slower than mass production processes

Most machines are designed in a way that they have inherent trade-offs between part size, accuracy and speed, with part accuracy often being sacrificed over speed or size

Many processes require highly skilled operators or need careful periodic tuning to operate optimally

Even the lowest-cost laser platforms cost more than \$10,000, which limits adoption by educational institutions and individuals

To overcome these limitations and barriers, a number of research priorities have been identified:

The most significant research need is a more complete, fundamental understanding of the basic science behind each AM process. In particular, a better understanding of the interaction between the various energy sources and materials is key.

Intelligent feed forward control schemes must be developed based upon a basic scientific understanding of the processes, coupled with the specific geometry and material knowledge for the part being built.

An increased focus on hybrid systems is needed to provide new processing capabilities which include: multiple additive processes, layer plus non-layer technologies, additive plus subtractive processing and the integration of sub-components utilizing automated component insertion. One example of this type of hybrid system could be a collection of additive technologies which create 3-dimensional structural materials with embedded and direct write electronics combined with automated insertion of pre-manufactured components, resulting in a fully integrated electro-mechanical product from a single hybrid system.

Goal-based design tools are needed to integrate general design for AM rules with process specific capabilities to rapidly produce computer aided design (CAD) geometry that meet specific design requirements. These tools should enable better utilization of the multi-material, preassembled, and complex-geometry benefits of AM.

Lower-cost machines are needed to reduce barriers to entry for individuals and educational institutions. Many AM machines could be redesigned and sold in higher volumes at a lower price if the machines were redesigned with lower cost as a primary design criterion. One potential way to accomplish this might be to modularize portions of AM processes which are shared amongst several diverse technologies, to increase the overall volume of each module, and thus reduce costs.

Current design education is inadequate for AM. Re-training of existing designers should be attempted. More importantly, a significant push to educate the next generation of engineers and designers to utilize AM must become a part of related technical training, community college courses, and university degrees.

Upper-level engineering courses must be developed to train the next generation of AM researchers. These courses should focus on the science of AM technologies, training engineers to develop better analysis tools, models, control schemes, and software tools for AM.

II.2. High-Power Laser Drilling For Oil and Gas

Laser drilling may be key to make previously uneconomic oil or gas deposits commercially attractive, as the Argonne National Laboratory's Laser Applications Laboratory (LAL) and a group of collaborators are examining the feasibility of adapting high-power laser technology to drilling for gas and oil (Argonne,2014)

The initial phase is designed to establish a scientific basis for developing a commercial laser drilling system and determine the level of gas industry interest in pursuing future research. If

drilling with lasers ultimately proves viable, it could be the most radical change in drilling technology in the last century as the basic mechanical drilling method has remained essentially the same. The novel drilling system would transfer light energy from lasers on the surface, down a borehole by a fiber optic bundle, to a series of lenses that would direct the laser light to the rock face. This would reduce the high cost of operating a drill rig significantly. Researchers believe that state-of-the-art lasers have the potential to penetrate rock many times faster than conventional boring technologies, a huge benefit in reducing the high costs of operating a drill rig. Another aspect of the study is the use of pulsed laser beam. Pulsed lasers have been used for better performance in cutting steel, for example. It may be likely that the pulsing action will flex and break the physical bonds between the rock grains, boosting the cutting effectiveness. A laser system could also contain a variety of downhole sensors, including visual imaging systems that could communicate with the surface through the fiber-optic cabling. Today, a typical land-based oil or gas well costs around \$400,000 to drill, while costs for an offshore well average nearly \$4.5 million. But in some deeper or more difficult drilling terrains, costs can be much higher. Reducing the time a drill rig remains on site can lower costs and make previously uneconomic gas or oil deposits commercially attractive. Earlier studies showed that laser systems now can provide more than enough power to cut rock (Hecht, 2012;IPG Photonics,2012; Dietrich,2012). Because the laser head does not contact the rock, there is no need to stop drilling to replace a mechanical bit.

II.3. Direct-Diode Laser for Cutting Steel

High-brightness direct-diode laser technology manufacturers have reached the 4kW mark, thus ushering in the [third generation of diode industrial lasers](#) and opening applications that were cost-prohibitive for previous generations. The 4kW [direct-diode laser](#), with a 100 μ m output fiber, has a beam-parameter-product (BPP) of 4mm-mrad, with superior beam quality needed for high-throughput cutting of steel over the range of thicknesses cut by laser cutters in job shops around the world. It can cut 12.7mm mild steel with cut quality and speed comparable to disk and fiber lasers (Belforte , 2014).

This is achieved by a combination of economy of scale of semiconductor diode laser array chips and wavelength beam combination (WBC), an MIT patented technology that enables the combination of energy from thousands of individual emitters into a single laser beam while preserving the beam quality needed for cutting and welding applications (Lincoln Laboratory,2012). WBC is unique for its inherent capability to preserve the wall-plug efficiency of direct-diode lasers while delivering the high brightness previously achieved only by lasers requiring more complicated gain/feedback architectures.

II.3. Printed Circuit Board Processing With UV Lasers

Ultraviolet lasers are one of the most versatile, efficient printed circuit board (PCB) processing technologies available. The beam from a laser generally provides a low-stress alternative to mechanical PCB processing methods such as milling or routing, but UV lasers provide an added benefit other laser sources do not, which is the ability to limit thermal stress. This is possible because most UV laser systems operate at low power levels. By utilizing a process known as "cold ablation," the beam from a UV laser produces a reduced heat-affected zone (HAZ) that minimizes burring, charring, and other negative effects of thermal stress normally associated

with higher-powered lasers. The very short wavelengths enable UV lasers to be precisely focused, allowing for the creation of very fine circuit features while maintaining superior positioning accuracy. Beyond short wavelengths and cooler workpiece temperatures, the high photon energy found in ultraviolet light makes UV lasers ideal for working with a large portfolio of PCB materials, everything from standard materials such as FR4 to high-frequency ceramic composites to flexible PCB materials including polyimide. UV lasers display very high absorption rates when working with resin and copper and also record decent absorption when processing glass. Only the pricy excimer laser (248 nm) posts better across-the-board absorption rates among these major PCB material groups. This material diversity makes UV lasers perfect for a wide variety of PCB applications across many industries, from creating the most basic of all-board features, circuit traces, to performing advanced processes such as pocket creation for embedding chips. UV systems work straight from CAD data to process boards, meaning any middle man in the board creation process is eliminated. This, coupled with ultraviolet light's precise focusing ability, allows UV systems to operate with high feature resolution and positioning repeatability. Another application that takes advantage of a UV laser's small beam size and low-stress properties is the drilling of vias, which includes through-holes, microvias, and blind and buried vias. UV laser systems drill holes in boards by focusing the vertical beam in such a manner as to cut straight through the substrate. Holes as small as 10 μm can be drilled. UV lasers can complete all the steps of PCB fabrication: surface etching, PCB depaneling, drilling in a single step. Instead of completing each application on different pieces of equipment with competing processes and methods, an entire part can instead be machined at once. This streamlined approach coupled with the low-stress, material diversity qualities of ultraviolet light makes UV lasers grow in popularity as a method for machining circuit boards (Stafford,2014)

II.4. Fiber Laser Drilling For Aerospace Applications

For a number of welding, marking, and cutting applications, the use of fiber lasers has become the standard. Remarkably, this has happened in a very short time. One area that has remained elusive is the drilling of effusion cooling holes for turbine engine components. In the past, Nd:YAG laser drilling has made it possible to machine both very small and precise holes, at normal to extreme angles to the surface, in a variety of shapes and orientations and in a wide variety of materials, including difficult-to-machine aerospace alloys. A high power (200 to 400 W average power) pulsed Nd: YAG laser is normally used. Processing is accomplished through either percussion drilling or trepanning. In a laser drilling process, high power density is accomplished with a focused spot size of 0.05 mm to 0.75 mm. Laser hole drilling technology has been employed for almost 45 years on turbine engine components used in aircraft and land (power generation) applications. Automotive engineers, filtration designers, and medical manufacturers are a few of the other users of laser technology that would not be able to manufacture their parts without the laser drilling process. Ytterbium (Yb) fiber lasers are the most common type of fiber laser used for material processing. The Nd: YAG lasers commonly used for hole drilling have peak powers to 50 kW, and many applications use peak power of 20 to 35 kW pulses. Preliminary results of studies on using fibre for drilling have demonstrated that QCW fibre lasers in the 9 to 12 kW range would make effective drillers with parameters very closely resembling the parameters used on a Nd:YAG laser (Thompson, 2013)

II.5. Laser Micro Glass Processing Using Co2 Laser

This year, Mitsubishi Electric Corp. announced it had developed patent-pending micro glass processing technologies that use a pulsed CO₂ laser to drill the world's smallest holes, measuring just 25 microns in diameter in a glass substrate. The technology is expected to enhance the use of glass circuit substrates for the improved performance of electronic devices.

A far-infrared CO₂ laser is used to drill transparent glass. Short microsecond laser pulses can reduce heating of the glass substrate during the laser drilling. Surface treatment technology is applied to suppress the over-enlargement of drilled holes. Some 200 holes per second can be drilled using a high precision, high-speed galvo mirror to scan the laser beam (Belforte , 2014,1)

II.6. Femtosecond Laser Processing Of Multiple Materials in Medical Device Applications

Femtosecond lasers are useful in micromachining applications for drilling and cutting high-precision holes and shapes free from thermal damage as they essentially vaporize matter without heat affected zone. This capability creates new opportunities for advanced micro designs, particularly for difficult to process metals that are not feasible with conventional lasers and for composite materials, including cutting of multiple materials at once or to drill and cut micro shapes, which reduces operations in the manufacturing of medical assemblies such as catheters. The ultrafast laser allows to process a wide range of materials and composites including polymers, platinum, stainless steel, and nitinol in size as small as 20 microns (Belforte , 2014,2)

II.7. Hybrid/Laser Welding

Welding of thick pipelines and metal sheets made of aluminum alloys or steel at high speeds of 6 m/min and 1.5 m/min, respectively, is accomplished with a hybrid welding process developed at the Laser Zentrum Hannover eV (LZH). In the future, the laser-based process can be used to shorten processing times and, thus, significantly reduce the processing costs of liquid gas tanks and pipelines. At the Centre, scientists have developed a process that can be used to make single-sided, zero-defect welds in aluminum sheets up to a thickness of 12mm by combining a laser beam with two gas metal arc welding (GMAW) torches. A scanner mirror makes the laser beam oscillate lengthwise or crosswise to the feed direction. The joining process can reach feed speeds of 5 to 6m/min, and gaps of up to 0.5mm and edge misalignment of up to 2mm can be bridged. The engineers have also been able to weld steel sheets with a thickness up to 23mm at a speed of 1.5m/min for single-layer welds. The innovative process is 12 times faster compared to conventional, multiple-layer GMAW processes, the seam geometry is very narrow and of better quality and filler material consumption is considerably lower. A further advantage of the combined processes is reduced thermal input and, thus, reduced component distortion. A solid-state disk laser with an output power of 16kW is used for the hybrid welding process. The main advantages of hybrid welding are the synergy effects between the arc of the GMAW process and the laser beam. In the combined process, the laser is coupled into the melt pool of the filler material of the GMAW process. The filler material is melted by the arc and in the molten state, it absorbs the energy of the laser beam and transfers the energy to the weld area between the sheets. The laser beam and the arc process stabilize each other, making relatively high welding speeds for arc processes possible and for high gap widths (Laser Zentrum Hannover, 2014; Hybrid welding, 2014)

CONCLUSION

This paper is a result of permanent monitoring of developments and innovations in laser sources and their recent and potential industrial applications in most diverse fields such as oil and gas drilling, hybrid welding, femtosecond laser medical devices manufacturing, glass

cutting, UV laser PCB prototyping. Despite the diversity of applications and laser sources, be fibre, UV or CO₂, the common denominator is that laser material processing remains a more dynamic, more reliable and more cost-effective and all the time improving technology compared to traditional industrial methods.

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SURVEY OF NATURAL LANGUAGE PROCESSING MACHINE TRANSLATION TECHNIQUES

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Abstract

There is exponential interest and development of information technology (I.T) products in the world especially mobile products. However, their usages are limited only to the language the product is created in. On contrary, in the world there are over 7000 living natural languages. Employing natural language processing (NLP) technique of machine translation can increase the usage of these I.T products. Therefore, this paper tries to bring together all possible methods that can be used to model a machine translation artifact in any language.

The methodology will involve documents reviews, examination of the current tools derived from each particular category and data analysis will utilize open, axial and selective coding which are qualitative methods. Open coding will identifying name, categories and describing phenomena found in the dataset. Then, axial coding will be used to make connections between the identified categories and finally, we will perform selective coding to select one category to be the core category, and relating all other categories to that category.

The main categories identified in the research where, rule based machine translation, statistical machine translation and corpus based machine translation, each with sub categories.

The work will be of significance to the African languages, which has suffered less translation tools as compared with Indo-European and Asiatic languages which have perfect working tools and will open the eyes of I.T products development firms to incorporate machine techniques hence wide population reach hence improving their sales.

Keywords: Corpus, Multilingual, Grammar, statistical, Machine learning, Rule-Based.

1. INTRODUCTION

Machine translation (MT henceforth) is a branch of computational linguistics which is an automatic process by computerized systems that convert a piece of text(written or spoken) from one natural language referred to as a source language (SL) to another natural language called the target language (TL) with human intervention or not, with the objective of restoring the meaning of the original text in the translated text. (Lopez, 2007.Cheragui, 2012.Jussa, 2012.Somya, 2012). The issues of machine translation has been in existence since 1940(

Cheregui, 2012) and over the time a lot of improvement has been witnessed in the approaches and architectures used to build the systems. However, despite the effort the translation performance in terms of fluency, fidelity, post edit and precision is quite low compared with that of human Translation though quite encouraging for computerized system. Today machine translation has diversified from just text based to speech based translation.

Language machine translation systems are either bilingual or multilingual (Interlingua). In any bilingual translation the system involves two languages (the source and target) and if the translation is from source language to target language only then it's referred to as unidirectional otherwise bidirectional. Multilingual involves more than two languages and by default are supposed to be bidirectional.

Translation comes with a cost which can be divided into three segments (Ranta, 2011). One needs to know the effort needed in terms of the linguistics knowledge of particular languages involved. Secondly, theoretical frameworks that are needed to be part of the system and finally the programming skills. Note, the actual cost of each segment depend on the methodology used to implement the translation.

2. MOTIVATION

Evolution of the internet and its continued exponential growth has provided a lot of data and information online for over 7000 world living languages (Gordon and Grimes, 2005). These data and information need to be consumed (dissemination and assimilation), however, Consumption is a big challenge where the information or data is available in a language that the consumer cannot understand or analyze. Moreover, Development of Information Technology (I.T) products/tools are resources extensive venture, requiring a lot of investment in terms of labour, time, monetary resources etc. Therefore, we need software localization (Though the software is available in one language at a time, it must be available in many language that the user can choose from) in different language in the globalizing world (Ranta, 2011). Especially in the third world countries where people speak the natives languages more effective than the official one.

The above challenges cannot be handled by the few Human translator experts (Jussa et al, 2012) available. Machine translation can fill this gap. Thus, this paper presents the different machine translation methodologies that are available to model a language translator.

3. METHODOLOGY

The methodology involved documents reviews mainly journal, conference papers and books on Machine translation plus examination of the various tools or prototypes which has been built using the approaches. Triangulation procedure was carried out to ensure reliability and viability of the whole process.

The data collected was inform of document, reviewing them will involve establishing categories, patterns, features and themes that are outstanding and then Pattern matching them. This called for Qualitative research (Myers ,1997).The categorization and themes was based on deductive approach while Strauss and Corbin(1998) selective, axial and open coding methods were employed in-order to get the patterns, categories and themes from all the documents on review.

Open coding identified name of categories as well as describing the phenomena found in the dataset. Then, axial coding was used make connections between the identified categories and finally, One category was chosen as the core in order to relate the others using selective coding.

4. APPROACHES TO MACHINE TRANSLATION

Meta phrase or Para phrase are two levels of translating a sentence using a machine translation system. In Meta phrase translation is word by word (Tripathi et al, 2010) resulting to the formal equivalence of the word in question. e.g. Tree in English will be translated to *Muti* in Kikamba language. The approach has a side effect of the original semantics of the sentence been lost during the translation. Therefore works well when dealing with word by word translation or building a Multi lingual dictionary.

In Para phrase level the translated text contain a gist of the original text meaning but may not contain word to word translation thus resulting to what is referred to as dynamic equivalence of the text being translated. (Tripathi, et al, 2010). Most of the current system uses the second options, while the Metaphase was used in the older system of 20th centuries.

Mainly there are three approaches to building a machine translator. Namely knowledge driven approach also known as Rule based Machine translation(RBMT), data driven approaches which is also know an Example based machine translation(EBMT). Finally, hybrid machine translation which combines both of the above mentioned methods.

4.1 Rule Based Machine Translation

It existence came to effect in 1940's and over the years it has continued to improve. Rule based systems consist of collection of rules, called Grammar rules, a bilingual or multilingual lexicon, and software programs to process the rules (Antony, 2013). The interaction of the components is has depicted in the diagram 1 below.

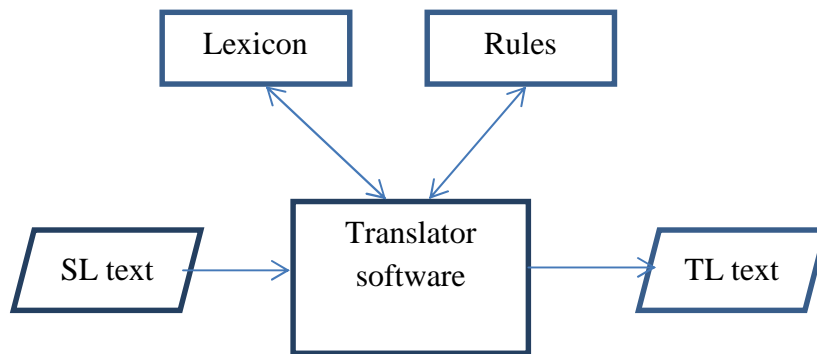


Fig 1 Rule base system

For any Natural language to be processed by Machine using this model, it must be changed to formal language (Wang, 2012, Jager and Rogers 2012) which is inform of computational grammar represented using the grammar rules. The grammar rules basically consist of analysis of SL and generation of TL in terms of syntax, semantic, morphology, part of speech tagging and orthographic features as depicted in the Vauquois triangle in diagram 2. Lexicon provides a dictionary for look up of words during translation while the software program allows effective and efficient interaction of the components.

The approach depend heavily on language theory hence resource intensive in terms human labour and hours spend when building the rules but easy to maintain, easy to extend other language and can deal with varieties of linguistic phenomena(Kaji ,1988.Jussa et al, 2010). Moreover, provide good translation performance which can be measured in terms of fluency, fidelity, post edit and precision thus can be effective model for under resource languages found mostly in Africa.RBMT can be approached from three angles namely direct, transfer and Interlinguaas shown in diagram 2

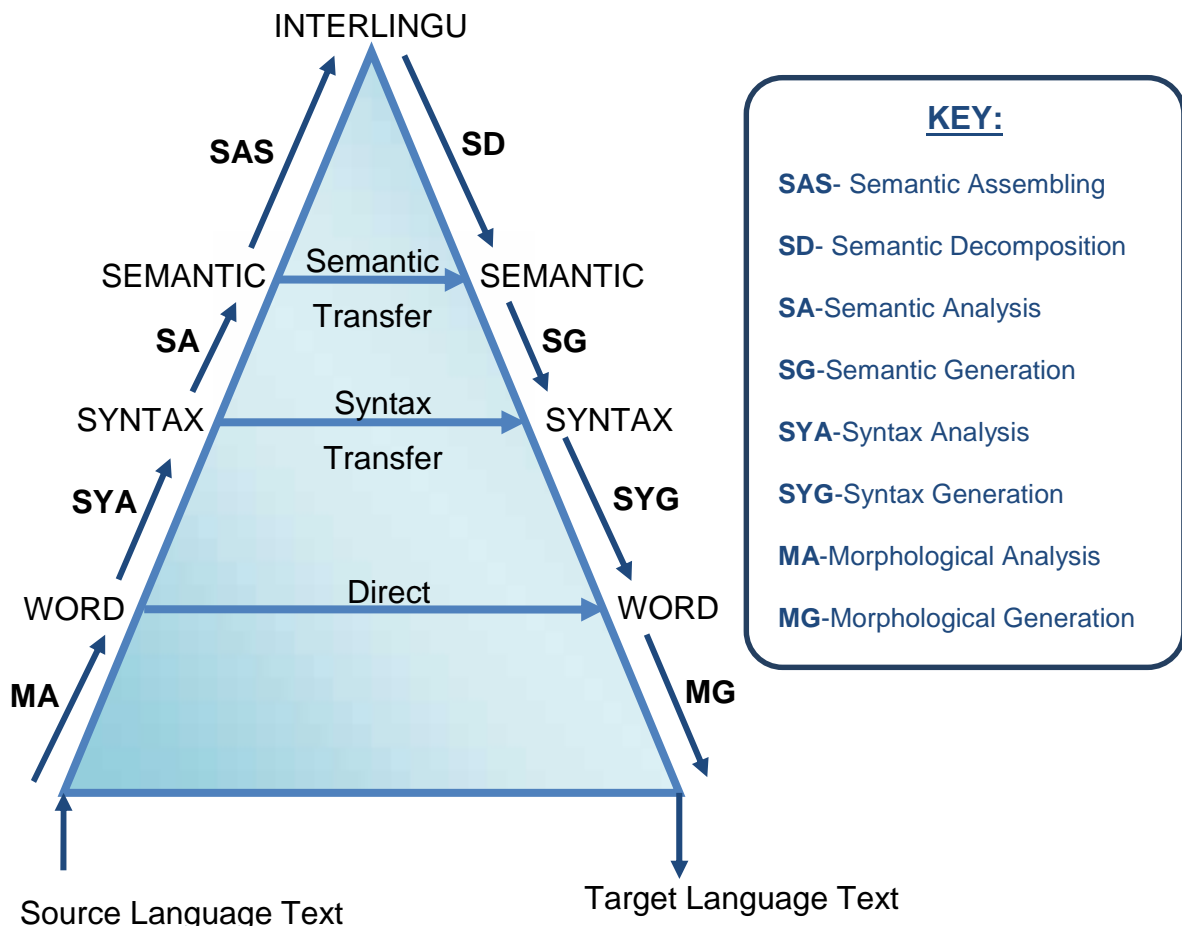


Diagram 2.0 Vauquois triangle (adapted form Dorr et al, 2004)

4.1.1 Direct translation

This is a unidirectional bilingual machine translation from the source text to target text. It involves analyzing the segmented source language texts so as to remove ambiguities, identify the correct target language expression and order in which they (segment) should appear after translation (Cheragui, 2012). Morphological inflections are removed from words in the source language text so as to identify their base forms enabling lookup in the bilingual dictionary. The structural analysis can only go as far as morphology in this case. According to Antony (2013) the quality and quantity of the source-target language dictionaries, morphological analysis, text processing software, and word-by-word translation determines the performance of the translation systems.

4.1.2 Transfer translation

The approach as three stages: Analysis, transfer and synthesis. In analysis stage, the source language text is segmented and analyzed in terms of morphology and syntax with the result of analysis being converted into an intermediate representation usually a parser tree dependent on the source language (Cheragui, 2012). The various part which might be analyzed to arrive at

this tree are such as, morphology, syntax, semantics, lexicon, part of speech, entities etc. By use of algorithm which might be heuristic or not, derivation of semantic and syntax structures are arrived at. This intermediate translation may be referred to as an abstract which is a higher form of language with less language specific representation.

Transfer involves generation of an equivalent abstract (parse tree) of the target language from the parse tree of the source language. Generally it involves transfer of the syntax/semantic structure of the source language input sentence into target semantic/syntax structure. Rules in regards to the content of the parse tree are used to guide the manipulation of the tree to generate SL tree.

Finally, by use of syntax and morphology synthesis one is able to generate the target language text from the parse tree.

4.1.3 Interlingua

According to Vauquois triangle drawn in diagram 2 this is the highest level of rule based machine translation and mostly used when developing multilingual translation tools. The major aims are to create linguistic homogeneity across the globe. Interlingua is a combination of two Latin words whereby Inter means intermediary and Lingua means language. It involves analysis of the source text in terms morphology, syntax and semantic, then assembling of the semantic in order to generated an Interlingua which is an independent language in respect to source and target language. Interlingua is usually intermediate language like how compiler converts high level programming languages into intermediate language before conversion to machine language. However, the unique of Interlingua language is once the independent abstract language is formed translation can be made to any language so long as there are generators for syntax, semantic and morphology for that language (Antony, 2013. Cheragui, 2012. Tripathi et al,2010)

4.2 Data driven approach to machine translation (DDMT)

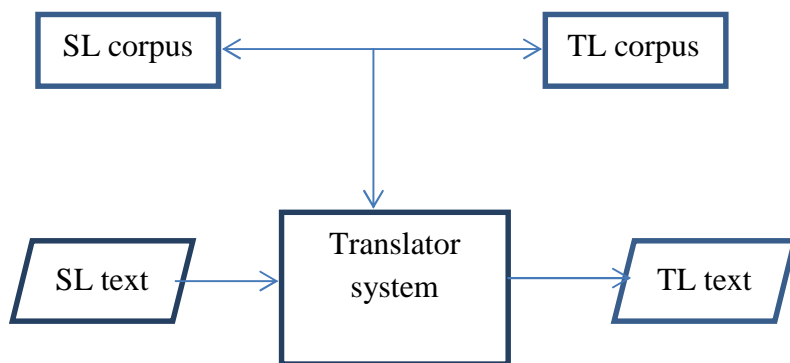
This model makes use of parallel bilingual aligned corpora as the basis of the translation. It is also known as corpus based translation..The parallel corpus is aligned through a process called annotation, then a classifier is created by supervised, semi- supervised, unsupervised or bootstrapping learning methods utilizing statistical, probability, clustering or classification method (jussa et al,2010)

Gupta (2012) state the architecture of this system consists of three stages namely: analysis (matching), transfer (alignment) and generation (recombination). In matching the source language text is segment into small unit according to the system granularity. Then from the source language corpus, a search is done for example or set of example which exactly or almost or closely matches the input segment of the input text. The search can be by syntactic or semantics or both. The former uses structural match of the phrases or words while the latter calculate the semantic distance between the words or phrases. Then retrieval of the corresponding words or phrases from the target language corpus is done.

Alignment involves use of the retrieval segments of the sets of example together with their translation to generate the appropriate translation fragments (Gupta, 2012). Finally,

recombination which identify which fragment correspond to the source text and how to appropriately put the fragments together to form grammatically correct translation

It's a cheaper way of generating natural language tools however it require parallel corpus that may not be there for under resource language unless someone generate it. It's widely used for the Indo-European and Asiatic languages. The model is divided into two major approaches that statistical machine translation (SMT) and Example based machine translation (EBMT).



Dig 3 Data driven based

4.2.1 Statistical Machine Translation (SMT)

SMT treats natural language translation as a machine learning problem (Lopez,2007) and gives an idea of mathematical reasoning in that every sentence in target language is a translation with probability from the source language. The higher the probability of the translated sentence implies high quality of translation. It's a data oriented with parallel aligned corpora for SL and TL. The parallel corpora are used to train a statistical translation model. In reference to Jussa (et al, 2012) this model mainly depend on statistical parameters and languages models apart from other data features for example morphology, lexicon, syntax, semantic etc. One may adapt supervised learning (engaging a teacher or critic) or unsupervised method where the system find the best probability of translation. Higher probability (accuracy) will depend on the quantity, quality and the domain of the data in the parallel text according to Lopez (2007).The model has three approaches word based, phrase based, hierarchical phrase based translation

4.2.1.1 Word based SMT

Sentence words are translated for source language to target language word by word at a time. Once the words are generated then they are arranged in a specific order by use of statistical value (probability) to generate the target sentence. However, compound words like idioms bring complexity here (tripathi et al 2010, Antony, 2007).This was the first approach to be used because of its simplicity.

4.2.1.2 Phrased based SMT

Koehn (et al, 2003) was the first to propose phrased based SMT. Phrases are several words together in a sentence. The source and target language sentences contained in the parallel corpora are divided into phrases. Phrased-based translation models are acquired from a word-aligned parallel corpus by extracting all phrase-pairs that are consistent with the word alignment based on Koehn (et al, 2007), In which case the input and output phrases are aligned according

to a specific order as suggested by Antony (2013). Though Phrased based SMT may result to better performance, Long phrases may degrade the performance.

4.2.1.3 Hierarchical phrase based SMT.

Involves the combination of phrase based SMT and syntax based translation. Phrase based consist the unit of block or segment of translation while the syntax translation brings the rules of translation. This model was proposed by Chiang (et al, 2007).

4.2.2 Example Based Machine Translation (EBMT)

Example based systems store huge knowledge base of translation examples which are maintained in the form source language- target language parallel corpus and may be aligned at the sentence level or word level. Any input is matched against repository in order to deduce the similarity match. The corpora need to be aligned It is also known as memory based translation. Its architecture is as per diagram 3. The matching here is based on distance metric which can be done by clustering, classification, association rule etc. The model has attracted a lot of attention because it requires minimal prior knowledge and quickly adapts to new language pair (Antony, 2007). The behavior of matching is similar to the one used by case based reasoning

4.3 Hybrid Translation Method

The RBMT and DDMT have merits and demerits. An hybrid translation model was developed to harness the benefit of the above two approaches. The pre-processor system of the translator is RBMT and a post editor of the DDMT mode. Most the organizations are adapting to such mechanisms due to the high translation performance. statistical translation model is usually used for the DDMT part.

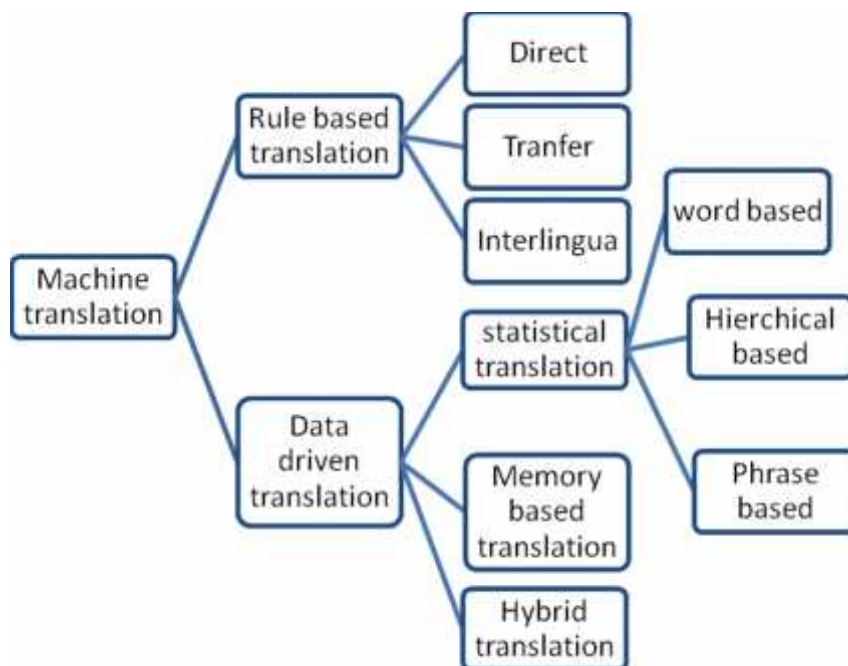


Diagram 4 machine translation summaries

5. CONCLUSION

The survey clearly shows since machine translation of human natural language came into effect, so many models have been developed to cater for different needs. Rule based model cater for the Linguistic domain while Example based caters for the data domain. The latter is widely used as compared with former but so for Indo-European and Asiatic language which are rich resource language.

There is need to examine the rule based system for developing machine translator for under resourced languages which are mostly based in African. This has been informed by research of Muhirwe(2007) who stated the under resourced languages are rich in grammar features which are the key ingredients for rule based system.

The way forward, we suggest use of hybrids translation models for under resourced languages, so as to ensure enough translators are made for this languages.

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LIST OF TABLES

Table 1 Carbon stocks volumes in Gatanga Constituency (Million Tonnes)

Location	Soil Carbon	Forest Carbon	Miscellaneous Carbon
Kimakia	2.012	5.265	0.521
Gatanga	2.365	6.824	0.687
Kiruara	4.235	7.564	0.597

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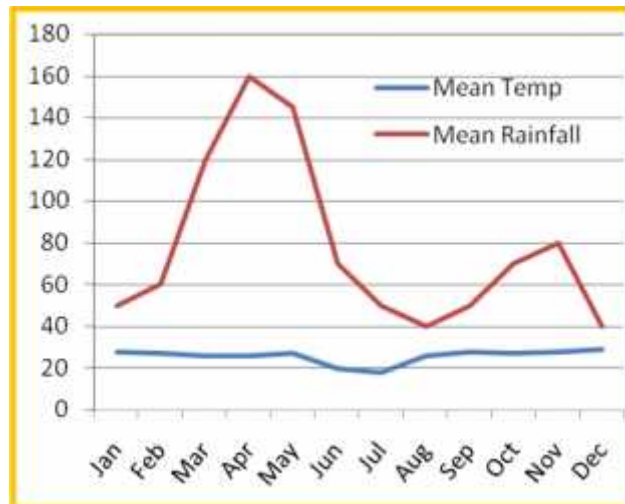


Figure 4 Seasonal fluctuations of monthly mean temperature and rainfall

MODELLING VIRTUAL ENTERPRISES USING MULTI AGENT SYSTEMS APPROACH

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Abstract

Enterprises can pool together their core competencies in a temporary organization mediated by information technology to exploit fast changing market opportunities. These inter-organizational collaborations of enterprises, referred to as virtual enterprises (VEs), often lack a formal facilitation platform. The competitive advantage of any VE is often jeopardized by the time it takes to set it up, especially if it is comprised of partners that are unknown to one another before the formation of the VE. The VE applications should be domain specific and dynamic. To achieve this dynamism, there is need for a framework for design and development of different VE applications. A generalized VE collaboration model will be helpful in facilitating enterprises that wish to cooperate to do so in a relatively shorter time and at fraction of the cost.

This research proposes to develop a generalized architecture for implementation of different VE applications. A multi-agent systems (MAS) approach is chosen aimed at providing efficient decision-making support by using software agents in the VE initiation, creation, implementation, and evaluation. The VE partner organizations are represented in the architecture as software agents while partner organizations' interactions are modelled as Agent Communication Protocols (ACPs).

State-of-art literature review formed the conceptual basis of this research, while case studies from industry provide the systemic framework for design, development and evaluation of VE. A proof-of-concept prototype has been developed to simulate and evaluate the case studies, and validate the proposed framework. The multi-agent systems architecture that implements VE's formation and collaboration is the main result of this work.

Keywords: Virtual Enterprise, Multi Agent System, Model, Agent Communication Protocol, Formation, Collaboration

1. INTRODUCTION

A virtual enterprise (VE) is a temporary organization that pools member enterprises' core competencies and exploits fast changing market opportunities [Crispin and de Sousa, 2010]. A VE, similar to life systems, follows a life cycle of creation, development, reproduction, and disappearance [Guerra 2006]. VEs are created to take advantage of a market opportunity. They develop by linking the core competencies of their members to provide products. Reproduction deals with the repetition of the product by other organizations with a better economy of scale. Finally, on satisfying the market opportunity, VEs disband and the same process starts all over again.

The Problem Statement and Motivation

There is a need for software applications that facilitate operations of virtual enterprises. A crucial competitive factor of a VE is its ability to form a customer-focused team. The competitive advantage of a VE is often jeopardized by the time it takes to set it up, especially if it is composed of partners that are unknown to one another before the formation of the VE, [Tølle and Vesterager, 2002]. The applications should be domain specific and dynamic.

To achieve this dynamism, there is need for a framework for design and development of different VE applications. A generalized VE collaboration model will be helpful in facilitating enterprises that wish to cooperate to do so in a relatively shorter time and at fraction of the cost.

Several agent-based approaches and systems have been described in the literature. While these address a wide aspect of multi-agent systems, they do not address a holistic model of a VE. They simplify the concept of a VE and focus on a single aspect or a single phase in the lifecycle of a VE. This research focuses on the initiation, formation and operation phases of the lifecycle of a VE.

Multi Agents Systems

A multi-agent system (M.A.S.) is a computerized system composed of multiple interacting intelligent agents within an environment [Kubera et.al, 2010]. Multi-agent techniques are used to address the issues of complex enterprises and solutions through intelligent behaviours, such as cooperation, competition, and coordination in a set of autonomous agents under a dynamic distribution-oriented open environment [John and Heavey 2006]. These features of multi-agents make them suitable for the representation of the entities in the enterprise environments (Niu et al. 2011).

Virtual Enterprises and Multi Agent Systems

There are a number of characteristics in the VE domain that make it a suitable application area for MAS as discussed by Camarinha-Matos and Afsarmanesh, [2005] and Kubera et.al, [2010]

Examples of such characteristics include:

A VE is composed of distributed, heterogeneous and autonomous components, a situation easily mapped into MAS.

The effective execution and supervision of distributed business processes requires quick reactions from enterprise members. Computer networks being the privileged media for communication, there is a need for each company having a “representative” in (or “listening” to) the network. This can be supported by agents.

Recent developments in VE are changing the focus from information modeling and exchange to role modeling, addressing aspects of distribution of responsibilities, capabilities and knowledge.

The phase of VE formation in which it is necessary to select partners and distribute tasks, shows market characteristics and negotiation needs that have been research issues in MAS.

A VE consortium is a dynamic organization that might require re-configurations e.g. replacement of partners, changes in partners' roles, etc., for which a flexible modeling paradigm is necessary.

The scalability property of MAS seems particularly adequate to support dynamic VEs in which different levels of cooperation with different sets of partners might be established at different phases. On the other hand, each enterprise might itself be seen as composed by a network of semi-autonomous entities (departments).

Continuous evolution of business models, technologies, organizational paradigms, and market conditions require effective support for evolution and a high level of modularity of the infrastructures.

Modelling Virtual Enterprises

The multi agent systems approach was used. In this approach, the VE, its formation and partner collaboration processes are supported by a multi-agents architecture. Using agents to represent the partners of a VE supports the selection of partners based on a detailed selection and evaluation criteria and collaboration of partners in a quick and efficient way. An overview of the multi-agent systems approach is shown in Figure 1 below and it consists of the following:

- a) An Agent-based model of a VE that represents the main entities in a VE and the relationships between these entities.
- b) VE formation and Partner Collaboration processes which describes how a VE is formed and operated, that is partners' selection and collaborations. The VE formation and partner collaborations are analysed in terms of the interactions among agents and can be represented as an Agent Communication Protocol (ACP).
- c) A Multi-Agent Architecture which supports the VE formation and Partner Collaboration.

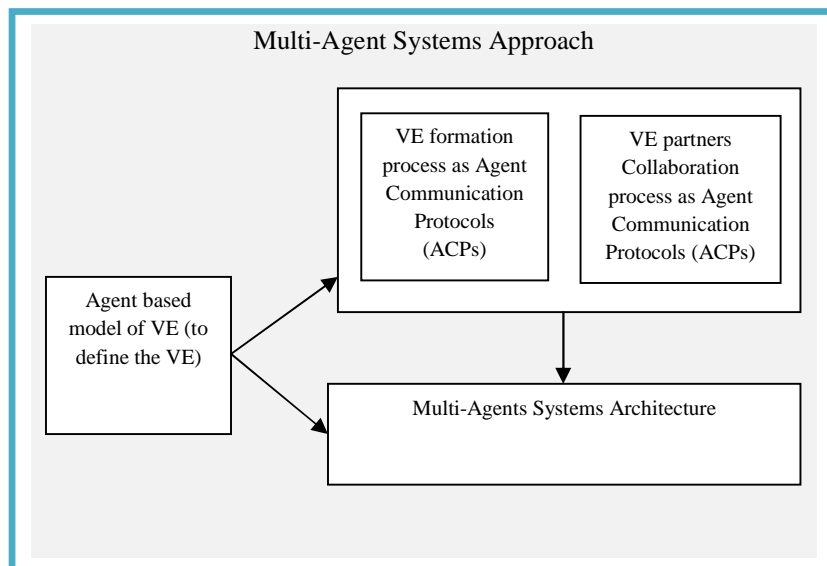


Figure 1: Multi Agents Systems Approach

Agent based model of VE

The agent based model of the VE plays a central role in this approach. The model defines the VE and contains all the information that is required for the formation of VEs and collaboration of partners. The model provides input to the VE formation and partners' collaboration processes and allows any partner information changes. The model and VE formation and partners' collaboration processes provide the input for the multi-agent systems architecture.

VE formation

In order to support the rapid formation of VEs, a model that describes the complete VE in terms of its entities and the relationships among them is important. Figure 2 shows different entities that are in the model and their relationships. A VE has a goal (or a set of goals) that is/are achieved by a set of activities that are performed by roles which are filled by agents. A role requires a certain set of skills. The agent that fills the role meets the skills requirement. The entities in the model are described using attributes; the relationships among the entities are represented using predicate calculus and a set of rules represent how they can be used.

An agent representing a VE Partner is described by multiple attributes, some of which may in turn be described by a set of attributes themselves, e.g. a particular skill of an agent. Each attribute is weighted to calculate a utility value that is used in the selection process.

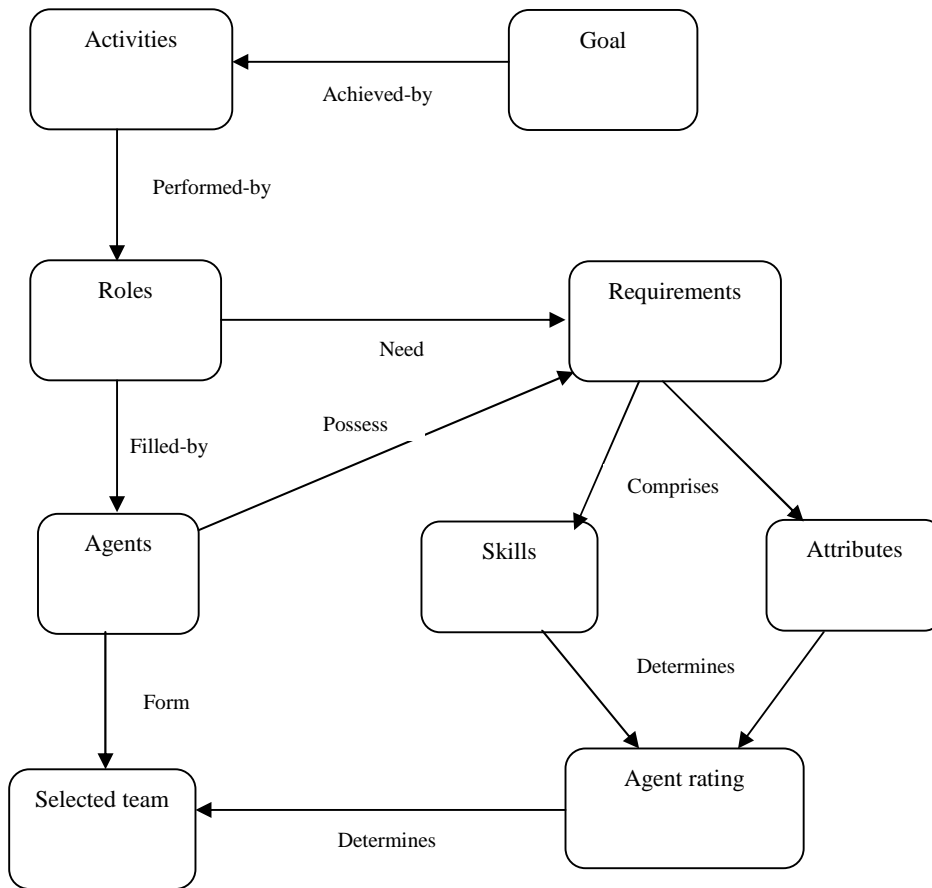


Figure 2: Agent entities' and relationships during virtual enterprise formation

Figure 3 gives an overview of the selection process. The sub-process “align goals” checks if the VE and the partner goals are aligned. If this is true, the partners now become Potential Partners and their skills and availability are matched against the requirements of the VE in the sub-process “match skills and availability”. The skills are matched by conducting a string match. The Potential Partners are now considered for selection.

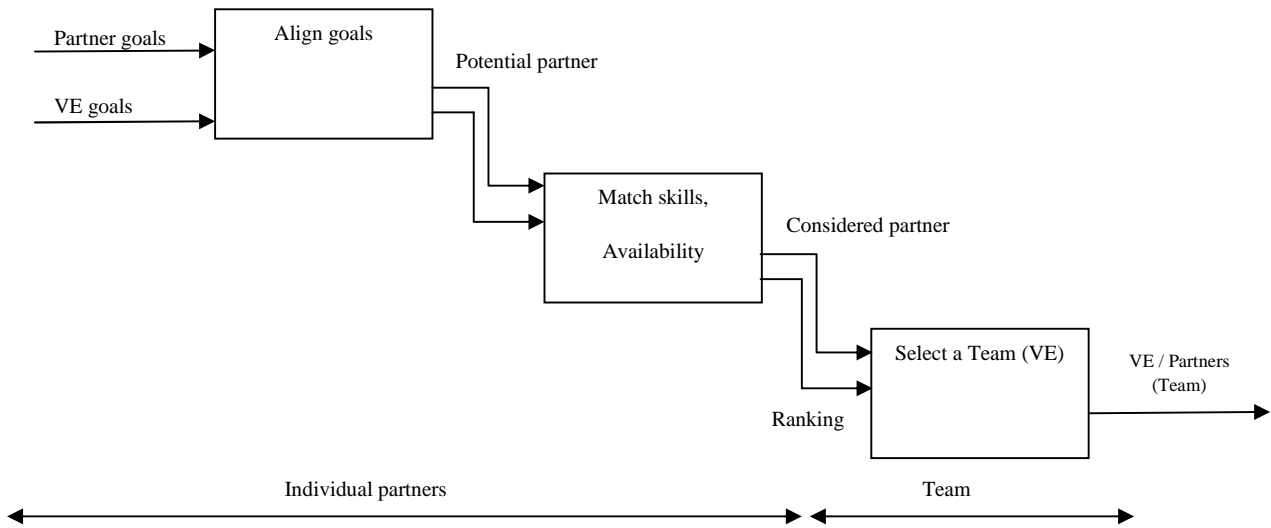


Figure 3 Selection of Virtual Enterprise partners

Communication during VE formation

Figure 4 shows the communication that takes place between the VE initiator and the partners. The VE is announced by inviting Interested Partners to bid (make a proposal with their skills and attributes) and the announcement contains the following information:

The goals of the VE

The roles in the VE

The skills that are required for the roles in the VE

The attributes of the VE (i.e. timeframe, cost and deadline for the response to the announcement).

The interested partners respond to the announcement by bidding (proposal), which contains the following information:

The goals of the partner

List of attributes (including partner skills) and their values.

The bids are qualified if the goals are aligned and skills match the skills of at least one of the roles. The bids that are disqualified are informed of their failure to qualify and the VE initiator then ranks the qualified bids in each role and prepares to negotiate with them.

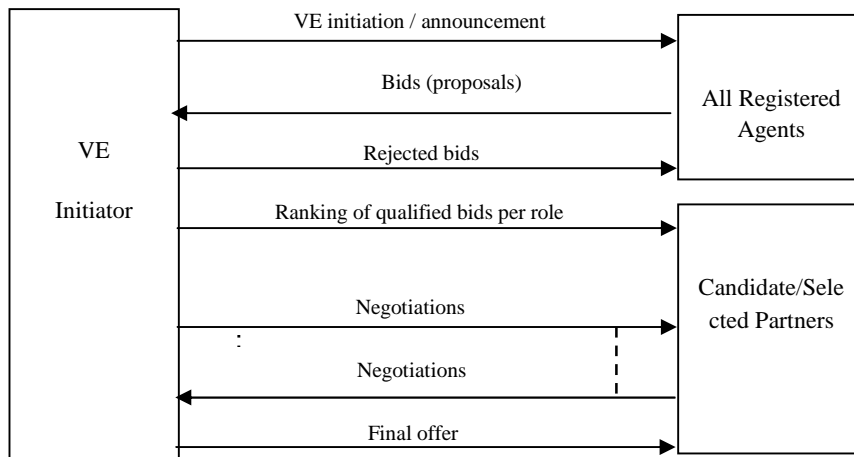


Figure 4: Agent communications during VE formation

Agent Communication Protocol for VE formation

An Agent Communication Protocol (ACP) describes the sequence of communication between two agents and the contents of the messages exchanged [FIPA, 2002] and [Labrou and Finin, 1998] respectively. ACP for VE formation and selection of partners can be compared to the basic auction protocols, [Bauer et al., 2001], and the Contract Net Protocols, [Davis and Smith, 1998].

In this research, the VE formation process is considered within the context of a market. During the formation phase of a VE, the Potential Partners and the VE Initiator communicate, for example, the VE Initiator initiates (announces) the VE in a marketplace. The Potential Partners disclose their interests and competencies (in the form of bid proposals whose contents correspond to the requirements expressed in the VE announcement).

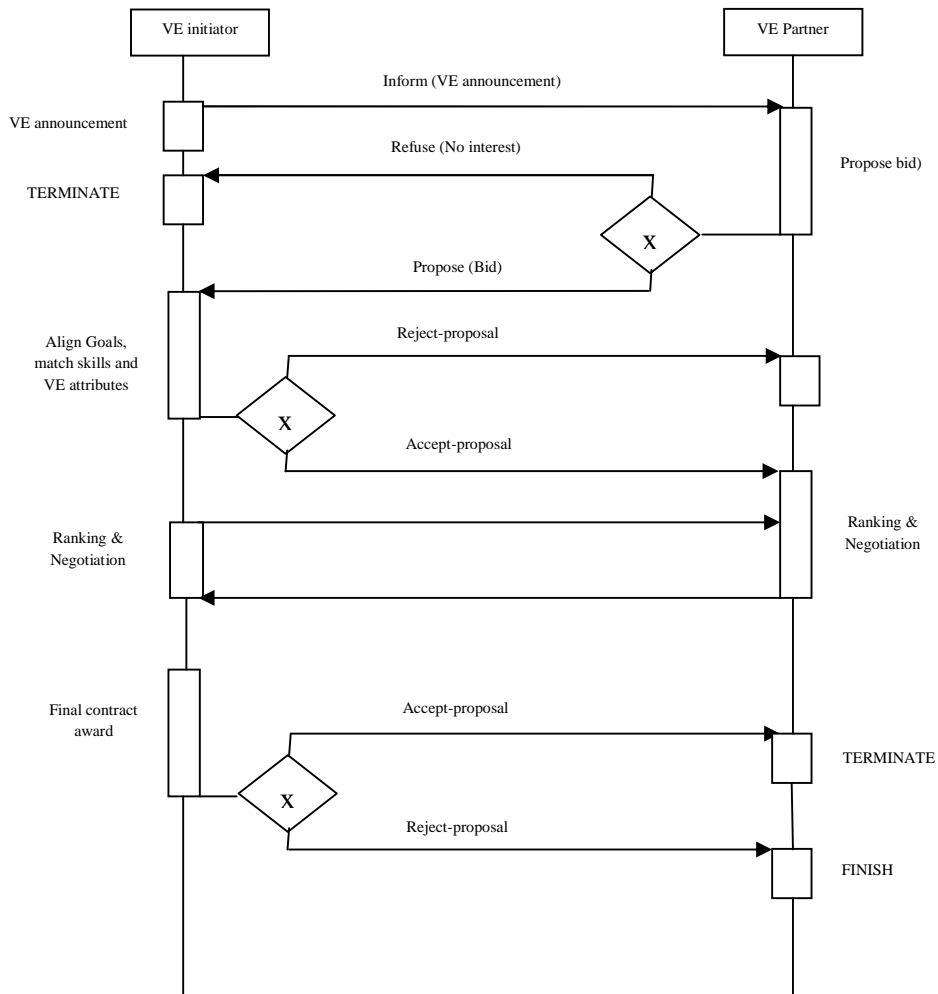


Figure 5 Agent Communication Protocol for VE formation

The VE initiator evaluates the bids based on some criteria and goes ahead with classifying the Potential Partners according to their characteristics and interests in relation to the VE characteristics and goals.

The VE Initiator then negotiates with the agents whose traits meet the requirements. Finally, a contract is awarded to the appropriate team of partner(s). This process can be considered a set of communications among agents and thus can be shown as an ACP using Agent UML, [Bauer et al., 2001], in figure 5 and VE formation process shown in figure 6 respectively.

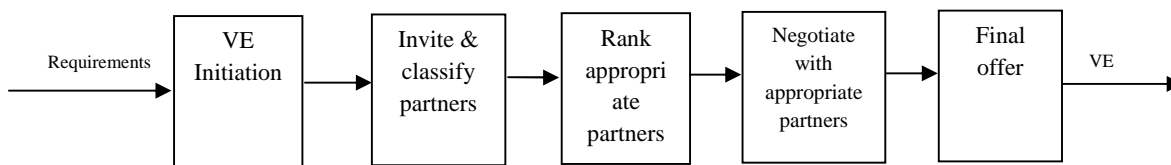


Figure 6 VE formation process

Virtual Enterprise Partners bid evaluation and Team selection

The partners are evaluated using a multi-attribute weighting function. For each qualifying partner in each role, their attribute values are weighted and total weights for all attributes are calculated. The calculated total weight values for all the considered partners are ranked, where the highest total weight is at the top. This is done by the VE Initiator. The VE Initiator then selects the best (highest ranked) Potential Partners for the VE or s/he can decide to negotiate with the Considered Partners for a better deal. Instead of selecting a number of highest ranked Considered Partners, the VE Initiator can also select the best team for the VE.

Partner Evaluator

Partner evaluator takes the attributes and attribute values for interested partners as input, and based on the evaluation criteria, either a ranked list of potential partners or ranked list of potential teams of partners is available as output. See figure 7.

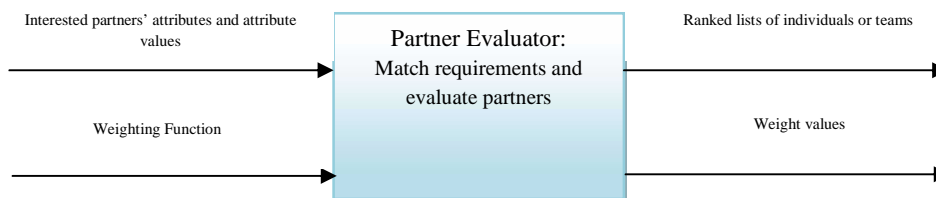


Figure 7: Partner Evaluator

The evaluation is based on the set of attribute values that are included in the function for calculating the weights and the weights that are assigned to them. The function can be changed by choosing a different set of attributes and/or by changing the weightings that are assigned to the attributes.

Negotiation between Virtual Enterprise partners and Team revision

The negotiation process or conversation is initiated by the initiator agent. A project initiator may want a particular partner to lower or increase particular *terms*, e.g. hourly rates or commitment fee. It initiates a dialogue by sending requests to agents to adjust certain terms. On reception of the request, the agent updates its terms if in agreement or declines the request if not

in agreement. If in agreement, the agent then replies with an “ok” or “done” token to trigger the updates. See figure 8.

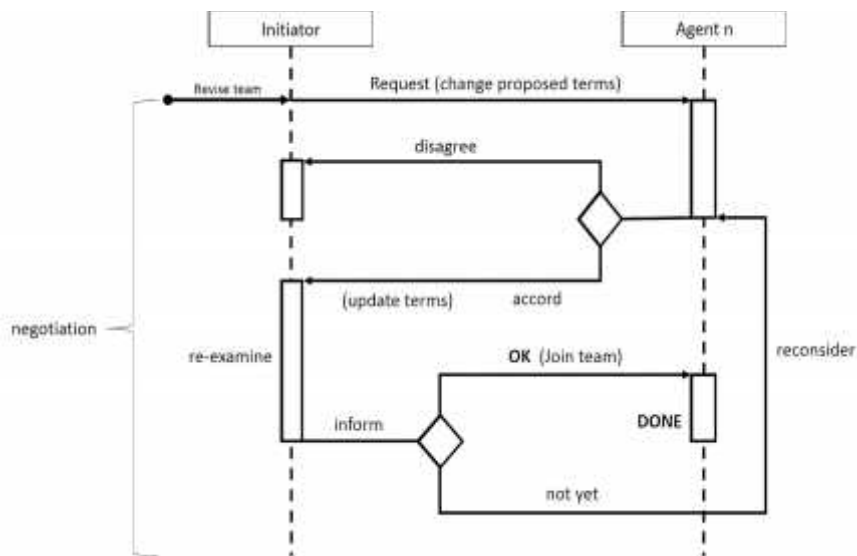


Figure 8: Agent Communication Protocol for Agent negotiations

VE collaboration

Once a team is formed, the coordinator gives each partner a go ahead to implement their roles and sets deadlines for each role in line with the expected project completion timelines. The coordinator also sets the dates for progress monitoring and quality checks for each role. See figure 9 below for the flow chart of collaborations among partner agents.

Each role can have one or more sections and each agent represents an organization which may have one or more personnel to perform activities within a role. If a role has more than one section and if each section is performed in sequence, then the agent begins and finishes a section before a quality check is done before proceeding to the next section.

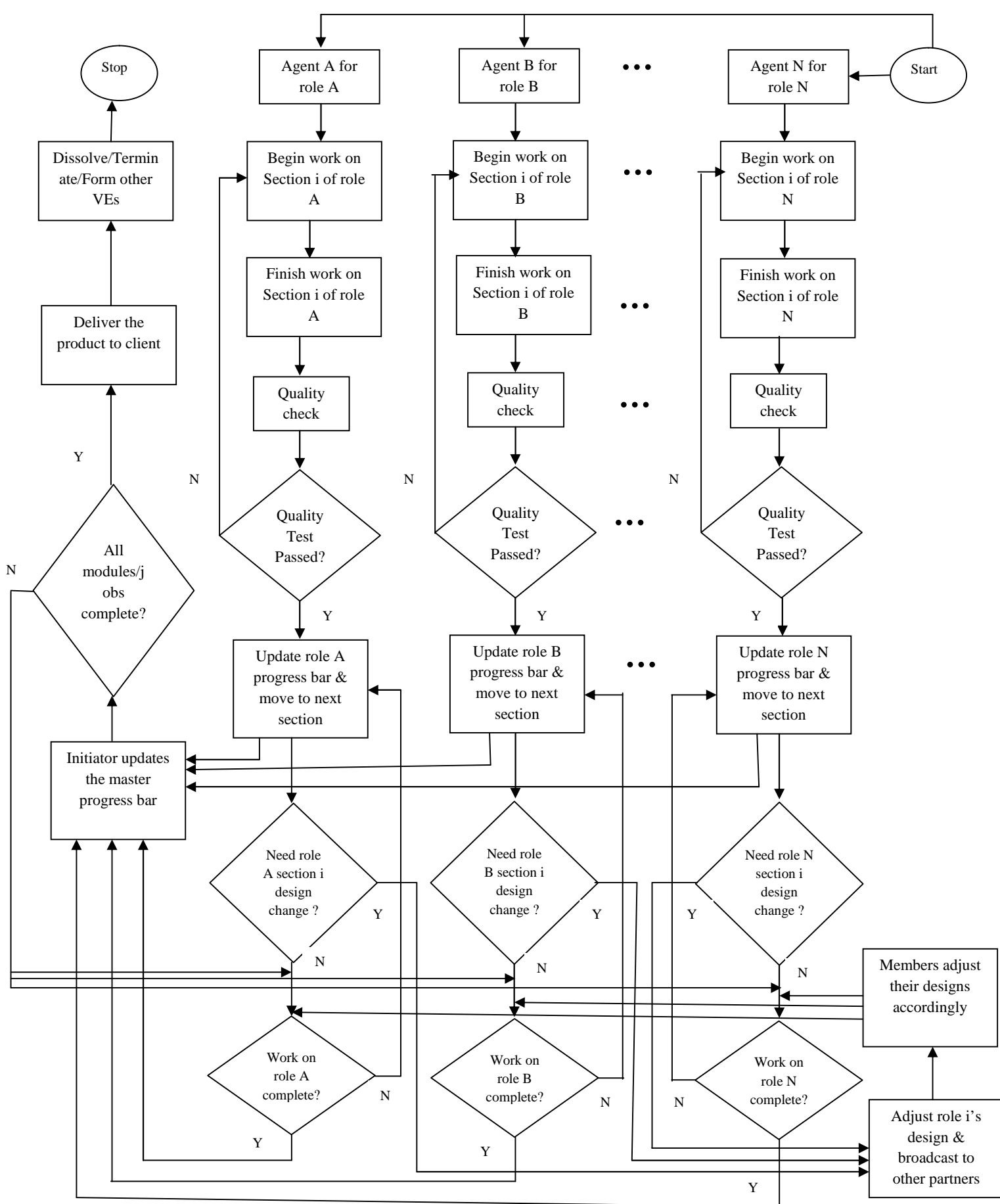


Figure 9 Flow chart of partners' collaboration

An e-white board synonymous with physical white board in hospitals Bardram and Hansen, [2010] is created which is accessed by all agents for the purpose of updating their progress reports. Any changes in the individual designs are broadcasted to all partners through the coordinator who updates the e-whiteboard for partners to see and make any of their adjustments appropriately. The coordinator synchronizes the jobs done by each partner and updates the e-whiteboard. The client can access the e-whiteboard and view the status and work progress.

Agent Communication Protocol for VE partner collaboration

An ACP for VE partner collaboration can be compared to the basic request-reply server based communications where the VE initiator (who now acts as the VE coordinator) takes the role of a server and the partners take the roles of clients. This server-client setup has reversed roles, where the server makes updates' requests from clients and the clients reply with update values. However, the clients can also send update values to the server without the server making the requests. The initiator requests the agencies working on the roles of the project. Each agent at different (random) wait time, reply back with the progress incrementally. See figure 10.

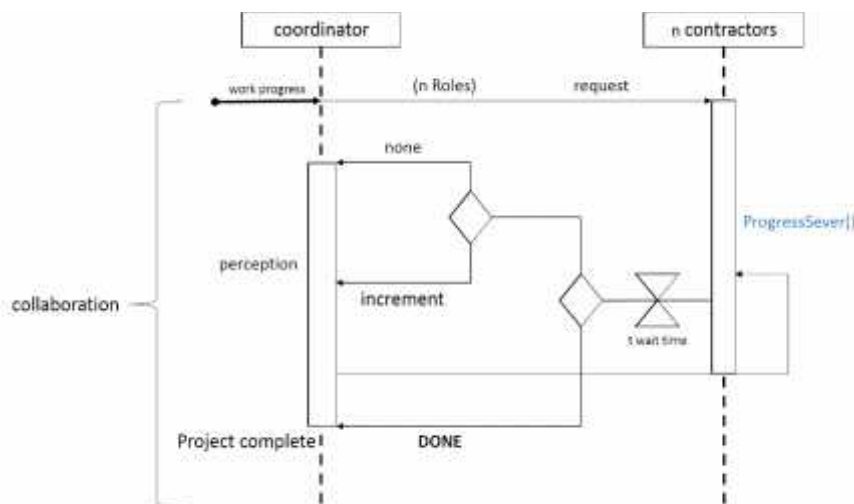


Figure 10: Agent Communication Protocol for VE partner collaboration

Case studies

Four case studies were done to validate the framework. Cooperative networked organizations are found domains such as the automotive industry, the food and agribusiness industry [Camarinha-Matos, Carelli, Pellicer, Martin, 1997], civil engineering [Zarli and Poyet, 1999], Ship building, and electronics [Azevedo, Sousa, Bastos and Toscano, 1998], Hospitality and Tourism industries [Afsarmanesh and Camarinha-Matos, 2000]. Based on the literature the case studies' organizations were selected.

Case Descriptions

Case 1: Mock-Soft Technologies (MST)

The organization formed an alliance, with other companies with complementary skills, technology and clients, in order to expand their own customer base and reduce product development to market delivery time. The partner companies are leaders in financial software development and engineering design and manufacturing software development.

Case 2: Civil Engineering Consultancy Limited (CECL)

The company is hired by a customer to oversee construction projects. They receive the requirements for a building and construction project from the customer and are responsible for forming and coordinating the VE that will deliver to the customer.

Case 3: Kenya Dairy Farmers Federation (KDFF)

This is a federation of dairy business associations (DBAs) in Kenya. It conducts detailed interviews with the potential DBAs to verify their capability to deliver. It then invites the DBAs to a workshop where their collaboration capabilities are assessed.

Case 4: Neptune-Financial Institution’s Operating System Setup (NFIOSS)

Neptune's main product is bank operations software. In order to deliver the product, the company collaborates with partners like IBM for hardware, Oracle for the dbms and Microsoft for Window OS.

Validation process

The case studies were used to validate the multi-agent systems approach as follows:

Creating an agent-based model of the case: Modelling the case using the agent-based model for the VE. This involved identifying the goals of the VE, the activities that need to be performed to achieve the goals of the VE, the roles to perform the activities, the requirements for the roles and how collaboration is achieved.

Comparing the attributes: Looking at the requirements for the roles and the kinds of attributes that have been used in the selection process. This is a comparison of the partner evaluation criteria.

Comparing the selection process: Comparing the partner selection process that was used in the cases to the selection process proposed in this work.

Identifying negotiation points: Identifying if and when there is negotiation in the partner selection process in the case. This includes the issues that were negotiated upon.

Comparing collaboration of partners: Comparing the partners’ collaboration process to the partners’ collaboration process proposed in this work.

A software model was developed using Java Agent Development Environment (JADE) and used to simulate the activities of MST and CECL. The researchers used the data from the organizations to form a team without using the model and then used the model to form a team and the results compared.

Table 1 MST-ERP-Selected Team

id	role_id	role_name	agent_id	agent_name
1	role1	ve_erp_role1_finance_resource_management	AG0024	kisauni_ltd
2	role2	ve_erp_role2_business_intelligence	AG0013	nakuru_ltd
3	role3	ve_erp_role3_supply_chain_management	AG0001	kirinyaga_ltd
4	role4	ve_erp_role4_human_resource_management	AG0019	bondo_ltd
5	role5	ve_erp_role5_client_relationship_management	AG0017	busia_ltd
6	role6	ve_erp_role6_production_resource_management	AG0016	kajiado_ltd

The results of the processes with the model for the first case were as shown in the figure 11 below:

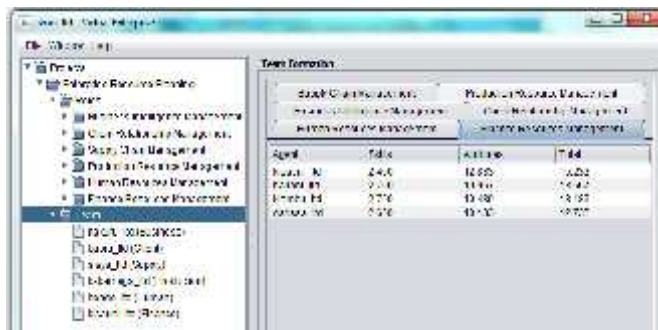


Figure 11 Agents ranking per role as extracted from the model

Both results were similar which confirmed the accuracy of the model.

Partner collaboration process

The collaboration process could not be simulated without the model. The selected role leaders organize their members into delivering their parts of the project. Each role leader updates their individual progresses. All updates are visible to the initiator through the e-white board. See figure 12 below.

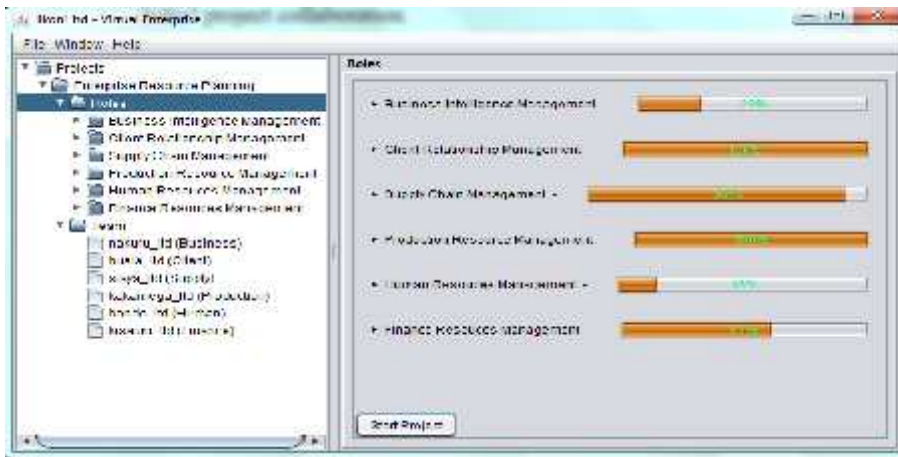


Figure 12 Progress of collaboration

After using model, questionnaires were distributed to representatives of the organizations that used the model and to organizations observed the use of the model. The themes of the questionnaire included: the use of the model to initiate a project, organize partner candidates into roles, negotiation with candidates, selecting a team, assigning tasks, monitoring progress per role and overall project progress. The model features were also assessed if they matched the ones proposed during requirements analysis.

The model fulfilled all the requirements as explained by the users. One respondent said “The model provides a platform to create projects and has a feature for running projects concurrently. It has provision for defining industry specific roles and enabling negotiations for terms adjustments and ranking. The model assist in decision making by providing information to select best team based on performance and assigns tasks appropriately. Once each party in the collaboration updates their bit, progress can be monitored centrally. This is powerful because it avoids the need for meetings to gather information on progress.” The table below summarizes the ratings as provided by the users of CECL and MST and an independent firm (ICDC).

Table 2-Comparison of activities in terms of duration and efficiency

Rating Organization	Team formation without the model	Team formation with the model	Partner collaboration without the model	Partner collaboration with the model
CECL	5/10	9/10	4/10	9/10
MST	4/10	7/10	4/10	8/10
ICDC	4/10	8/10	3/10	8/10

CONCLUSIONS, RECOMMENDATIONS AND FURTHER RESEARCH

A multi-agent systems approach for modelling virtual enterprises has been proposed in this research. The approach comprises agent-based model for VE to create the VE, VE formation model-for selecting partners and VE collaboration model-for partners' collaboration in the VE. JADE, which is a multi agent systems tool has been used to model Virtual Enterprises application that was used by test cases to validate the approach.

Recommendations

Research on how to implement social media techniques in VEs is recommended. In addition, research should be carried out to determine how to employ remote desktops and roles' automatic specification generation in virtual enterprise applications.

It was noted that each agent represent an enterprise, whose staff collaborate to complete the role's specifications. This requires implementation of sector- or domain-wise collaborations and then collaborating these collaborations. Further research is therefore recommended.

Investigations should be done to determine the applicability of this model in the entertainment and media industry. Moreover, security aspect of virtual enterprises should be investigated and appropriate techniques employed.

Most organizations do not participate in the formation of virtual enterprises because there is no policy framework to guide and protect the process. There is need for policy makers to fast track policy formulation and implementation to strengthen the use of the concept.

Each enterprise has its own set of software applications, cultures and traditions which may be unique. There is need to integrate these differences in the virtual enterprise model.

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TRACK 2: GIS, REMOTE SENSING AND SPATIAL PLANNING

GEOSPATIAL INFORMATION SCIENCE APPLICATION IN TOURISM: INTERNET BASED GIS FOR TOURISM MARKETING AND MANAGEMENT

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Abstract

Tourism is a major source of income in the country. Nyeri County has a rich heritage of both historical sites as well as several scenic areas. As such, aggressive marketing of the county's resources is required to ensure that the potential for the tourism sector has been fully utilized. With the advent of the devolved government system in the country, several functions of the government were transferred to the county levels. This is inclusive of management of the tourism sector within each county. Therefore, city's tourism sector may be promoted by global marketing of its tourist attractions, facilities and services.

World-wide web is fast becoming useful tool for the tourism industry presenting a platform that brings products and services to the tourists. A web based tourism information system may provide on-line brochures along with both value and services.

The study on the use of web GIS for tourism marketing aims at taking into account tourist user needs in a geographical context while incorporating other supporting infrastructure on interactive tourist maps. The study covered parks and resorts, hotels, restaurants and historical sites. The supporting infrastructure for the tourism sector included nightspots, banks, major shopping centers inclusive of open air markets, as well as transportation services. Tour companies offering affordable packages to both local and foreign tourists were also identified. Accessibility to points of interest was modeled using GIS overlay and proximity geoprocessing analyses. The final map output was made available via the internet through the use of internet GIS APIs.

Keywords: Tourism, Geographical Information Systems (GIS), Internet mapping

1.0 INTRODUCTION

Tourism has been defined as the activities of people during their leisure period, apart from their usual environment for a fixed period of time and performing some other activities. It is essentially an assortment of activities, facilities, services and industries that deliver a travel experience, that is, transportation, accommodation, eating and drinking establishments, entertainment, recreation, historical and cultural experiences, destination attractions, shopping and other services available to travelers away from home, as defined by the Tourism and Leisure Committee(1997).

Tourism is among the highest revenue earners in any region's economy. Its success is however highly dependent on the ability to sufficiently develop, manage and market the facilities available to both local and foreign potential customers. For this purpose, spatial data is required since all tourist activities are inherently tied to a geographical location as well as an environment.

Geographic Information System (GIS) is an analytical computer aided system for the capture, storage, retrieval, analysis and final display of spatially related datasets (Clarke 1986). It has the capabilities of tying spatial data to its other attributes via linking tabular data to spatial data, resulting in maps(both static and dynamic) created at different scales and projections depicting a wide array of information. These spatial based capabilities make the use of GIS a good fit for the success of any tourism business as determined by its planning, development and marketing.

With the tremendous growth of the Web, a broad spectrum of tourism information is already distributed over various Web sites. Maps have been in use as a natural means of indexing and presenting tourism related information. Travelers have been using maps to navigate during their travels and for preparing their routes for a long time.

In the spirit of realizing the Kenya Vision 2030, tourism management and marketing systems need to be effective and efficient. This will offer sustainable development and foster economic growth within the county and the country at large. The improved technology of Internet GIS allows the integration of the previous basic map uses with the extensive information available on the World Wide Web making it easier to access multiple themes on an area which is a major advantage.

2.0 LITERATURE REVIEW

GIS has the capabilities of displaying both geographical and attribute data. Geographical data is that which has the location aspects referred to explicitly, using a standard frame of reference such as latitudes and longitudes, or implicitly, using surrogate spatial references such as postal codes or zip codes.

GIS technologies can thus be used to describe and identify tourism infrastructure elements geometrically, thematically and topologically. Moreover, GIS can deal with both object data (e.g., visitor centers, trails) as well as field data (e.g., humidity, altitude) of which both types can be represented in either raster or vector data format.(& Njeguš, 2008)

The advantages to both tourists and tourism development authorities who choose to utilize GIS are many (Application Of GIS in Tourism, 2009). The advantages to tourists include:

The ability to visualize the tourist sites

The ability to analyses the available infrastructure in the preferred sites thus allowing for itinerary and route planning

Easy access to information via web GIS

Availability of embedded information within the GIS on the chosen sites. This information could be videos, photos and product brochures.

Availability of interactive maps that respond to user queries.

The advantages to tourism development authorities include the ability to find out where most tourists come from thus allowing for regional marketing and also the ability to plan for new site

selections furnishing them with the suitable facilities. (“1997_Bertazzon_Crouch_Draper_Waters GIS in tourism marketing.” n.d.)

A thematic map could be used to integrate tourism information (e.g., object symbol to identify the object type, object name, category (stars) of hotels, a link to the object homepage for further navigation, etc.) and GIS data to build tourist maps (Shojaee,2009). A hotel search can be a time-based search which extends the map with available information of rooms (e.g., the color of the hotel symbol emphasizes the availability). To guarantee a sensible use, the user could have the possibility to zoom in/out to change the scale of the map, scroll on the map and print as well. When returning the map to the Web-client, only queried layers are set to be visible to give the user a more detailed impression of where things are, how they can be reached, and which things are located nearby. All layers can be combined without restrictions to achieve the goal of the user.(Wessel & Vuong, n.d.)

3.0 OBJECTIVES

General objective

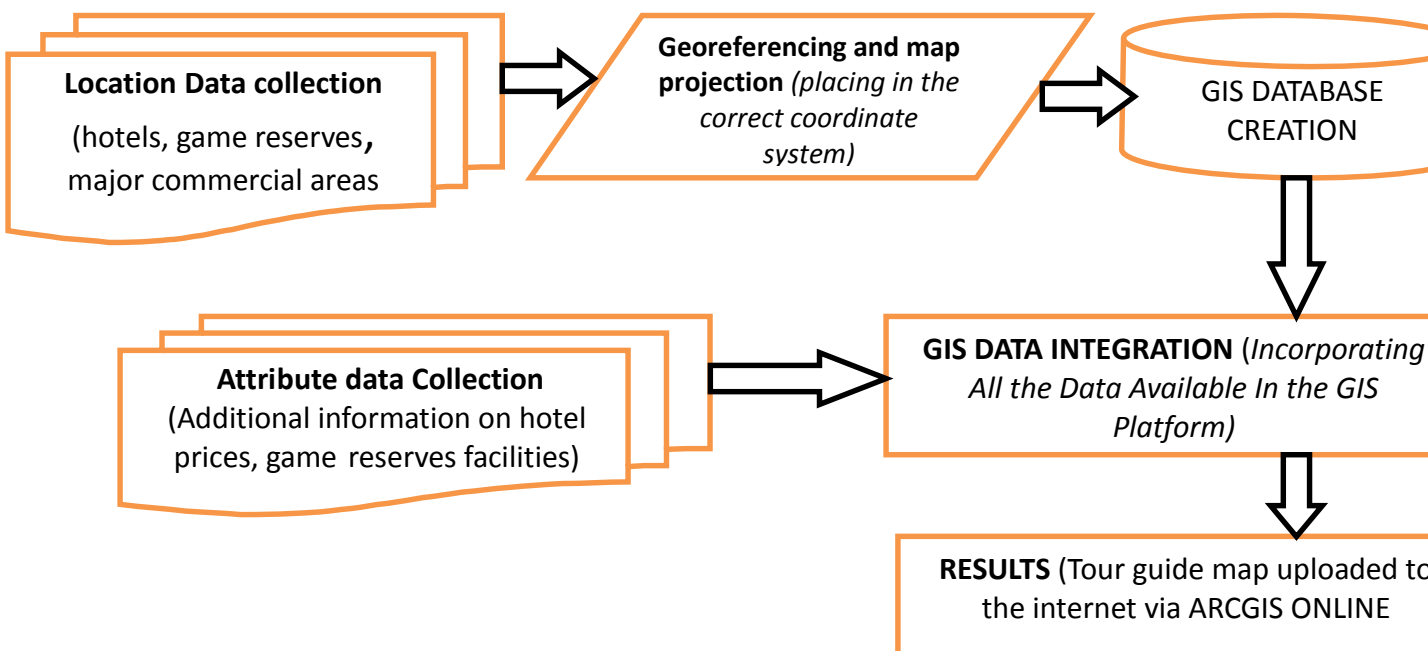
To utilize the capabilities of internet based geospatial technology for the marketing of tourist attractions within Nyeri County while providing information to potential tourists and investors on the available supporting infrastructure necessary for access to the attractions.

Specific objectives

- To identify the tourist attraction sites within the County.
- To produce a map on the sites depicting their location and accessibility routes.
- To identify available infrastructure for use by the tourists i.e. bus and taxi bays as well as recreational amenities.

4.0 METHODOLOGY

2.1 Flow Diagram for Methodology



STUDY AREA

The study area for this research was Nyeri County which is located at $0^{\circ} 23' 50''$ S, $37^{\circ} 0' 0''$ E at an elevation ranging from 1600m (5,249ft) to 1,900 m (6,234ft) .

Some of the historical sites in Nyeri include Mt. Kenya, Aberdare ranges, Baden Powell memorial site, Chaka ranch, Nyeri war cemetery, Zaina falls and Dedan Kimathi conservancy among others. As such, it is fast growing to become one of the promising tourist destination points for both local and international tourists.

NYERI COUNTY

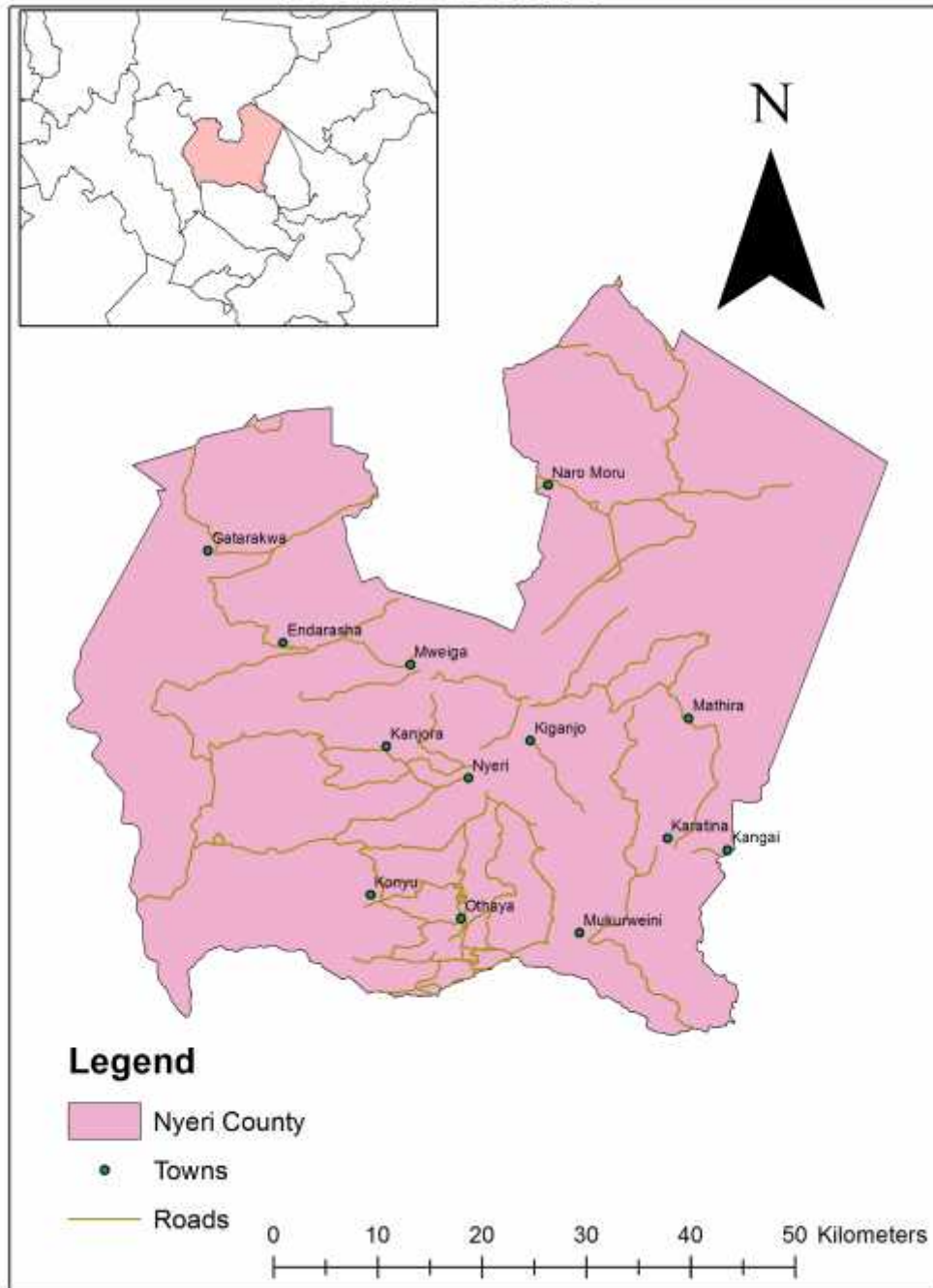


Figure 2.1 Map of Study Area

2.3 Data

Table 2 Data and Data Sources

DATA	SOURCE
Major commercial areas	Collected using a GPS
Hotels, historical sites and game reserves	Google Earth

Coordinates for hotels, historical sites and game reserves were retrieved from Google Earth and loaded as points in ArcMap. Data on commercial areas and transport routes was collected using GPS and exported to ArcMap.

NYERI COUNTY GAME AND FOREST RESERVES

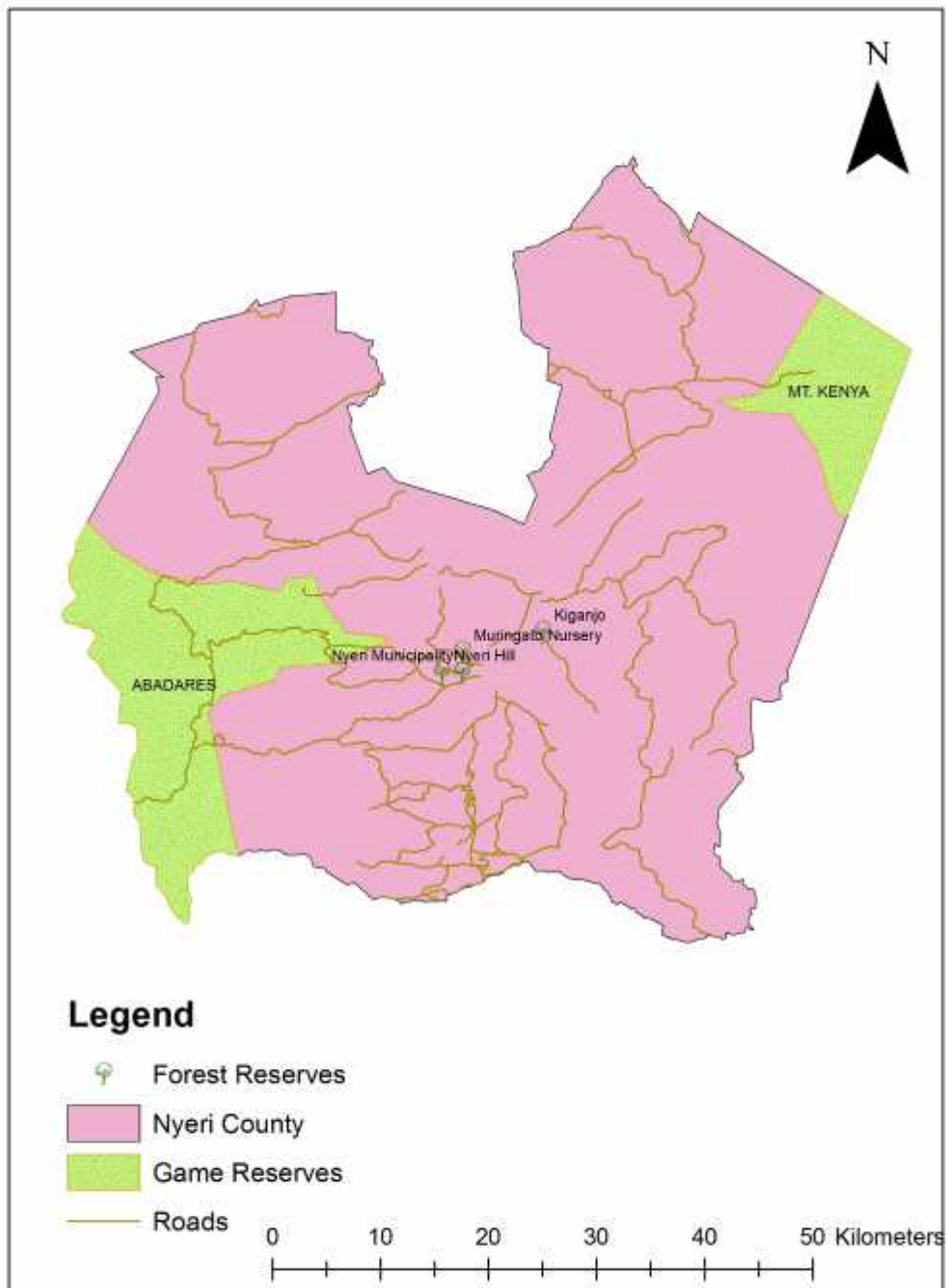


Figure 2.2 Forest and Game Reserves

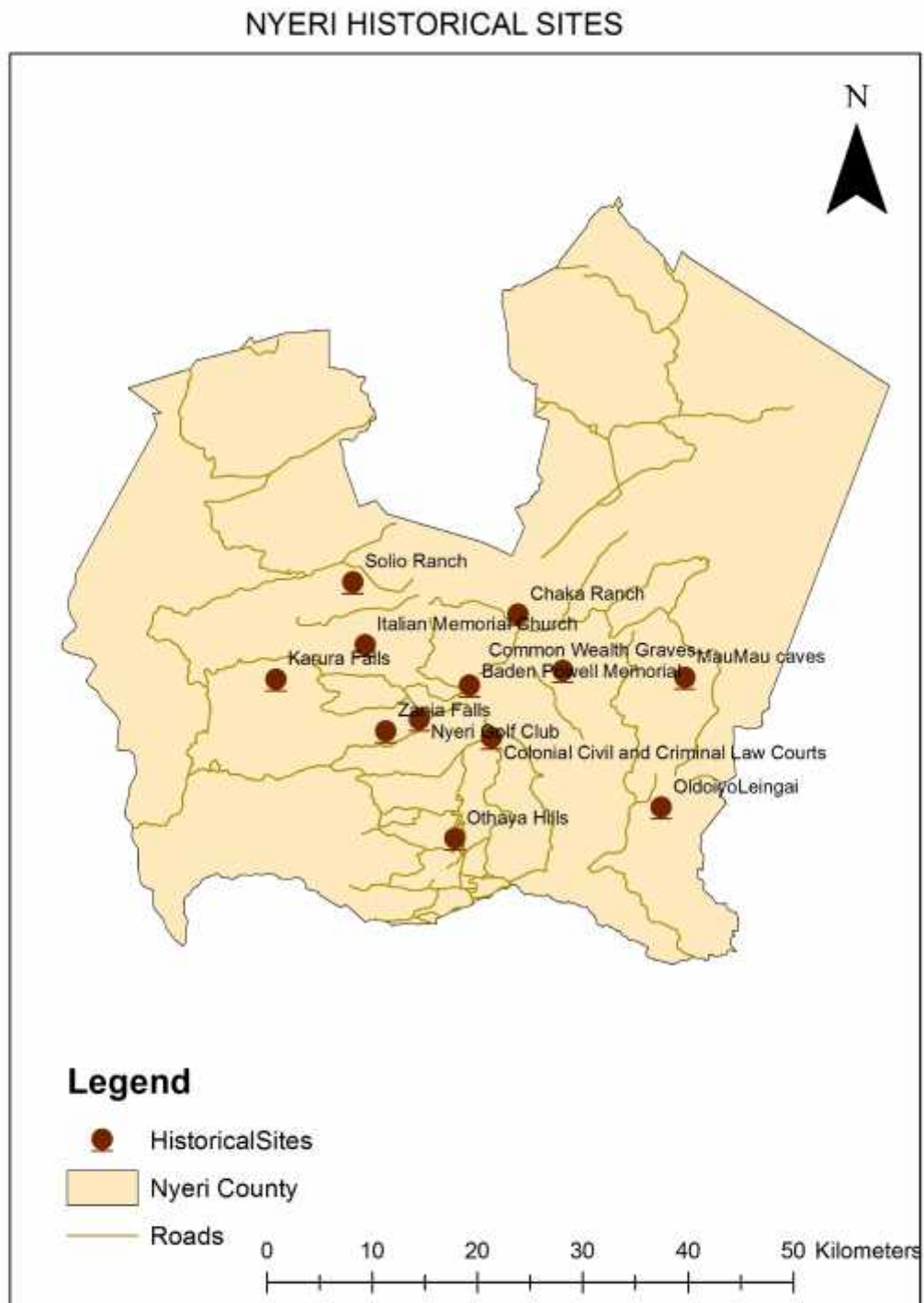


Figure 2.3 Historical Sites

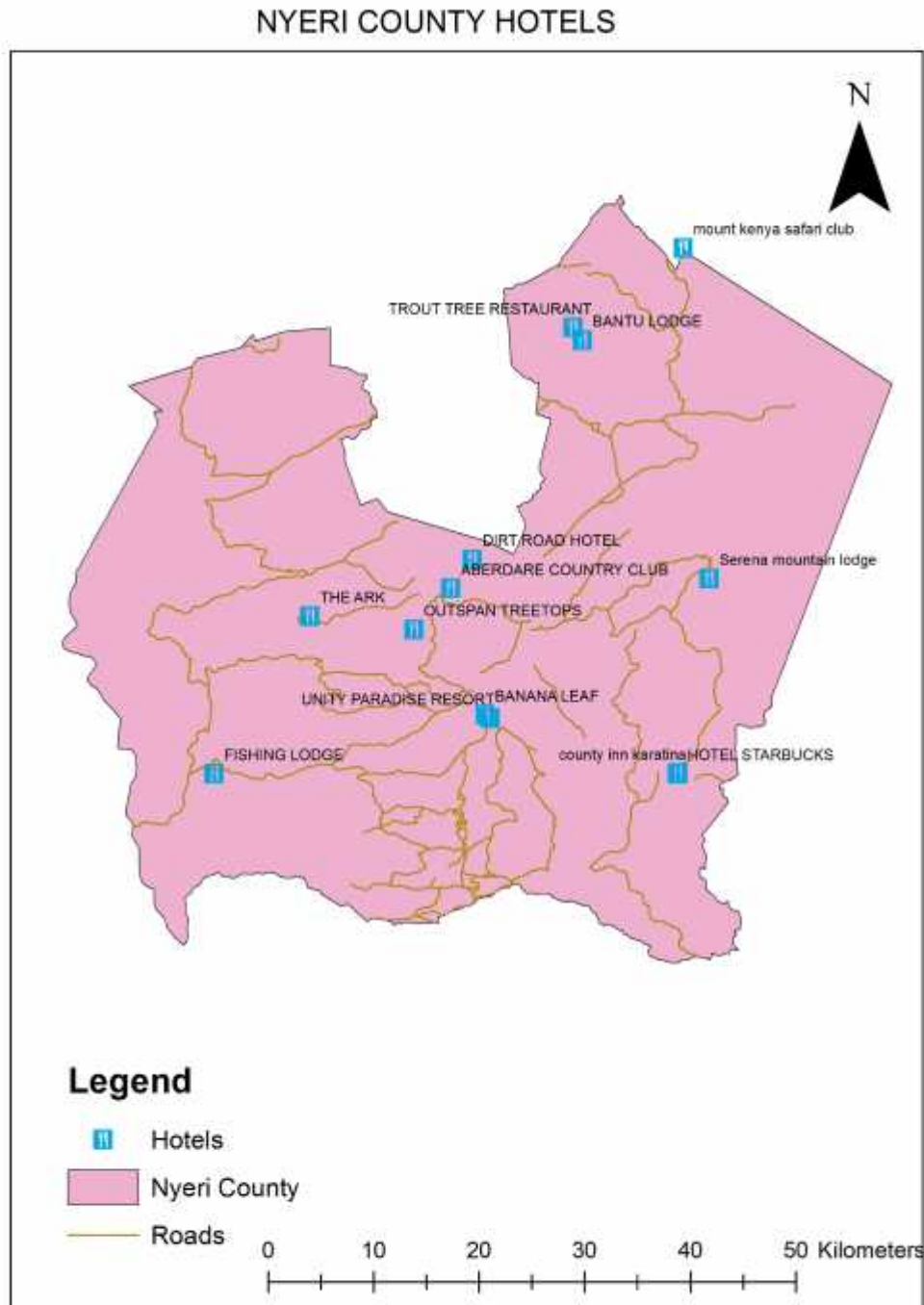


Figure 2.4 Hotels and Lodges

5.0 RESULTS AND ANALYSIS

After collection of all data layers, integration into ArcMap was done. So as to make the layers visible online, the data layers were converted to shapefiles and uploaded onto ArcGIS Online. Anyone with an ArcGIS Developer’s Account can view the information upon searching for ‘INTERNET BASED TOURISM MAP NYERI COUNTY’. Information on the exact location of the different forest reserves, game reserves, historical sites, hotels and lodges as well as major town and roads nearby is visible from the map.

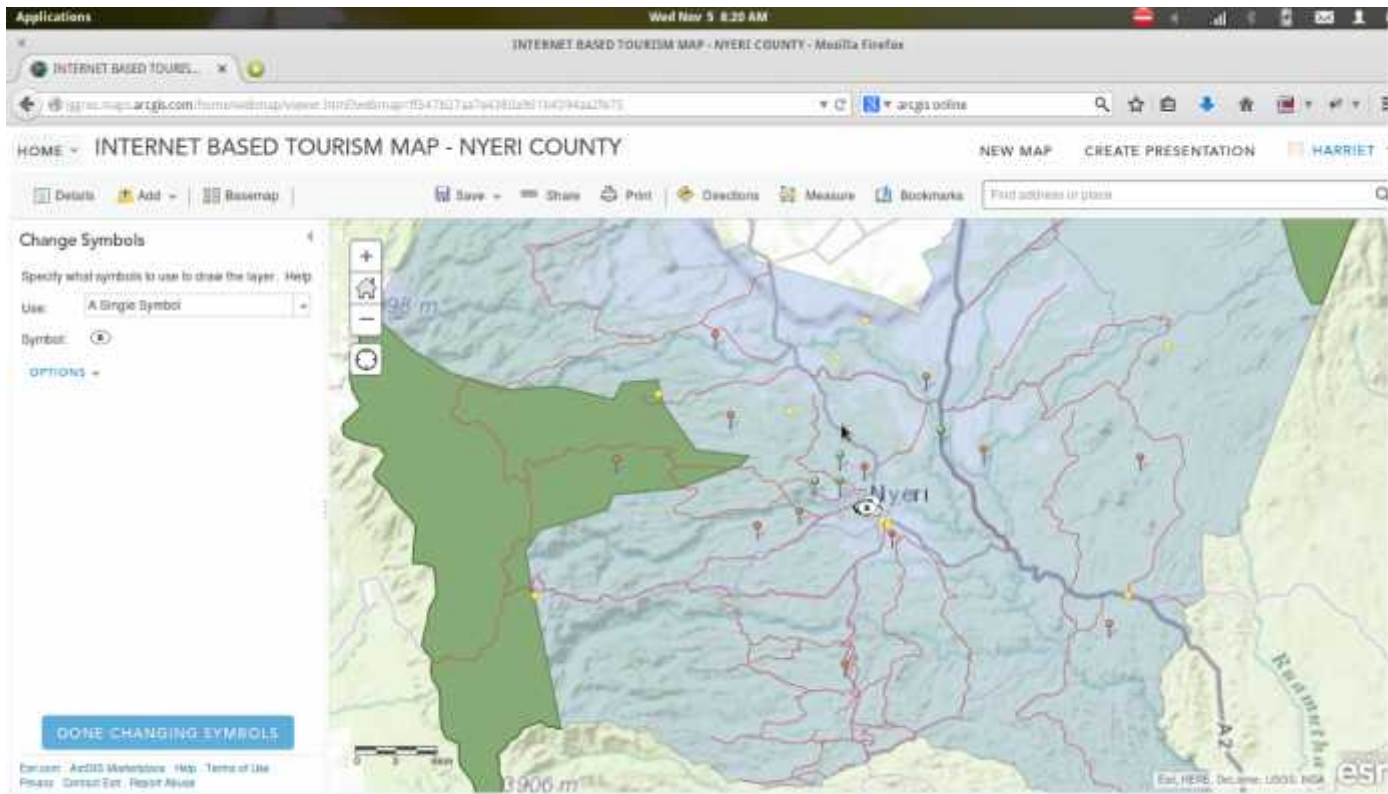


Figure 3.1 Tourism Map as viewed on ArcGIS Online

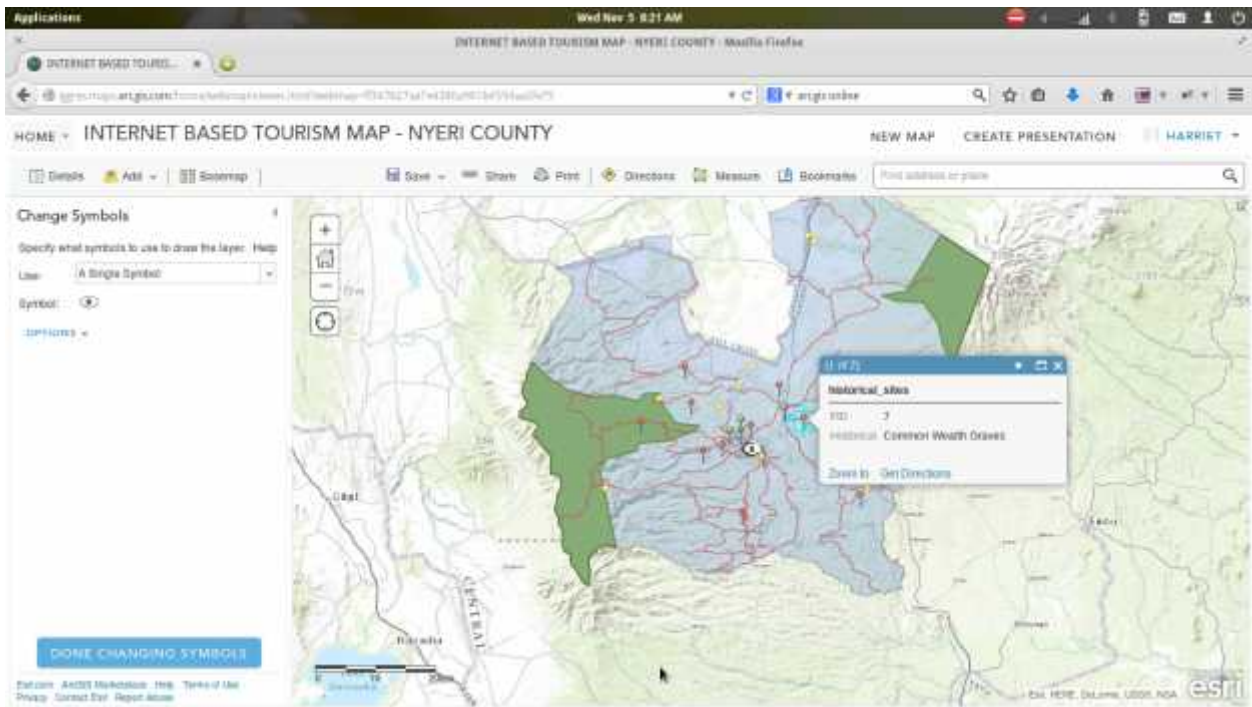


Figure 3.2 Pop-up showing historical site information

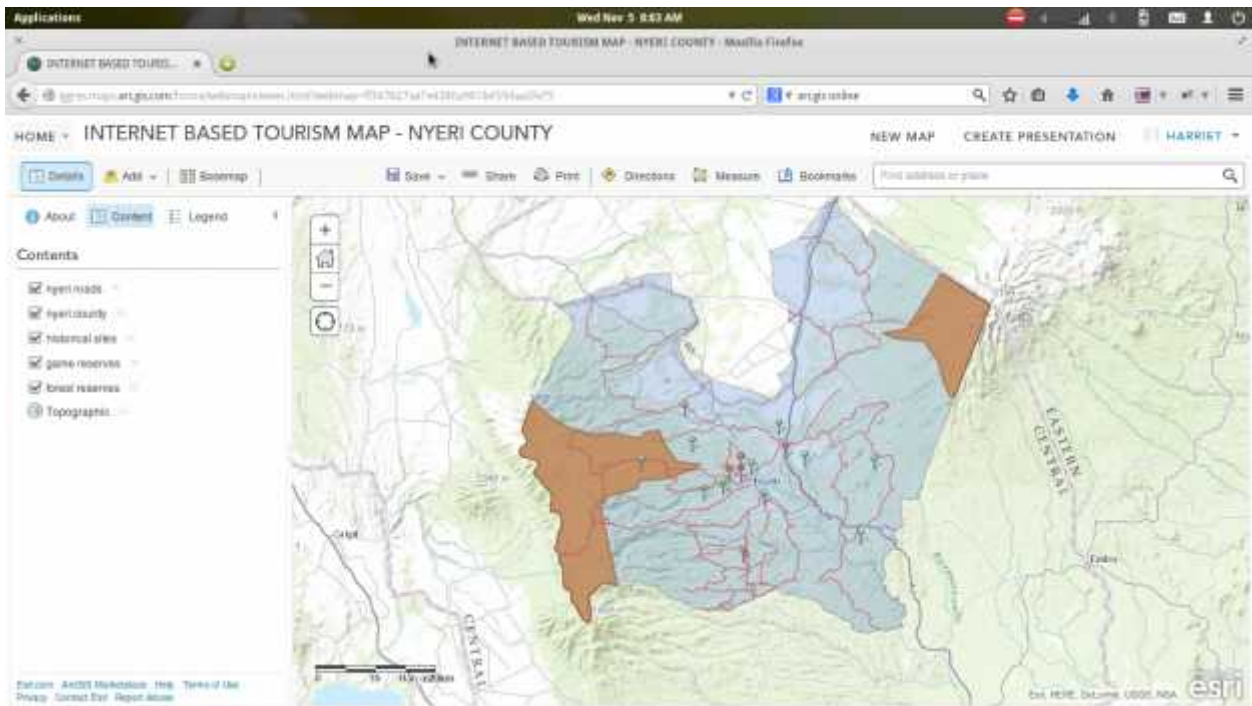


Figure 3.3 Tourism Data Layers as viewed on ArcGIS Online

6.0 CONCLUSION

From the study, GIS as a whole, when incorporated in the tourism industry, has proven to be efficient and effective in offering faster and better services especially via the web GIS which realizes the need to save time and money.

Internet GIS also provides comprehensive and easy analytical capabilities thus getting more information from the data one has e.g. from the above one can perform a route analysis of the road network, show where different facilities like hotels are and the services they offer.

Last but not least web GIS goes beyond the geographical limitations in that one can search for what he/she wants, how to get there and even have a view of the services and facilities before getting to the actual place. This creates a business avenue for online booking of facilities and services in the county.

According to the objectives of the study, the tourist attraction sites, their accessibility routes as well as supporting infrastructure were identified and displayed on an online map.

The gap left by the research include creation of a comprehensive database that is inclusive of all datasets and information for better management, access and services, the suggested use of an open source platform such as QGIS Cloud and the adoption of the system by county governments for the promotion of the tourism industry.

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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: TerrarSAR -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 $49^{\circ} 9' 0''$ N, $9^{\circ} 7' 0''$ 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 $48^{\circ} 24' 23''$ N, $9^{\circ} 03' 27''$ 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 16th of March and latest in the Moessingen test site, which is around the 15th 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.

2.2. Data

2.2.1. 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.

2.2.2. *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

2.2.3. *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.

	LEINGARTEN JULY	LEINGARTEN AUGUST	MOESSINGEN JULY	MOESSINGEN AUGUST
ACQUISITION MODE	SM/Strip_006 VV "R"	SM/ Strip_006 VV "R"	SM/ Strip_006 VV "R"	SM/ Strip_006 VV "R"
PRODUCT TYPE	EEC/SE	EEC/SE	EEC/SE	EEC/SE
ACQUISITION DATE	10/07/2010	01/082010	10/07/2010	01/082010
ORBIT CYCLE/NO./DIR	102/17021/154/ "D"	104/ 17355/154/ "D"	102/ 17021/154/ "D"	104/ 17355/154/ "D"

Table 1: Information about the satellite images that were acquired for the study.

2.3 Data Preparation

This involved the following steps as summarized in the work flow diagram, figure 2:

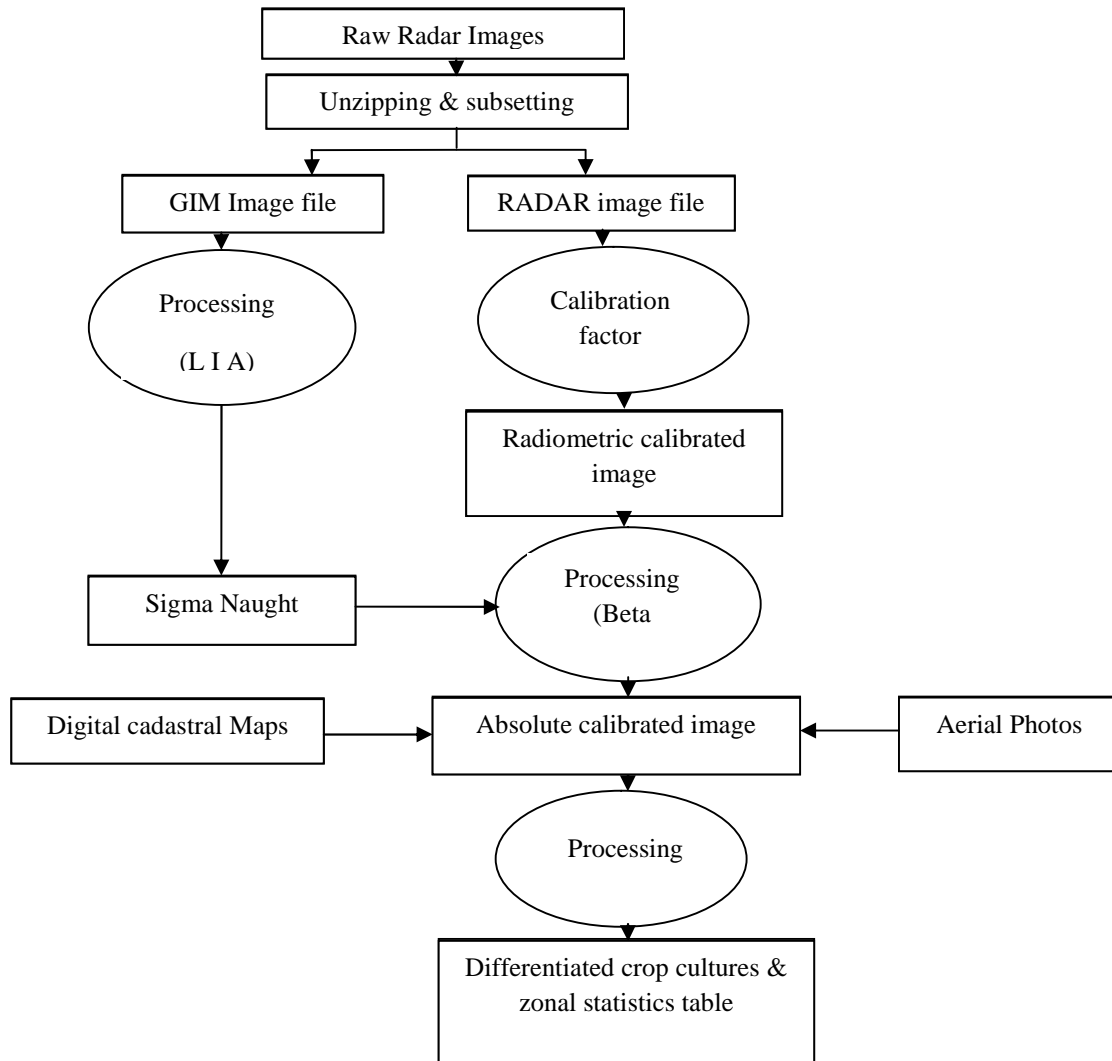


Figure 2: Flow diagram showing the work flow

2.2.4. 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 σ^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].

$$\sigma^0 = k_s * |DN|^2 \dots\dots\dots \text{Equation 1}$$

$$\sigma_{db}^0 = 10 * \log_{10}(\sigma^0) \dots\dots\dots \text{Equation 2}$$

Where:

σ^0 = Beta Naught or radar brightness representing the radar reflectivity per unit area in slant range.

σ_{db}^0 = Beta Naught in decibels

DN = Digital numbers or image pixel values

k_s = Calibration factor

For the Sigma Naught σ^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° 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].

$$\theta_{ioc} = \frac{(GIM - (GIM \text{ mod } 10))}{100} \dots\dots\dots \text{Equation 3}$$

$$\sigma^0 = (k_s * |DN|^2 - NEBN) * \sin \theta_{ioc} \dots\dots\dots \text{Equation 4}$$

$$\sigma^0 = \sigma^o * \sin \theta_{ioc} - NESZ \dots\dots\dots \text{Equation 5}$$

$$\sigma^o = \sigma^o * \sin \theta_{ioc} \dots\dots\dots \text{Equation 6}$$

$$\sigma^o = \sigma_{dB}^o + 10 * \log_{10}(\sin \theta_{ioc}) \dots\dots\dots \text{Equation 7}$$

Where:

σ^0 = Sigma Naught

θ_{ioc} = local incidence angle

NEBN = Noise Equivalent Beta Naught

NESZ = Noise Equivalent Sigma Zero

$$NESZ = NEBN * \sin \theta_{ioc}$$

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.

OBJECTID	VALUE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
1	997	4552	7112.5	25.053641	23.311859	27.396602	8.705017	4.376142	39625.238
2	1306	300	401.25	-22.01090	-1.430076	21.020000	-9.2100	0.750000	-2036.3047
3	1368	12888	20127.5	-25.597271	1.922626	27.515297	-9.301498	4.239212	-119877.72
4	1372	1330	2002.1875	-26.04134	-0.833073	25.201427	-10.762127	4.37610	-14410.48
5	1373	423	660.9375	-29.276999	-2.57409	26.404909	-12.369243	4.222751	-5227.5866
6	1375	1935	3023.1375	28.416634	1.251346	29.66618	9.815208	4.636504	19052.412
7	1422	12633	19739.063	-25.442221	2.890366	36.335567	-9.454227	4.36946	-119435.25
8	1443	1626	2540.625	-28.406128	2.910829	31.316957	-8.53489	4.339567	-13926.517
9	2570	701	109.0025	-25.9020	-0.745074	25.077705	-9.927002	4.52057	-7054.7227
10	2572	124	2000	-24.047718	-2.113833	21.964885	-10.264938	4.310888	-1374.5527
11	2573	1167	1823.4375	-26.626488	1.332373	27.056700	-10.660380	4.752126	-12451.177
12	2576	1229	1920.3125	-27.552719	-0.657966	26.694754	-10.627723	4.604264	-13061.472
13	2577	685	1070.3125	26.476634	0.913397	25.526238	10.987737	4.406999	7526.5957
14	2587	3062	4784.375	-24.265365	1.204954	35.490341	-9.705909	4.323366	-29779.492
15	3628	12619	19717.188	-29.783073	2.870744	32.653616	-9.215509	4.386228	-116290.49
16	3629	315	492.1075	-20.910009	-0.424925	20.490005	-10.001054	4.752024	-3049.3042
17	7520	754	1085.9375	-25.990938	2.001352	28.004884	-10.124434	5.456703	-7684.4492
18	13500	3157	4932.8125	-30.72671	2.504266	33.322068	-10.023106	4.810060	-37656.73
19	15088	16569	25669.063	-22.656169	1.240397	33.896567	-9.712559	4.336337	-160927.39
20	15089	11383	17786.938	29.12638	3.035774	32.206154	9.171688	4.407668	104401.32
21	24656	2283	3535.9375	-25.423613	1.957475	27.381066	-9.325326	4.421725	-21703.217

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.

CROSS MEAN BACKSCATTER VALUES FOR THE MONTHS OF JULY AND AUGUST (dB)								
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

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).

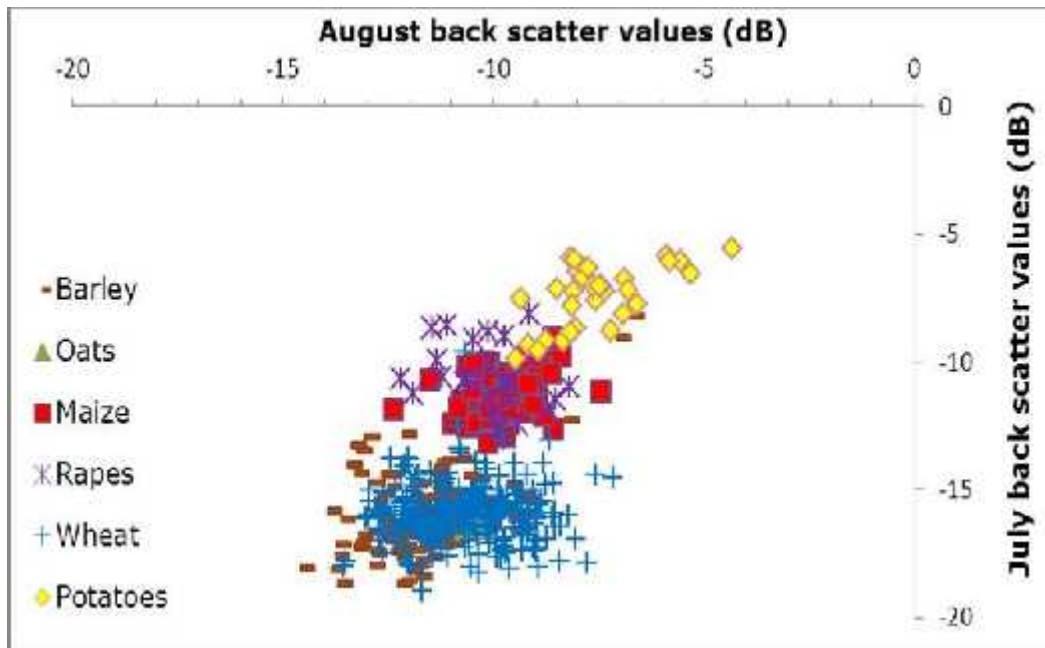


Figure 5: Mean back scatter values display of crop cultures in Leingarten test site.

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).

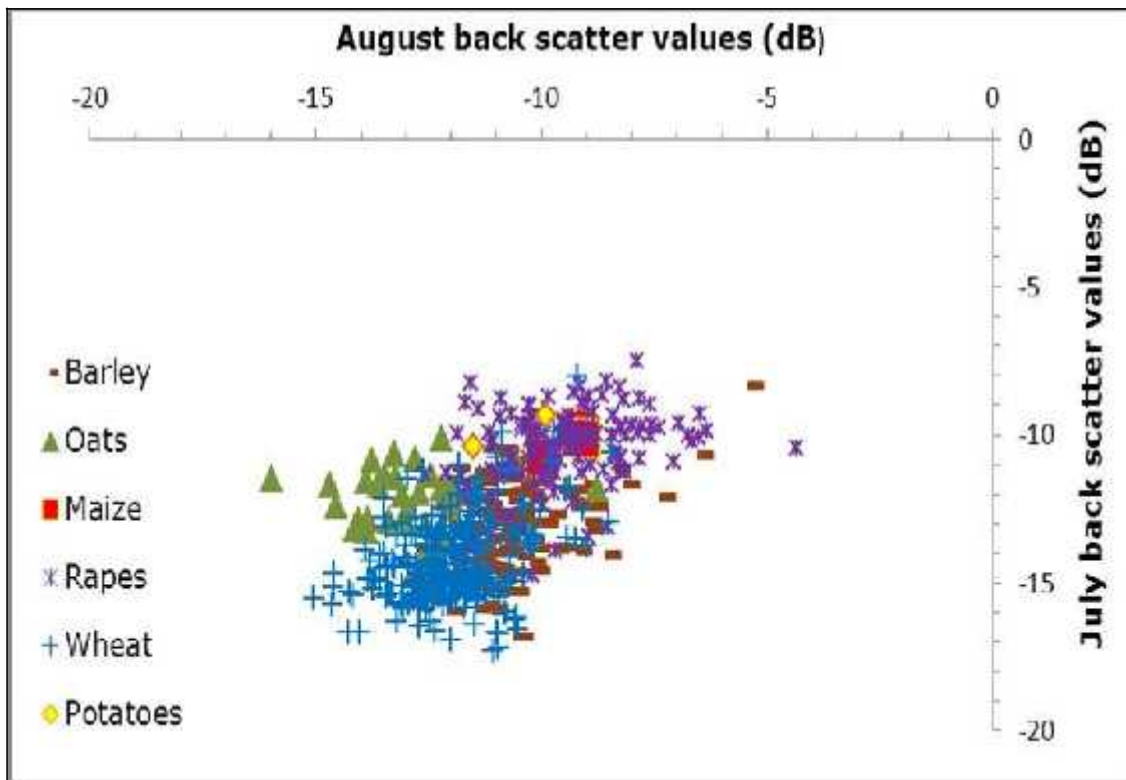


Figure 6: Mean backscatter values display of crop cultures in Moessingen upper test site.

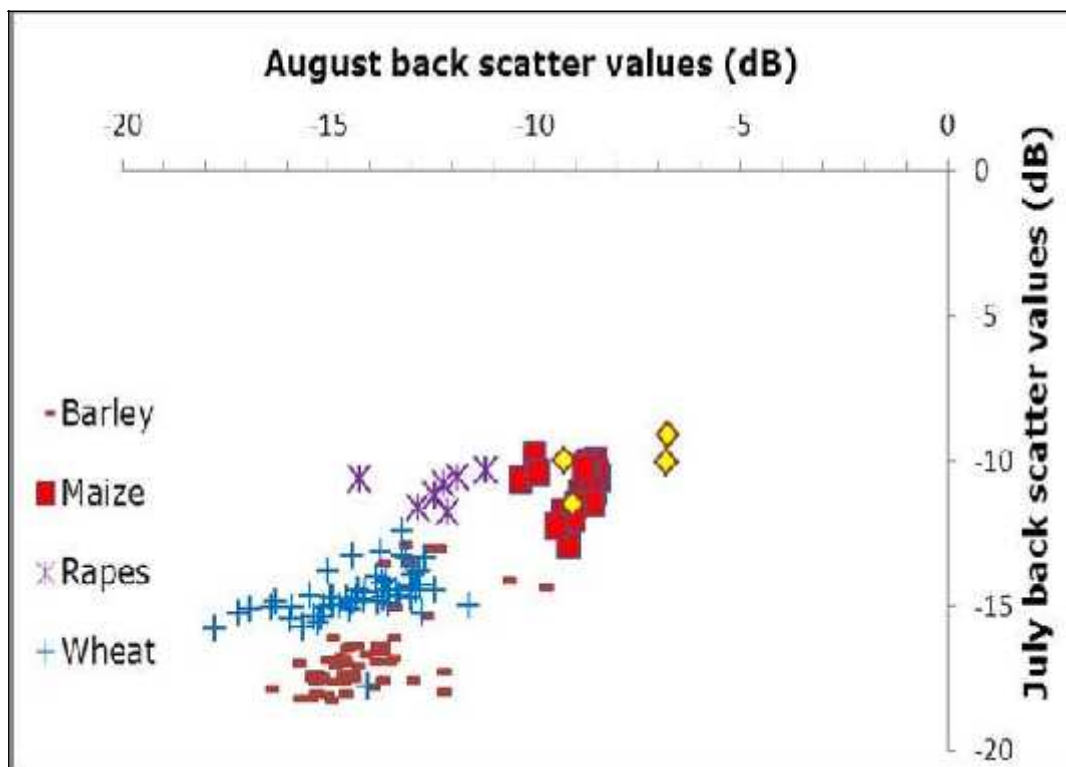


Figure 7: Mean backscatter values display of crop cultures in Moessingen lower test site.

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.

TEST SITE	JULY	AUGUST
LEINGARTEN	Potatoes	Potatos
	Rapes, Maize	Rapes, Maize
	Barley, Wheat, Oats	Barley, Wheat, Oats
MOESSINGEN UPPER	Potatoes, Maize, Rapes	Maize, Rapes
	Oats	Potatoes, Barley
	Barley	Oats
	Wheat	Wheat
MOESSINGEN LOWER	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	August	-11.5	-10.5	-9.7	-10.1	-10.7	-7.5
	July	-15.9	-16.1	-11.2	-10.6	-16	-7.4
Moessingen Upper Test Site	August	-10.8	-12.8	-9.4	-9.5	-11.9	-10.7
	July	-13.1	-12.3	-10.3	-10.4	-14.3	-9.9
Moessingen Lower Test Site	August	-14.2		-9.0	-12.4	-14.2	-8.0
	July	-16.6		-11.0	-11.0	-14.7	-10.2

Reference Values	July	-12	-12	-8	-10	-14	-8
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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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EXTENSION GEODETIC REFERENCE NETWORK USING SATELLITE POSITIONING TECHNIQUES FOR GEOSPATIAL APPLICATIONS

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Abstract

A national geodetic network provides the fundamental support for land surveying, mapping, Remote Sensing, engineering and related applications and is the basis for integrating all such activities. About 80 percent of the primary geodetic control points in Kenya, established in the early twentieth century on hilltops, have been destroyed. This has resulted in expensive and time consuming operations and processes for geospatial professionals and scientists. This situation is even worse in central region of Kenya, hence the need to extend the geodetic control by establishing more control points on secure and accessible sites for use by geospatial professionals and scientists in a wide variety of applications.

In this study, modern satellite positioning techniques have been utilised to extend geodetic reference network in Nyeri and Kirinyaga Counties. Four (4) existing geodetic control points were used to establish up to fifty two (52) newly constructed geodetic control points distributed within the counties. Field observations were carried out using Global Positioning System (GPS) in eighteen (18) sessions. The raw data was downloaded, edited, processed and adjusted using Leica Geo-Office GPS processing software. The resulting final adjusted coordinates had a maximum standard deviation of 2cm and 5cm on horizontal and vertical coordinates respectively and the general loop misclosure of less than one parts per million. The results showed that the quality of established control point positions was high and demonstrates the extension of geodetic control network using modern satellite positioning systems and efficient computational techniques in situations such as the ones currently prevailing in Kenya.

Key Words: geodetic control network, satellite positioning techniques, Global Positioning System, Leica Geo-Office

1. INTRODUCTION

During the colonial era, before Kenya attained its independence in 1963 from the British rule, there had been geodetic control points established by the colonial government and evenly distributed throughout the country. However, towards attainment of independence, the established geodetic network has suffered hugely due to vandalism of the geodetic control point monuments by the locals who erroneously believe that the monuments contain some treasures e.g. valuable minerals such as gold, diamond and mercury. About 80 percent of the primary geodetic control points in Kenya, established in the early twentieth century on hilltops, have been destroyed (Okumu, 1990 and Aduol 1998). As a result, the status of the geodetic reference network in country is quite pathetic and in dire need of re-establishment preferably with employment of the new technologies such as the Global Navigation Satellite System (GNSS).

The destruction of primary geodetic control points has resulted in expensive and time consuming operations and processes for geospatial professionals and scientists. This situation is even worse in central region of Kenya, hence the need to extend the geodetic control by establishing more control points on secure and accessible sites for use by geospatial professionals and scientists in a wide variety of applications.

A geodetic network consists of control monuments – often referred to as bench marks or control points – distributed across landmass for surveyors and other users to occupy and access the geodetic grid as well as provide a reference for control of their surveys (Obel,1985). However, with advancement in technology and subsequently advent of Global Navigation Satellite System (GNSS), geodetic controls became accessible from space in addition to terrestrial access with great accuracy leading to establishment of active spatial reference systems. This active reference systems consists of network of continuously operating GNSS receivers that continuously track GNSS satellites and compute their precise orbits eventually determining their (receivers) precise locations horizontally and vertically (Wannocot,2005). A national geodetic network provides the fundamental support for land surveying, mapping, Remote Sensing, engineering and related applications and is the basis for integrating all such activities for enhanced economic growth and development.

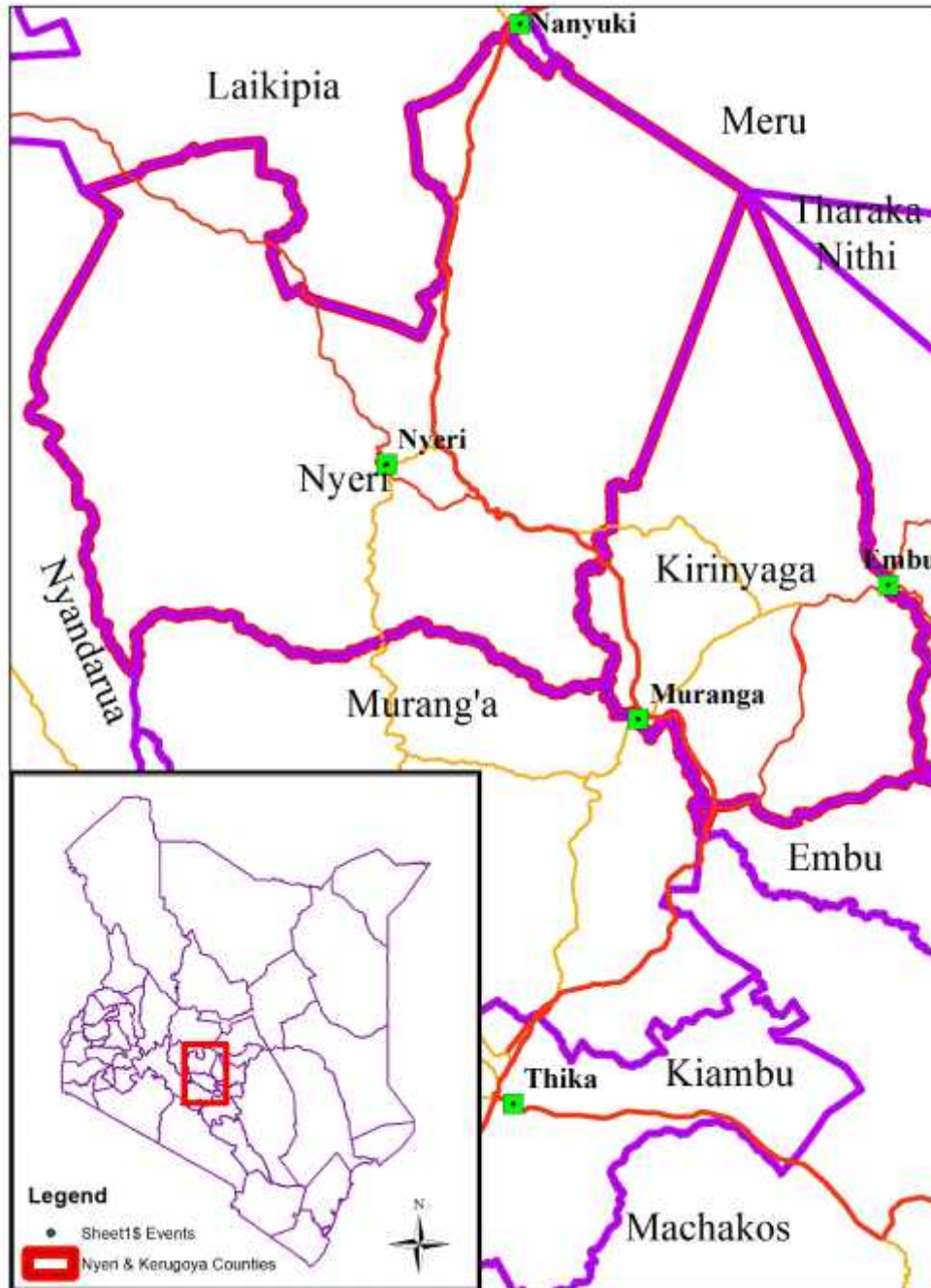
According to Kenya Vision 2030 a long-term vision to guide the country's development towards realization of a globally competitive and a prosperous nation – a comprehensive national land policy has been proposed to provide an overarching framework for access to, planning, management and administration of land in the country. The lack of such a framework has derailed so many development projects due to the contentious and unresolved nature of land in pre and post-colonial Kenya. Land is not only regarded as a factor of production among other factors but also a vital factor that directly and indirectly influences the performance of all other factors. It has high aesthetic, cultural and traditional value so huge to be quantified and subsequently, its access and utilization by key sectors of the economy has been affected greatly since time immemorial.

A comprehensive and accurate geodetic reference framework for control and reference provision for all types of survey on, above and below the earth surface, scientific research, exploration, mining, engineering and other development projects is a vital part of the national land policy (Acheampong, 2008). The frame is expected to bring a common reference control to all surveys carried out in the country as well as providing an excellent integration with those of neighbouring countries. A Geographical Information System (GIS) based land information system and a national spatial data infrastructure have also been proposed in the national land policy to facilitate effective and reliable management of land resources and all its parameters.

2. METHODS

Study Area

The study focused on the central region of Kenya due its central geographical location with respect to the international boundary of Kenya. Nyeri and Kirinyaga Counties were ~~ehosen~~ selected as the suitable study area. The two counties ~~seet~~ are located next to Mt. Kenya with Nyeri County to the west while Kirinyaga County is to the south-west. Nyeri and Kirinyaga Counties are two of the 47 Counties of former Central Province and forms part of Kenya's eastern highlands. They cover a total area 4,744 sq km situated between Longitudes 36° and 38° East and between the equator and Latitude 0° 38' South. The counties borders Laikipia and Meru Counties to the North, Embu County to the east and South, Muranga County to the South and Nyandarua County to the West,. The main physical features of Nyeri and Kirinyaga Counties are Mt. Kenya (5,199m) to the North and the Aberdare range (3,999m) to the West.



Study Objectives

The main objective of the study was to create a reliable and an accurate geodetic reference network connected with the existing local reference frame using GNSS for spatial applications in Central region of Kenya.

Specific objectives included:

- To design, locate, distribute and establish new geodetic control points for a new geodetic reference network for the study area
- To geo-reference non-georeferenced images; aerial photos, images captured from Google Earth and other raster images using the new geodetic control points through rubber sheeting method
- To prepare a simple geospatial geo-database of DeKUT University from the geo-referenced images as a sample representation of the study area

3. METHODOLOGY

The study employed a conceptual methodology to achieve its objectives. The flow diagram (Figure 1) shows the methodology used in the study.

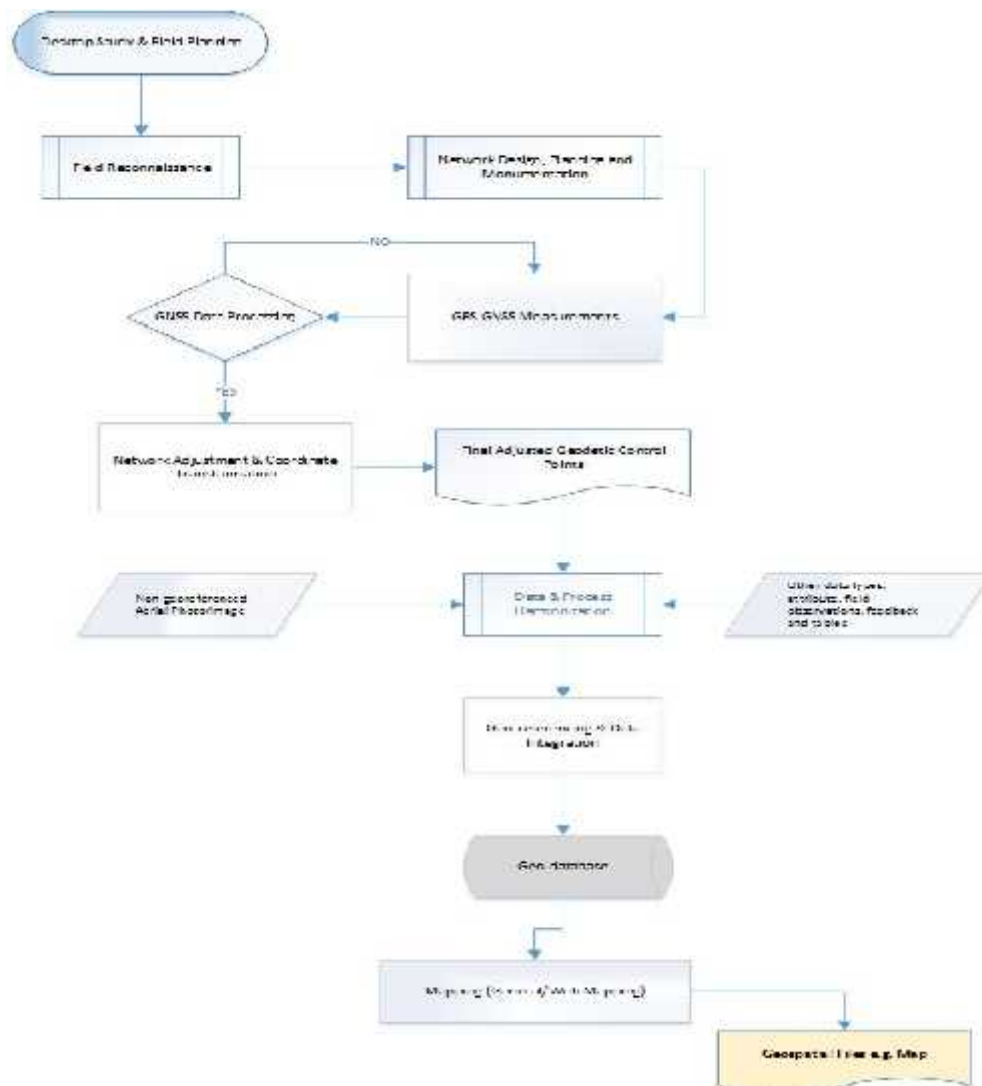


Figure 5 Methodology Flow Diagram

Desktop Study

This was carried out to identify existing geodetic control points in the study area to facilitate control for the geodetic measurements as well as relating the new network with the old one. To achieve this, technical team from Survey of Kenya (SOK) and County Survey Offices of the two counties; Nyeri and Kirinyaga was involved. Equipment and materials used at this stage included a set of GNSS equipment for measurements, SK81F Kenya at a scale of 1:1,000,000, Triangulation Cards with UTM Coordinates, control pillar information and a 1:50,000 topographic maps of the study area.

Project planning

Two phases were planned for the study. In phase one, the following activities were carried out: a reconnaissance of the study, plotting of the existing geodetic control points on the topographic maps, design of new geodetic control points locations (preference was given to areas considered safe to avoid destruction of control points. These areas included the offices of sub-county commissioners, chiefs, schools, churches and police stations among others) and establishment of monuments for the new points.

The phase two of the study entailed field measurement and data processing. A group of higher diploma students in surveying and mapping from the Kenya Institute of Surveying and Mapping (KISM) was used in carrying out the field work. Five teams were made from the group and each team had the following equipment: one set of GNSS equipment (Leica GPS Base and Receivers), tripods, external batteries, a digital camera, three four wheel drive vehicle and all other necessary materials for the field work such a stationery among others. In each session of the field measurement, each team took GPS measurement of the new control points and other survey marks using the stipulated procedure of GNSS measurement. Each session was accorded ample time of data recording/logging to enhance accuracy and data overlap.

The data collected was then processed in two stages. The first stage was pre-processing that involved data conversion into useful formats (Rinex Format), checking for errors, completeness and preparing for actual processing. In the second stage, Leica Geo-Office (Version 8.3), a GNSS data processing software, was used to process, analyses the data and perform network adjustment and transformation of coordinates.

Network Adjustment and Coordinate Transformation

From the processed data, all the baselines in the network were adjusted using least square adjustment program to get the final coordinates of the new geodetic control points. Adjustment also provided a room for quality evaluation of both the field observations and the final coordinates. The transformation parameters were obtained by occupying a number of control stations that had their coordinates in local coordinate system. The processing software was then used to calculate the transformation parameters between Universal Transverse Mercator (UTM) and World Geodetic System (WGS 84) system. Finally, the baseline data

was transformed using the obtained parameters and subsequently final UTM Coordinates of the new geodetic control points obtained.

4. RESULTS

This section of the paper presents results of the major stages of the study. During the reconnaissance of the study area, four existing national geodetic control pillars were found intact as per photo below.



Existing and destroyed national geodetic control points in study area

Their coordinate information as provided by Survey of Kenya is as shown in the Table1 below.

Point	Name	UTM Zone	1:50,000 Topo	Northing	Easting	Ortho. Hgt (ft)	Order
SKP 211	Nyeri	37	120/4	9954810.146	266508.302	2182.380	1 st
120S1	Rakasa	37	120/4	9963932.073	269718.833	2031.780	2 nd
120S2	Kiadongoro	37	120/4	9949485.060	261852.810	2225.970	2 nd
135S10	Gitaima	37	135	9923934.280	759535.630	2068.590	2 nd

Table 1: Existing national geodetic control points in study area (Source: SOK)

From the field measurements, processed and adjusted data, a total of fifty two (52) geodetic control stations (also referred to as pillars or points) were established in the study area and their final adjusted coordinate information recorded as shown in the table below. The resulting final adjusted coordinates had a maximum standard deviation of 10mm and 20mm on horizontal and vertical coordinates respectively and the general loop misclosure of less

than one parts per million. In addition to this, nine (9) control points were also established within the the main campus of Dedan Kimathi University of Technology for training and research purposes. These points were meant to facilitate students practical and research activities in the University.

No.	Point Id	Point Class	Easting	Sd. Easting	Northing	Sd. Northing	Ortho. Hgt.	Posn. + Hgt. Qlty
1	A	Adjusted	286712.131	0.010	9961214.781	0.004	1858.213	0.017
2	B	Adjusted	286103.688	0.010	9960889.414	0.004	1835.260	0.015
3	CHAKA	Adjusted	277335.926	0.010	9960742.988	0.003	1756.919	0.014
4	CHIN	Adjusted	266402.469	0.005	9933695.957	0.003	2034.373	0.011
5	DeKUT10	Adjusted	272635.742	0.010	9956966.468	0.004	1783.619	0.015
6	DeKUT2	Adjusted	273023.395	0.010	9956379.491	0.004	1773.236	0.015
7	DeKUT3	Adjusted	273118.073	0.010	9956287.620	0.004	1769.655	0.015
8	DeKUT4	Adjusted	272990.027	0.010	9956216.898	0.004	1776.754	0.016
9	DEKUT5	Adjusted	272693.632	0.010	9956706.188	0.004	1778.463	0.014
10	DeKUT7	Adjusted	272903.561	0.010	9956825.063	0.004	1779.868	0.014
11	DeKUT8	Adjusted	272848.116	0.010	9956892.173	0.004	1781.772	0.015
12	DeKUT9	Adjusted	272689.247	0.010	9956897.896	0.004	1786.453	0.015
13	DKUT	Adjusted	272861.233	0.010	9956561.598	0.003	1772.068	0.014
14	GATH	Adjusted	265073.741	0.005	9945979.771	0.004	2069.870	0.012
15	GIAT	Adjusted	274911.906	0.005	9942658.083	0.003	1834.858	0.010
16	GKI	Adjusted	305038.571	0.004	9947521.326	0.002	1675.070	0.007
17	IRUR	Adjusted	281088.431	0.004	9933638.574	0.002	1717.819	0.009
18	ITUN	Adjusted	297857.333	0.005	9954209.850	0.003	1940.109	0.009
19	KAGI	Adjusted	305552.354	0.005	9930894.536	0.003	1235.725	0.010
20	KAGU	Adjusted	308925.992	0.004	9935247.687	0.002	1274.261	0.007
21	KAIR	Adjusted	264813.641	0.005	9941349.125	0.003	2044.642	0.011
22	KANG	Adjusted	295429.296	0.005	9944400.298	0.003	1653.505	0.009
23	KARA	Adjusted	291733.379	0.004	9946814.318	0.002	1754.268	0.008
24	KARI	Adjusted	263957.000	0.005	9936552.724	0.003	2068.669	0.011

25	KARIA	Adjusted	311691.377	0.004	9940281.696	0.002	1347.832	0.007
26	KARO	Adjusted	288128.573	0.004	9944352.870	0.003	1717.974	0.009
27	KBGT	Adjusted	298395.276	0.004	9937772.664	0.002	1376.476	0.007
28	KBR	Adjusted	310460.895	0.004	9946635.853	0.002	1576.085	0.008
29	KDC	Adjusted	310121.217	0.005	9926608.206	0.004	1189.540	0.013
30	KHC	Adjusted	294436.964	0.005	9928236.421	0.003	1389.383	0.010
31	KIAN	Adjusted	316371.209	0.004	9945638.105	0.002	1497.209	0.008
32	KIRI	Adjusted	271813.738	0.005	9934070.785	0.003	1869.981	0.010
33	KPPI	Adjusted	299793.574	0.004	9932189.485	0.002	1244.209	0.008
34	KPS	Adjusted	307014.005	0.005	9926896.717	0.003	1201.604	0.012
35	KRG	Adjusted	308667.470	0.004	9944043.277	0.002	1511.918	0.007
36	KRIO	Adjusted	300172.357	0.004	9946448.829	0.002	1618.752	0.008
37	KRTU	Adjusted	293204.267	0.005	9957401.188	0.003	1991.993	0.010
38	KUTU	Adjusted	313560.207	0.004	9937474.922	0.002	1289.307	0.008
39	KWV	Adjusted	304782.327	0.006	9925344.554	0.004	1157.568	0.015
40	MAKA	Adjusted	311528.114	0.006	9917164.145	0.004	1163.181	0.015
41	MARU	Adjusted	282469.611	0.004	9949971.745	0.003	1626.229	0.009
42	MIHU	Adjusted	286370.943	0.004	9937402.193	0.002	1709.031	0.008
43	MIIR	Adjusted	295484.023	0.004	9947011.710	0.002	1742.634	0.008
44	MKN	Adjusted	307989.675	0.006	9916181.220	0.004	1156.508	0.015
45	MTU	Adjusted	304965.023	0.004	9943115.534	0.002	1497.879	0.007
46	MUTH	Adjusted	267408.937	0.006	9950276.695	0.005	1968.598	0.016
47	MUTI	Adjusted	313257.946	0.006	9919808.497	0.004	1149.370	0.013
48	MWDC	Adjusted	287020.628	0.004	9947845.609	0.003	1772.364	0.009
49	MWEI	Adjusted	266519.362	0.010	9963935.158	0.003	1960.835	0.014
50	NDIA	Adjusted	276564.828	0.005	9937647.097	0.003	1823.696	0.011
51	NDUN	Adjusted	286078.566	0.010	9959173.110	0.004	1843.453	0.015
52	NGO	Adjusted	306791.794	0.006	9920774.134	0.004	1154.864	0.014
53	NGOR	Adjusted	284061.136	0.004	9939534.064	0.002	1735.717	0.008

54	NYAN	Adjusted	317197.865	0.004	9933838.041	0.002	1238.563	0.008
55	OTHA	Adjusted	270817.484	0.005	9938117.904	0.003	1877.404	0.011
56	RC2	Adjusted	272943.316	0.010	9956273.590	0.004	1789.856	0.015
57	RURI	Adjusted	272866.861	0.006	9951414.677	0.005	1776.730	0.014
58	RWAM	Adjusted	316585.087	0.004	9941841.946	0.002	1392.171	0.007
59	SAMS	Adjusted	317863.707	0.004	9938775.016	0.002	1337.252	0.007
60	SUP	Adjusted	300055.650	0.004	9927070.868	0.002	1200.404	0.008
61	WANG	Adjusted	318861.726	0.007	9923764.919	0.005	1148.843	0.018

Table 3 Showing Final Adjusted UTM Grid (Clarke 1880, Arc 1960, Zone 37 South) Coordinates of some of the new geodetic control points

A three dimensional transformation was performed using the Modelenky-Badekas model that derived seven (7) transformation parameters that would allow transformation of coordinates from KENREF to UTM systems. The parameters derived are as shown in the table below:

1.	Shift dX	158.7351m	0.0305 rms
2.	Shift dY	2.1067m	0.0305 rms
3.	Shift dZ	297.6477m	0.0305 rms
4.	Rotation about X	-4.40526m	0.6652 rms
5.	Rotation about Y	4.79097m	0.8152 rms
6.	Rotation about Z	18.28060m	0.4690 rms
7.	Scale	-2.9178m	1.3073 ppm

Table 3: Transformation parameters between WGS84 and UTM

To explore the application of the established geodetic control points in GIS applications, aerial photograph covering Dedan Kimathi University of Technology – which is located within the study area – was georeferenced using some of the new geodetic control points. The control points used are the ones that were established within the University main campus. Rubber Sheeting method (also referred to as Stretching method) of georeferencing was used to georeference the non-georeferenced image into a georeferenced file that was latter digitized to develop a simple GIS geodatabase and map of the University as shown by the figures 2 and 3 below.



Figure 6 Georeferencing aerial photo using new geodetic control points at DeKUT

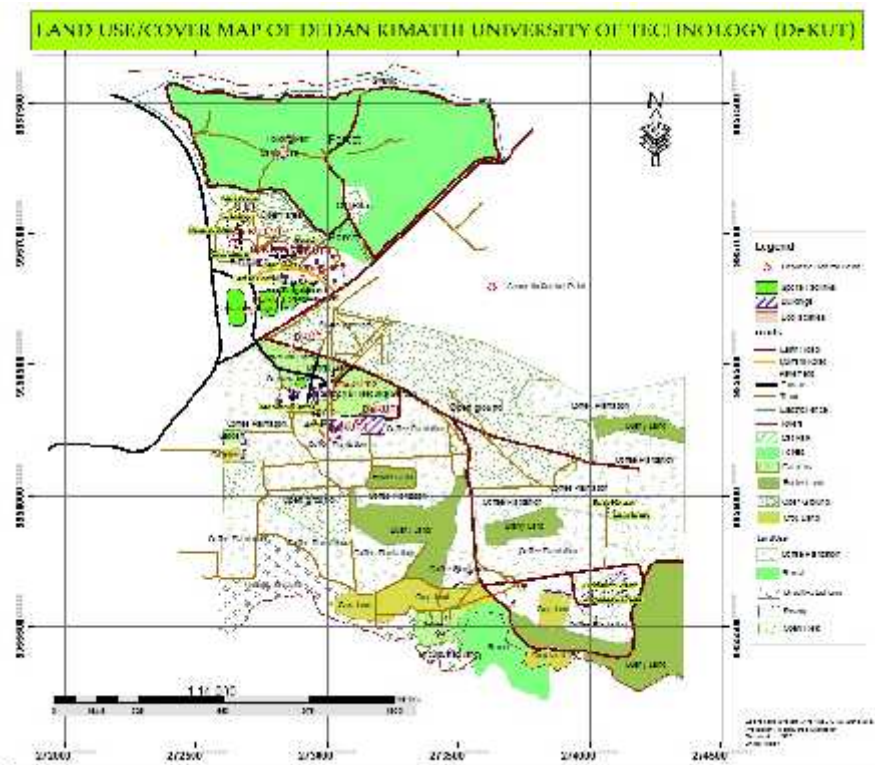


Figure 7 A simple map developed from georeferenced image of DeKUT

5. CONCLUSION

This paper has demonstrated the use of modern techniques in extension of national geodetic network in Nyeri and Kirinyaga Counties within a duration of less than one month contrary to

the classical methods which were laborious and time consuming. The results showed that the quality of established control point positions was high and demonstrates the extension of geodetic control network using modern satellite positioning systems and efficient computational techniques in situations such as the ones currently prevailing in Kenya. There is urgent need for Survey of Kenya to establish a homogenous reference coordinate system that would be used in surveying and mapping for infrastructural development towards the attainment of Vision 2030.

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**EXPLORING THE RELATIONSHIP BETWEEN LAND SURFACE
TEMPERATURE AND LAND USE LAND COVER IN KENYA. (A CASE STUDY OF
NAIROBI COUNTY).**

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Abstract

The environmental and social effects of predicted climate change are expected to increase in our built-up environments as a result of increased temperatures which are attributed to the phenomenon known as the Urban Heat Island (UHI). With vegetation cover that could provide for cooler microclimates through its process of evapotranspiration being depleted to pave way for the concrete urban jungle, then its predicted for the worse effects of the climate change. Land surface temperature (LST) forms an important climate variable related to climate change and is an indicator of the energy balance at the surface since it's a key parameter in the physics of the land surface processes. The main aim of the study is to explore the relationship between the LST and the LULC through analysis of the LST difference NDVI and LULC for a period of 24 years. The study area is Nairobi between 36°4' and 37°10'. Landsat satellite images of 1986, 1995, 2002 and 2010 were used to derive land use land cover (LULC), normalized difference vegetation index (NDVI) and LST. It was found out that LST and NDVI shared an inverse relationship, implying that an increase in vegetation abundance would generally reduce surface temperature and thus UHI intensity. The relationship demonstrated the existence of distinct differences depending the on LULC type hence indicating that decrease in amount of vegetation as a result of urbanization and lack of controlled development would increase the UHI intensity. The study therefore illuminates which types of actions would be most conducive to mitigate this effects.

Keywords— Landuse Landcover, Land Surface Temperature, Normalized Difference Vegetation Index, Urban Heat Islands.

1.0 INTRODUCTION

Global warming is increasing as a result of massive changes in land use land cover more so due to urbanization which leads deforestation and reduction in agricultural areas. Most urban areas have higher temperatures as compared to the country side according to the greenhouse effect derived from carbon effluent machinery and use. With different land use types having different land surface temperature indicate that it can be used to show LST trends [1].

With ground-based observations reflecting only thermal condition around the station, it's somewhat difficult to estimate LST with expected precision hence in recent times thermal remote sensing has been used to assess the LST. Satellite Images are widely used to track changes in LULC due to their spectral, temporal and spatial characteristics. The thermal band widely used to estimate the thermal condition of land surface is less utilized due to its low resolution. Surface temperature can be estimated on daily basis using thermal bands of NOAA/AVHRR, GEOS, MTSAT. However, this kind of data has a low resolution of around 1-5 km spatial resolution making it suitable for climate studies at a more regional level. This poses a challenge in recognition of different land cover types within a single pixel. The Landsat TM and ETM+ with 60m spatial resolution of thermal infrared band enable users to define the more detailed surface temperature.

Land use land cover changes alters the sensible and latent heat fluxes that exist within and between the earth's surface and boundary layers thus influencing land surface-atmosphere interactions [2]. The changes in LULC affects land surface properties where LST is one of the properties and is assessable continuously using satellite imagery.

The NDVI refers to a dimensionless variable and its index provides information on vegetation vigor situation [3]. This means it can be used as an indicator of climate change since it assesses vegetation which is a major component of land cover.

This research aims to examine the spatial-temporal effects of land use changes on land surface temperature through analysis of the LST difference NDVI and LULC using Landsat TM and ETM for a period of 24 years.

2.0 STUDY AREA

The study area, Nairobi County, extends between 36° 4' and 37° 10' E and approximately between 1° 9' and 1° 28' S, covering an area of 689 km². The average altitude is approximately 1700m above sea-level with a mean annual rainfall of about 900 mm. Nairobi County has vegetation varying from grassland scattered with acacia trees in the east with some hardwood forests in the higher areas to the west.



Fig. 1: Map of the study area

The General Land use within the study area varies from Urban-built, agriculture, rangeland and forests. Nairobi has recorded urban explosion in recent years with conversions of pervious surfaces to impervious surfaces. Nairobi County has a population of about three million, with population densities varying widely within the county.

3.0 DATA AND METHODOLOGY

The following procedure was carried out to derive the NDVI and surface temperature.

3.1 Conversion of the Digital Number (DN) to Spectral Radiance (L)

The spectral radiance (L) is calculated using the following equation [4]:

$$L_{\lambda} = LMIN_{\lambda} + \left(\frac{DN - QCALMIN}{QCALMAX - QCALMIN} \right) (LMAX_{\lambda} - LMIN_{\lambda}) \quad (1)$$

Where,

- QCALMIN = 1, QCALMAX = 255 and QCAL = Digital Number.
- The LMIN and LMAX are the spectral radiances for band 6 at digital numbers 1 and 255 respectively.

$$\rho_p = \frac{\pi \cdot L_{\lambda} \cdot d^2}{ESUN_{\lambda} \cdot \cos \theta_s} \quad (2)$$

Where: L is the spectral radiance, d is the Earth-Sun distance in astronomical units, θ_s is the solar zenith angle in degrees. ESUN is the mean solar exoatmospheric irradiance. ESUN values from the *Landsat 7 Science Data Users Handbook* for Landsat 7 ETM+. ESUN, [5]. The above computation ensured accurate values for the inputs and outputs.

3.2 Land Use Land Cover Retrieval.

The land use and land cover classification system used in this report conforms to the classification process level I as outlined by [9]. A total of five land use land cover classes were derived namely; built-up, Agricultural/forest, shrubs/grassland, water and bare land.

Landsat data was used to carrying out classification using the maximum likelihood algorithm and supervised classification for all the years under study to obtain land use land cover classes. Various types of classes were identified using false colors of the different band combination which enhanced features and improved on the interpretations.

Accuracy assessment was done by randomly selecting points in which the two high resolution images were used to check against the classified images for all the images and the accuracy assessment results produced.

3.3 Conversion of the Spectral Radiance to Temperature

$$NDVI = \frac{NIR - R}{NIR + R} \quad (3)$$

Where: NIR is the near infrared band 4, R is the red band 3[3]

3.4 Land Surface Temperature Retrieval

The brightness values obtained was then converted into land surface temperature. Since brightness temperature from equation 4 refers to black body with emissivity equal 1, the temperature of real surface would be different.

3.4.1 Brightness Temperature Retrieval

The ETM+ thermal band data can be converted from spectral radiance temperature, which assumes surface emissivity = 1 [4]:

$$BT = K2 / \ln(K1 / L + 1) \quad (4)$$

Where,

- T = Effective at-satellite temperature in Kelvin
- K1 = Calibration constant 1 (watts/meter squared*ster*μm) (666.09)
- K2 = Calibration 2 (Kelvin) (1282.71)
- L = Spectral radiance (watts/meter squared*ster*μm)

3.4.2 Emissivity Retrieval

In this study the method of emissivity estimation from the NDVI by [7] and [8] has been applied.

$$\varepsilon = \begin{cases} 0.979 - 0.035NDVI & NDVI < 0.2 \\ 0.986 - 0.004NDVI & 0.2 \leq NDVI \leq 0.5 \\ 0.99 & NDVI > 0.5 \end{cases} \quad (5)$$

Under this method pixels were divided into three groups according to the NDVI value. If NDVI exceeds 0.5 then pixel is assumed to be entirely covered by vegetation. Under such cases the ε equal 0.99 were assigned to them. For the pixels where NDVI ranges from 0.2 to 0.5 the Fractional Vegetation Cover (PV) was calculated using the below equation 6.

$$PV = \left[\frac{NDVI - NDVI_s}{NDVI_v - NDVI_s} \right]^2 \quad (6)$$

Where $NDVI_s = 0.2$ which is value for pure soil pixel and $NDVI_v = 0.5$ which is value for pure vegetation pixel.

Finally the ε was obtained from simple linear regression using PV values using above equation 6. Where pixels had NDVI values lower than 0.2 the ε is calculated from reflectance in red band

If the emissivity is known the LST could be determined from simple formula [6]

The algorithm for conversion applied is as shown below;

$$LST = \frac{BT}{\varepsilon^{0.25}} \quad (7)$$

Both BT and LST are expressed in Kelvins. Most of the emissivity estimation is based on Normalized Difference Vegetation Index (NDVI) from equation 3.

4.0 RESULTS AND ANALYSIS

The land use land cover maps derived from the multispectral Landsat data using the maximum likelihood classification method for the years 1986,1995,2002 and 2010 images are as shown below in figure 2.

Land use land cover Maps

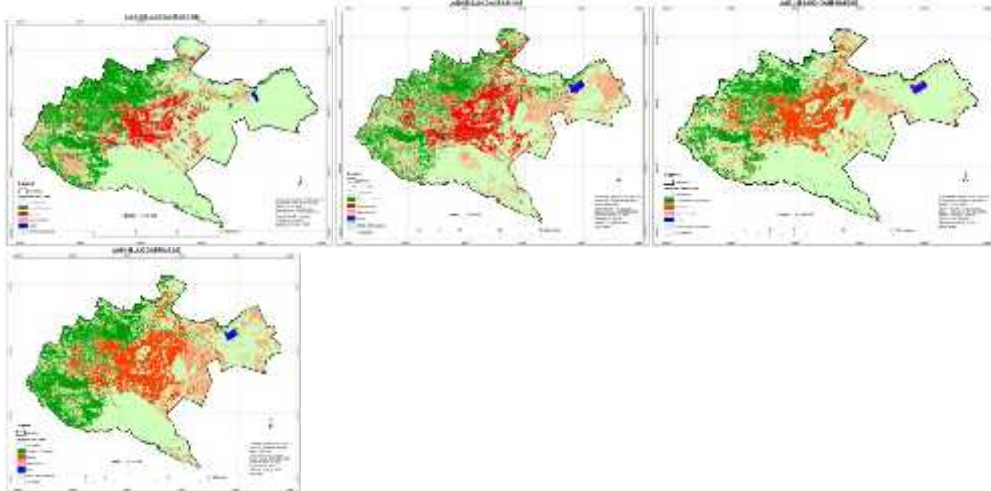


Figure 2: Land use land cover maps

From the above maps it seen that the built up has increased of the years being a clear indication of urbanization. Forest/plantations, shrubs and grassland have significantly reduced over the time hence increasing the amount of latent heat flux from the surface to the atmosphere. Visual interpretation indicates increase in bare land.

LST was generated for the years 1986, 1995, 2002 and 2010 for the study area as shown below in Figure 3.

Land surface Temperature maps

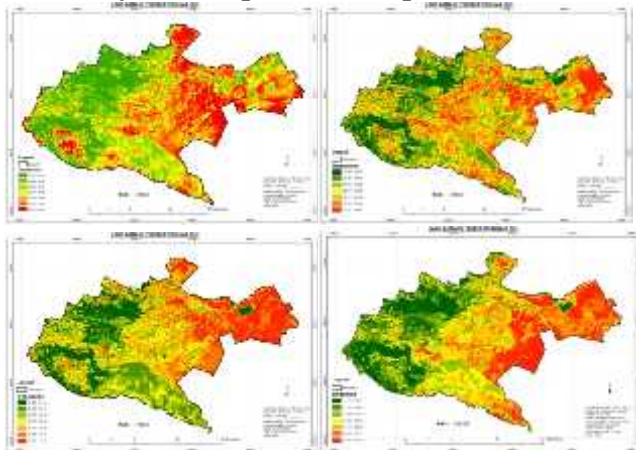


Figure 3: LST maps

From the visual interpretation of the above maps, its clear that areas covered by green vegetation contains the lowest temperature and built-up and bare land having the highest temperature. To show a spatial distribution of the surface radiant temperature, LST map was classified as shown above into 7 classes based on a classification scheme using the standard deviation. The averaged LST in the classes was regarded as LST in Nairobi hence depicting spatial distribution

4.1 Correlating LULC and LST

The relationship between LST and LULC has shown a positive correlation between Built-up and bare grounds. A cross comparison between the LST and LULC map indicated a minimum of about 20° in water bodies and a maximum of 34°-36° in bare grounds and built-up areas. Areas of moderate vegetation had moderate temperatures. The temporal distribution can be explained using the figure 4 below. Generally the figure indicates a general and steady increase in LST for bare grounds and built-up. Vegetated areas have a negative correlation hence having very low temperatures. Areas occupied by water too had low temperatures.

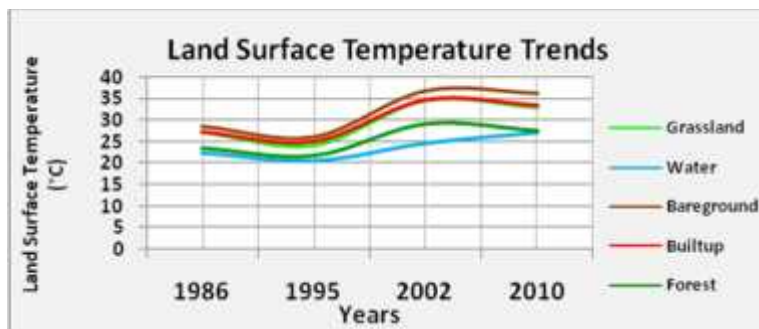


Figure 4: LST Trends

NDVI was generated for the study period as shown in figure 5 below.

Normalized Difference Vegetation Index maps

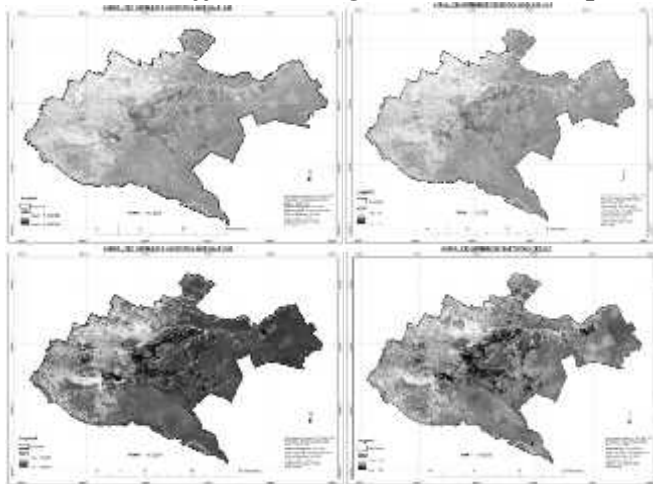


Figure 5: NDVI maps

To examine the spatial distribution of the NDVI, NDVI maps were produced for the entire study period and a classification assigned to denote the distribution. In the study, NDVI was calculated to provide estimates of the abundance of actively photosynthesizing vegetation. Large NDVI denoted large fraction of vegetation per pixel.

4.2 Correlating NDVI and LST

The results indicate a significant inverse correlation between LST and NDVI. This generally means that the LULC areas with high LST generally registered low NDVI readings while

LULC areas with low LST generally registered high NDVI readings. The correlation between NDVI and LST has shown to be valuable for studies of urban climates [10]. For this study, the use of NDVI was to examine the relationship between the vegetation cover and LST.

The temporal distribution of the NDVI can best be explained from the below figure 6. Vegetated areas were found to have the highest NDVI values as compared to built-up and bare grounds that had the lowest values.

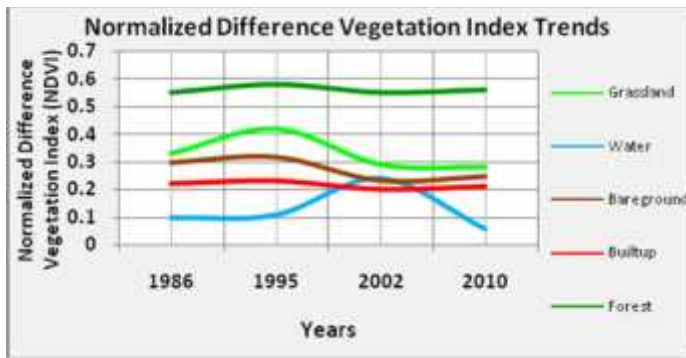


Figure 6: *NDVI Trends*

5.0 DISCUSSION AND CONCLUSION

From the research results, it's demonstrated that LULC and their land surface characteristics are more related to LST and in more sense affect the general pattern of the UHI. Different LULC have shown to have varied effects on LST and NDVI. The Inverse relationship between LST and vegetated LULC were observed for the study area.

Areas of high LST were identified as the built-up, i.e. the central business districts, industrial areas and the informal settlements and bare grounds mostly around the quarry's.

The results also suggest a high correlation between LST and LULC hence revealing different environmental impact factors attributed by urbanization process in Nairobi. Increase in urbanization process leads to replacement of natural surfaces and a continuous increase in artificial LULC in form of roads, buildings and other anthropogenic surfaces making it impervious [11]. The continuous and enormous changes of the LULC with urban sprawl and encroachment and destruction of the ecosystem in our urban green space has led to the increase in LST intensity.

With the world's population estimated to live in urban areas said to increase significantly over the coming years, and with the highest growth said to happen in developing world, its imperative the problem in urban areas will be the increase in surface temperature as a result of continuous alteration and conversion of previously pervious surfaces to impervious surfaces. The changes will cause environmental impacts with air pollution a factor that contributes to global warming increasing the surface temperature. Others affect the absorption of solar radiation, evaporation rates, surface temperature, the storage of heat and wind turbulence all conditions fit to contribute to the urban heat island phenomenon [12].

Based on the current rate of urbanization coupled with ever increasing population growth, it is assumed that the urban built-up areas may continue to increase further with the same projection as the past, hence further increase in LST values around the urban areas can be predicted. This is based on increase in population and anthropogenic materials.

With the research study results indicating a positive correlation between LST and LULC, it can be concluded that an increase in LULC would mean an increase in LST too. This indicates the importance of the research findings to planners, urban managers, and decision makers and of particular importance to the county government of Nairobi to take up actions and draft of policies to further control the LULC changes so as to minimize and reduce their impacts hence mitigating the urban micro-climates. It is recommended for action to be taken to introduce green building as well as adopt measures that would ensure continuous preservation of Nairobi green corridors and space.

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CROP-LAND SUITABILITY ANALYSIS USING GIS AND REMOTE SENSING IN NYANDARUA COUNTY, KENYA

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Abstract

Land suitability analysis is a method of land evaluation, which measures the degree of appropriateness of land for a certain use. The aim of this research was to identify and delineate the land that can best support potatoes, using GIS-based Multi Criteria Evaluation technique and Remote Sensing. The study was carried out in Nyandarua County in Kenya. Agriculture is the mainstay of local economy in the study area, but the production is very low because some of the crops being introduced are not doing well. There is need therefore to identify and delineate suitable areas for growing various crops to achieve maximum potential yield.

Three suitability criteria i.e. soil (PH, texture, depth, drainage), climate (rainfall, temperature) and topography were evaluated based on agronomist experts opinions and FAO guideline for rainfed agriculture. An Analytical Hierarchical Process was used to determine relative importance of criteria and the resulting weights were used to construct the suitability maps/layers using GIS software. Finally, land suitability map was generated by overlaying these maps with current land cover map generated from Landsat images through supervised classification.

The results of this research revealed that in the study area, 37.6% of the agricultural land is highly suitable for potatoes cultivation, 51.5% is moderately suitable and 10.9% is marginally

suitable. The results can be used by the County government to advise the local farmers on the suitable areas for potatoes cultivation.

Keywords: Land suitability analysis, GIS, Remote sensing, Multi-Criteria Evaluation, AHP, Potatoes cultivation.

1.0 INTRODUCTION

The population of the planet is growing dramatically and in order to meet the increasing demand for food, the farming community has to produce more and more. However, under present situation where land is scarce, it is impossible to bring more area under cultivation to satisfy the growing demand (Teka & Haftu, 2012). In order to increase food production and provide food security, crops need to be grown in areas where they are best suited. In order to achieve this, the first and foremost requirement is carrying out land suitability analysis (Kihoro et al., 2013). Land suitability analysis is a method of land evaluation, which measures the degree of appropriateness of land for a certain use. The Analysis allows identification of the main limiting factors of crop production and enables decision makers to develop crop management system (Halder, 2013).

Many of GIS-based land suitability analysis approaches such as Boolean overlay and modelling for land suitability analysis lack a well-defined mechanism for incorporating the decision-maker's preferences into the Geographic Information System (GIS) procedures. This may be solved by integrating GIS and Multi Criteria Evaluation (MCE) methods (Mustafa et al., 2011). Among the various MCE methods, the Analytical Hierarchy Process (AHP) is a well-known multi-criteria technique that has been incorporated into GIS-based suitability procedures to obtain the required weightings for different criteria. GIS based AHP has gained popularity because of its capacity to integrate a large quantity of heterogeneous data, and because obtaining the required weights can be relatively straightforward, even for a large number of criteria (Feizizadeh & Blaschke, 2012). GIS based MCE approach has been widely used in land suitability analysis in other countries. However, in Kenya, from the available literature, the application of the method in potatoes suitability analysis has not been done.

Agriculture is the mainstay of local economy in Nyandarua County, but the production is very low. Hence, comprehensive, reliable and timely information on agricultural resources is very much necessary to ensure use of land in the most rational and optimal way. Over the years, farmers have been abandoning crops that are well established in the County, to venture into alternative crops. This has affected the total yield because some of the crops being introduced are not doing well. Nyandarua County has potential in agriculture that can absorb majority of youths seeking employment. The county government has plans of boosting production of potatoes, carrots and other crops that do well in the region (Kahenda, 2013).

The main objective of the research is to identify and delineate the land that can best support potatoes in Nyandarua County, using MCE technique. The specific objectives is to develop a spatial model for land suitability evaluation for potatoes cultivation using GIS, to classify agricultural land in the County into different suitability classes and to develop suitability maps for potatoes cultivation in Nyandarua County.

Mustafa et al (2011) in the study of land suitability analysis for different crops using MCE approach, remote sensing and GIS, found that AHP is useful method to determine the weights. Khoi and Murayama (2010) used a GIS-based MCE of biophysical factors and Landsat imagery to delineate the areas suitable for cropland in protected area-buffer zone of Tam Dao National Park region, Vietnam. Other studies using this approach include; Suitability analysis for rice growing sites using a MCE and GIS approach in great Mwea region in Kenya by Kihoro et al. (2013) and Land suitability analysis for Tabriz County, Iran using MCE approach and GIS by Feizizadeh and Blaschke (2012).

2.0 MATERIALS AND METHODS

2.1 Study area

The research was carried out in Nyandarua County, Kenya, covering an area of approximately 3,270 square km (Figure 1). It has a predictable weather patterns with temperatures ranging between 12°C during the cold months (June and July) and 25°C during the hot months (January and February) and rainfall of between 700mm and 1,500mm per annum. The county comprises five constituencies: Ol-Kalou, Ol-Joro-Orok, Kinangop, Kipipiri and Ndaragwa.

Nyandarua County is home to 596,268 people, according to the 2009 National Census. The population which grows at 2.4% annually is expected to grow to 688,618 and 722,498 persons in 2015 and 2017 respectively. Farming is the major economic engagement with dairy and crop production such as potatoes, wheat, maize, beans and vegetables as the mainstay of the local economy.

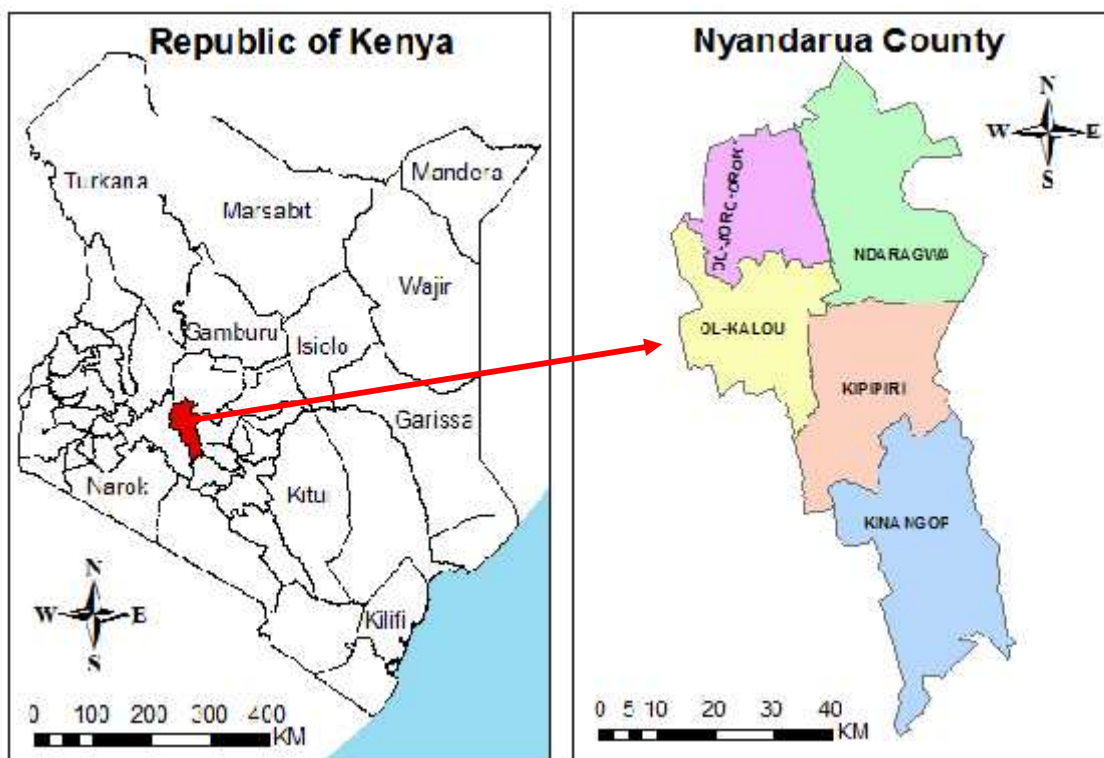


Figure 1: Location of the study area

2.2 Methodology

2.2.1 Selection of evaluation criteria

A study by Kuria et al. (2011) has shown that it is important to consider other terrain features in addition to soil characteristics in order to come up with a more informed decision on optimal crop growing areas. The relationship between the objectives and their attributes has a hierarchy structure. At highest level one can distinguish the objectives and at lower level, the attributes can be decomposed (Mustafa et al., 2011). Opinions of agronomist experts and literature review of various references helped in identifying three main criteria (soil, climate and topography) and seven sub-criteria (soil PH, soil texture, soil drainage, soil depth, rainfall, temperature and slope) necessary to determine suitable areas for growing potatoes (Figure 3).

The suitability levels were based on the structure of Food and Agriculture Organization (FAO) land suitability classification and ranked as highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and not suitable (N) (Table 1). Suitability levels for each of the sub-criteria were defined according to the FAO guideline for rainfed agriculture, literature review and agronomist expert's opinions (Table 2).

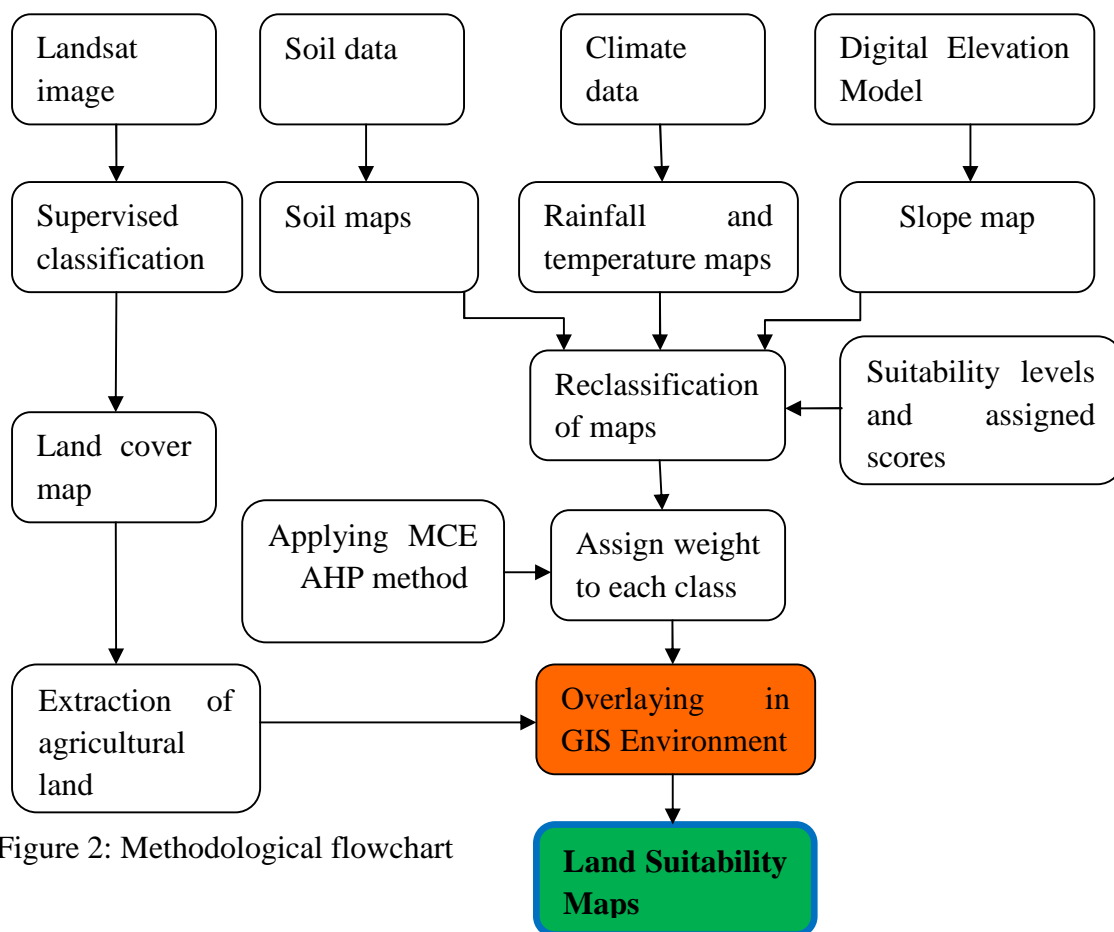


Figure 2: Methodological flowchart

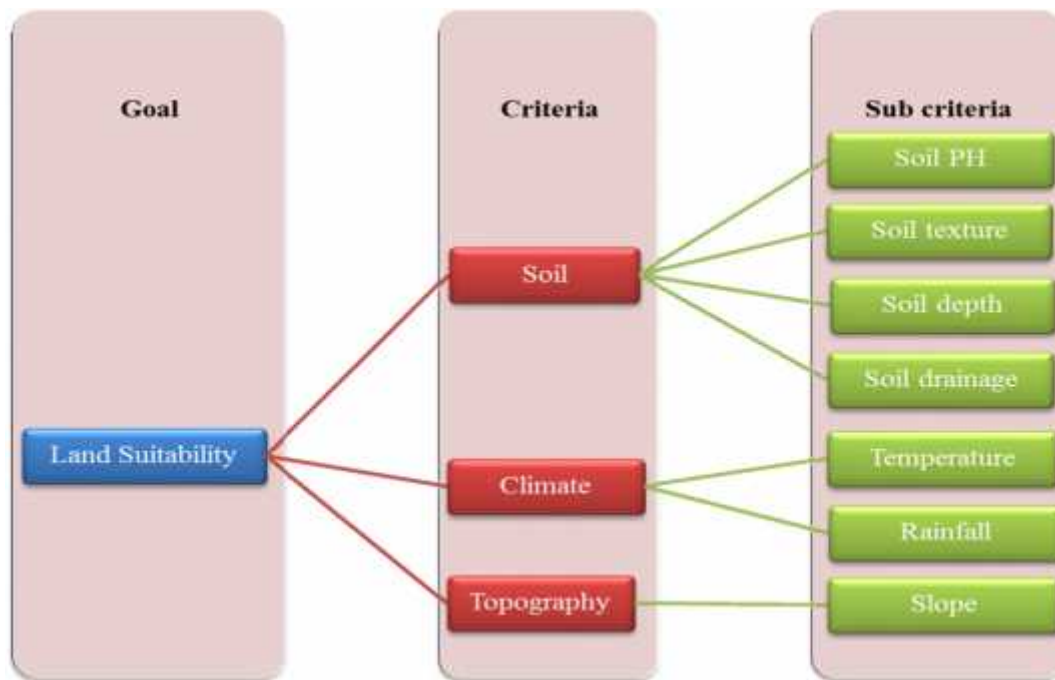


Figure 3: Hierarchical organization of the criteria considered in the study

Table 1: Structure of the suitability classification

Order	Class	Description
S (Suitable)	S1 (Highly Suitable)	Land having no significant limitations to sustained application of a given use, or only minor limitations that will not significantly reduce productivity and benefits and will not raise inputs above an acceptable level.
	S2 (Moderately Suitable)	Land having limitations which in aggregate are moderately severe for sustained application of a given use, the limitations will reduce productivity or benefits and increase required inputs to the extent that the overall advantage to be gained from the use.
	S3 (Marginally Suitable)	Land having limitations which in aggregate are severe for sustained application of a given use and will so reduce productivity and benefits, or increase required inputs, that this expenditure will be only marginally justified.
N (Not Suitable)	N1 (Currently Not Suitable)	Land having limitations which may be surmountable in time but which cannot be corrected with existing knowledge at currently acceptable cost, the limitations are so severe as to preclude successful sustained use of the land in the given manner.
	N2 (Permanently Not Suitable)	Land having limitations which appear as severe as to

Not Suitable)

preclude any possibilities of successful sustained use of the land in the given manner.

Source: FAO Soils Bulletin 32, 1976

Table 2: Land use requirements of potatoes

Parameters	Unit	Suitability class and degrees of limitation			
		S1	S2	S3	N
Soil PH	Reaction	6.0-5.0	6.0-7.0	7.0-8.0	> 8.0
			5.0-4.0	4.0-3.5	< 3.5
Soil texture	Class	Loamy	Sandy	Clayey	Very clayey
Soil depth	meters	0.75	0.75 – 0.50	0.50-0.25	< 0.25
Soil drainage	Class	Well/ moderate	Imperfect	poor	very poor
Rainfall	mm	1,000	1,000 - 800	800-600	< 600
Mean Temperature	°C	18	18 - 20	20 - 22	> 22
Slope	%	6	6 - 13	13 - 25	> 25

2.2.2 Data collection and preparation

Soil data (soil PH, soil texture, soil depth and soil drainage) was obtained from Kenya Soil Survey (KSS). Climate data (temperature and rainfall) was obtained from Kenya Meteorological Services. There is only one meteorological station in Nyandarua County. The climate data from the station and stations from neighbouring Counties of Nyeri, Kiambu and Nakuru were interpolated to get the climate information of Nyandarua County. Satellite image was from a Kenyan mosaic prepared from Landsat images acquired in 2013. The mosaic had been processed and rectified to WGS84 coordinate system. Slope information was obtained from Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model Version 2 (GDEM V2), (Table 3).

Table 3: List of data used

Type of data	Description of data	Source of data
Soil data	Soil PH, Soil depth, Soil texture and soil drainage	KSS
Climate data	Rainfall and Temperature data of Nyahururu Agromet Station, Nyeri Meteorological Station, Kabete Agromet Station, Naivasha Water Bailiff, National Animal Husbandry Res. Centre – Naivasha and Nakuru Meteorological Station: Duration: 1980-2013	KMS
Digital Elevation Model	ASTER GDEM V2 of 2011 Resolution: 30m	RCMRD
Satellite image	Landsat 8 of 2013: Resolution: 30m	RCMRD
Ground truth data	20 samples collected using Handheld GPS Accuracy: 1-10m	Field survey

Thematic maps for each of the soil parameters and slope were developed using ArcGIS 10.2 software. Annual rainfall and mean annual temperature thematic maps were generated using Inverse Distance Weighted (IDW) interpolation. IDW interpolation determines cell values using a linearly weighted combination of a set of sample points. The weight is a function of inverse distance (Mustafa et al., 2011). All the maps were geo-referenced to WGS84 coordinate system.

Supervised image classification was done using 20 training sites which had been picked using handheld GPS and the knowledge of the researcher on the relative locations of land cover types.

Suitability levels S1, S2, S3 and N were assigned score 9, 7, 5 and 3 respectively after discussion with experts. Classes with higher scores are most suitable for suitability evaluation. Using these scores and the defined suitability levels, all thematic maps were reclassified.

2.2.3 Applying MCE and Assigning weight of factors

To determine relative importance/weight of criteria and sub criteria, AHP method of MCE was used. In order to compute the weights for the criteria and sub-criteria, a pairwise comparison matrix (PWCM) was constructed using information obtained from experts through interviews, each factor was compared with the other factors, relative to its importance, on a scale from 1/9 to 9 introduced by Saaty (2008) (Table 4).

The diagonal elements of PWCM are assigned the value of unity (i.e., when a factor is compared with itself). Since the matrix is symmetrical, only the lower triangular half actually needs to be filled in. The remaining cells are then simply the reciprocals of the lower triangular half (Kihoro et al, 2013).

Table 4: The Saaty Rating Scale

Intensity of importance	Definition	Explanation
1	Equal importance	Two factors contribute equally to the objective.
3	Somewhat more important	Experience and judgement slightly favour one over the other.
5	Much more important	Experience and judgement strongly favour one over the other.
7	Very much more important	Experience and judgement very strongly favour one over the other. Its importance is demonstrated in practice.
9	Absolutely more important	The evidence favouring one over the other is of the highest possible validity.
2,4,6,8	Intermediate values	When compromise is needed

The weight for each criterion/sub-criterion was calculated through PWCM by determining the approximate eigenvector. This was done by multiplying together the elements in each row of the matrix and then taking the nth root of that product (where n is the number of elements in the row). The nth roots are then normalized by dividing them with their sum.

When performing pairwise comparison, some inconsistencies may typically arise. The AHP incorporates an effective technique for checking the consistency of the evaluations made by the decision maker. In the AHP the pairwise comparisons in a judgment matrix are considered to be adequately consistent if the corresponding consistency ratio (CR) is less than 10% (Triantaphyllou & Mann, 1995).

To calculate CR, the consistency index (CI) is estimated by multiplying judgment matrix by the approximated eigenvector. Each component of the resulting matrix is then divided by the corresponding approximated eigenvector. This yields an approximation of the maximum eigenvalue (λ_{max}). Then, the CI value is calculated by using the formula: $CI = (\lambda_{max} - n) / (n - 1)$. Finally, the CR is obtained by dividing the CI value by the Random Consistency index (RCI) generated by Prof. Saaty (Table 5).

Table 5: Random Consistency Index

n	1	2	3	4	5	6	7	8	9	10
RCI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Table 6: Pair wise comparison matrix of criteria

	Soil	Climate	Topography	n th root of product of values	Eigenvector
Soil	1	3	7	2.759	0.649
Climate	1/3	1	5	1.186	0.279
Topography	1/7	1/5	1	0.306	0.072
Sum				4.251	1
$\lambda_{max} = 3.067$	CI = 0.034		CR = 0.06		

Table 7: Pair wise comparison matrix of sub-criteria with respect to soil

	Soil PH	Soil texture	Soil depth	Soil drainage	n th root of product of values	Eigenvector
Soil PH	1	1/3	1/3	1/3	0.439	0.093
Soil texture	3	1	3	3	2.280	0.480
Soil depth	3	1/3	1	1/2	0.841	0.177
Soil drainage	3	1/3	2	1	1.189	0.250
Sum					4.749	1
$\lambda_{max} = 4.214$	CI = 0.071		CR = 0.08			

Table 8: Pair wise comparison matrix of sub-criteria with respect to climate

	Temperature	Rainfall	n th root of product of values	Eigenvector
Temperature	1	1/3	0.577	0.250

Rainfall	3	1	1.732	0.750
Sum			2.309	1
$\lambda_{\max} = 2.00$	CI = 0.00	CR = 0.00		

2.2.4 Overlaying map layers

The reclassified thematic maps/layers of each variable were weighted using the weights derived from the AHP process. The weighted maps/layers were combined by performing the weighted overlay using spatial analyst tools. Finally, the suitability map was prepared.

3.0 RESULTS AND DISCUSSION

3.1 Spatial Variations of sub-criteria

The spatial variation of each of the seven sub-criteria is discussed below.

3.1.1 Spatial variation of soil PH

Soil PH provides the information about the solubility and thus potential availability or phytotoxicity of elements for crops and subsequently specifies the soil suitability for specific crop (Halder, 2013). The soil PH of the study area ranged from 3.9 to 5.9. The reclassified soil PH map shows that only 18.7% of the study area has S1 soil PH (Figure 4 and Table 9).

3.1.2 Spatial variation of soil depth

Soil depth refers to the estimated depth in centimetre to which root growth is unrestricted by any physical or chemical impediment such as impenetrable or toxic layer. There are five soil depth classes in the study area namely; very shallow (<30cm), shallow (30-50cm), moderately deep (50-100cm), deep (100-150cm) and very deep (>150cm). The reclassified soil depth map reveals that, 55.4% of study area has very deep or deep soils (Figure 5 and Table 10).

3.1.3 Spatial variation of soil texture

Most of the physical characteristics of the soil depend upon texture class (Mustafa et al, 2011). There are four textural classes in the study area namely, very clayey (more than 60% clay), clayey (sandy clay, silty clay and clay texture classes), loamy (loam, sandy clay loam, clay loam, silt, silt loam and silty clay loam) and sandy (loamy sand and sandy loam texture classes). The reclassified soil texture map shows that, 32.7% of the study area has loamy soil (Figure 6 and Table 11).

Table 9: Spatial variation of soil PH

Suitability class	Soil PH range	Area (Ha)	Area (%)
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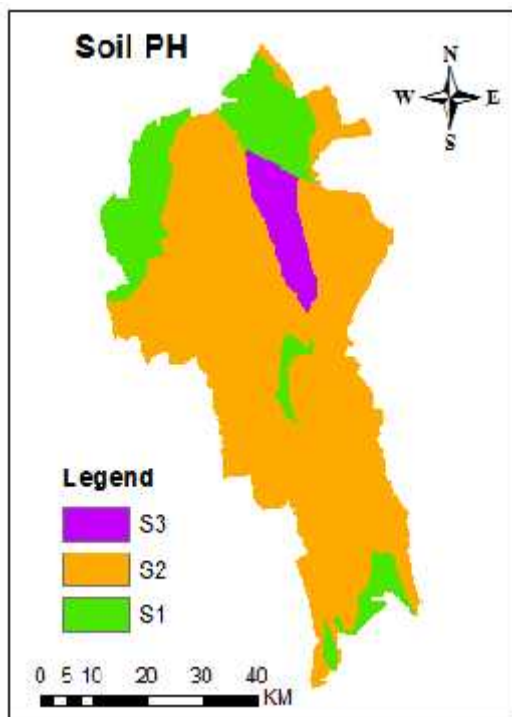


Figure 4: Spatial variation of soil PH

S1	6.0-5.0	61275	18.7
S2	5.0-4.0	248399	76.0
S3	4.0-3.5	17361	5.3

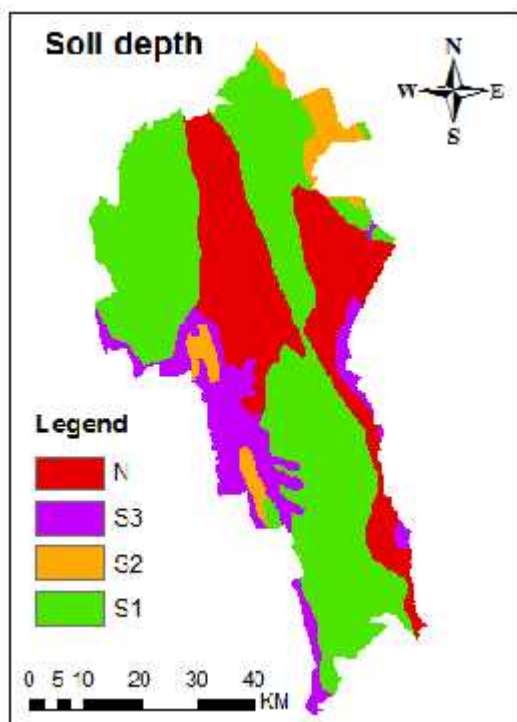
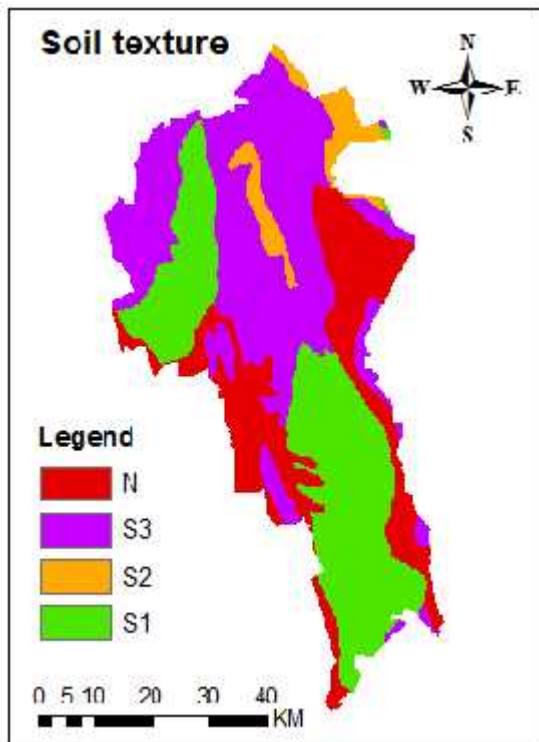


Figure 5: Spatial variation of soil depth

Table 10: Spatial variation of soil depth

Suitability class	Soil depth	Area (Ha)	Area (%)
S1	Very deep/deep	181158	55.4
S2	Moderately deep	15713	4.8
S3	Shallow	40296	12.3
N	Very shallow	89868	27.5

Table 11: Spatial variation of soil texture



Suitability class	Soil texture	Area (Ha)	Area (%)
S1	Loamy	106729	32.7
S2	Sandy	16448	5.0
S3	Clayey	129172	39.5
N	Very clayey	74686	22.8

Figure 6: Spatial variation of soil texture

3.1.4 Spatial variation of soil drainage

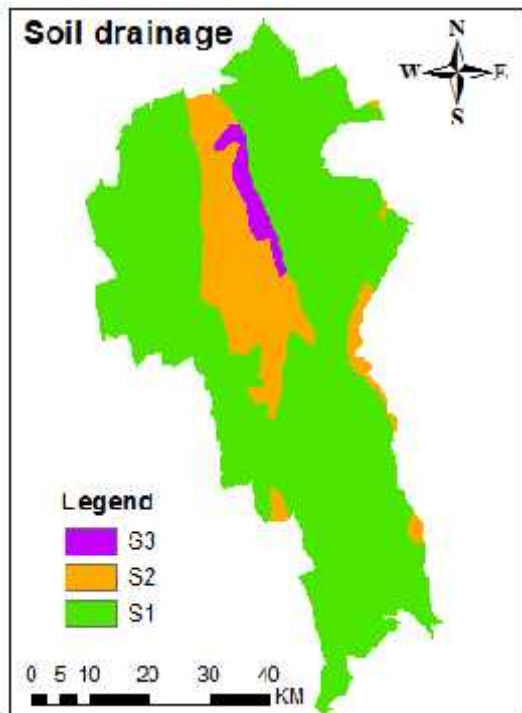
The study area has the following drainage classes;

- Well drained, water is removed from the soil readily but not rapidly.
- Moderately well drained, water is removed from the soil somewhat slowly during some periods of the year.
- Imperfectly drained, water is removed slowly so that the soils are wet at shallow depth for a considerable period.
- Poorly drained, water is removed so slowly that the soils are commonly wet for considerable periods.
- The result from the reclassified map shows that, 82.0% of the study area has well/moderately well drained soil (Figure 7 and Table 12).

3.1.5 Spatial variation of slope

The slope of the study area varied between 0-247percent. The reclassified slope map reveals that, 17.3% of the study area has slope 6%, which is highly suitable for potatoes cultivation (Figure 8 and Table 13).

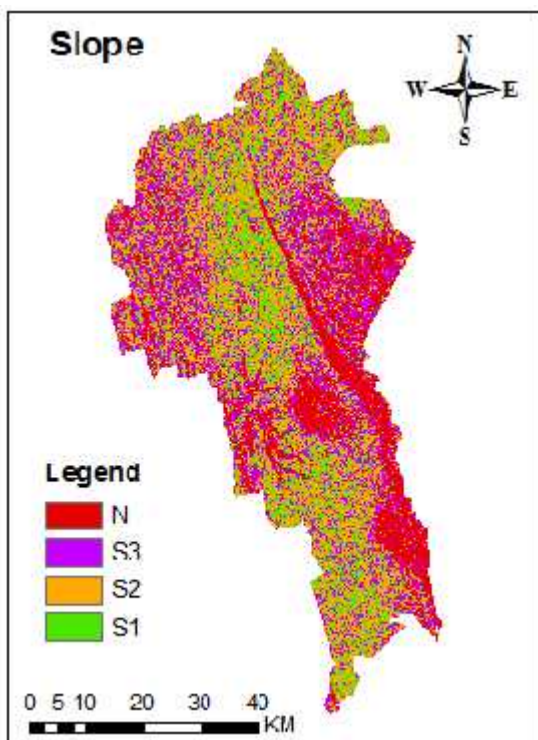
Table 12: Spatial variation of soil drainage



Suitability class	Soil drainage	Area (Ha)	Area (%)
S1	Well/ Moderately well drained	268208	82.0
S2	Imperfectly drained	51801	15.9
S3	Poorly drained	7026	2.1

Figure 7: Spatial variation of soil drainage

Table 13: Spatial variation of slope



Suitability class	Slope (%)	Area (Ha)	Area (%)
S1	6	56458	17.3
S2	6-13	112335	34.4
S3	13-25	85188	26.0
N	>25	73054	22.3

Figure 8: Spatial variation of slope

3.1.6 Spatial variation of rainfall

The annual rainfall varied between 642mm and 1014mm per annum. Rainfall reclassified maps shows that 6.9% of the study area receives rainfall 1000mm, 73.9% receive between 1000mm-800mm and 19.2% receive between 800mm-600mm (Figure 9 and Table 14).

Table 14: Spatial variation of rainfall

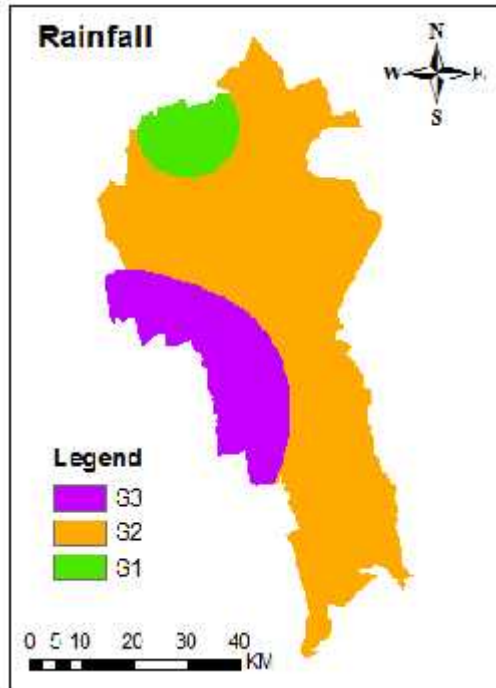


Figure 9: Spatial variation of rainfall

Suitability class	Rainfall (mm)	Area (Ha)	Area (%)
S1	1000	22700	6.9
S2	1000-800	241601	73.9
S3	800-600	62734	19.2

3.1.7 Spatial variation of temperature

The mean annual temperature in the study area varied between 15° C and 19° C. The reclassified maps shows that, 83.8% of the study area has temperatures 18 °C and 16.2% has 18 °C-19 °C (Figure 10 and Table 15).

Table 15: Spatial variation of temperature

Suitability class	Temperature (°C)	Area (Ha)	Area (%)
S1	18	274198	83.8
S2	18-19	52837	16.2

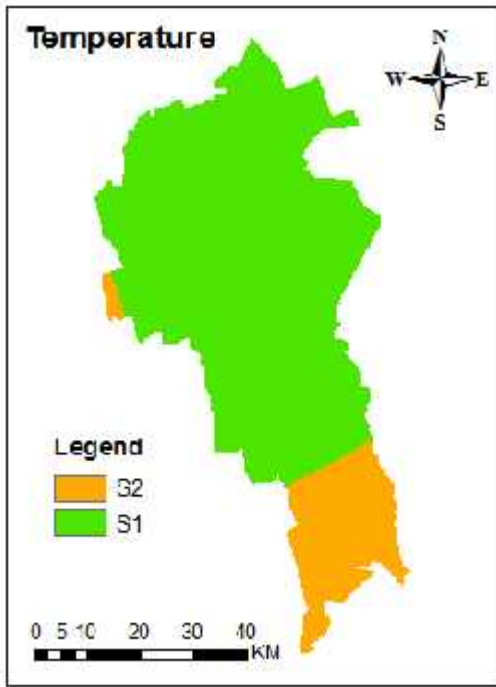


Figure 10: Spatial variation of temperature

3.2 Supervised classification results

Landsat satellite image of the study area was classified into four major land cover classes (agricultural land, water bodies, forest and rocky). The results revealed that, 68.3% of the study area is agricultural land, 25.0% is forest, 1.5% is water bodies and 5.2% is rocky (Figure 11-12 and Table 16).

Table 16: The area of different land use

Land use	Area (Ha)	Area (%)
Forest	81706	25.0
Rocky	17091	5.2
Water bodies	4825	1.5
Agricultural	223413	68.3

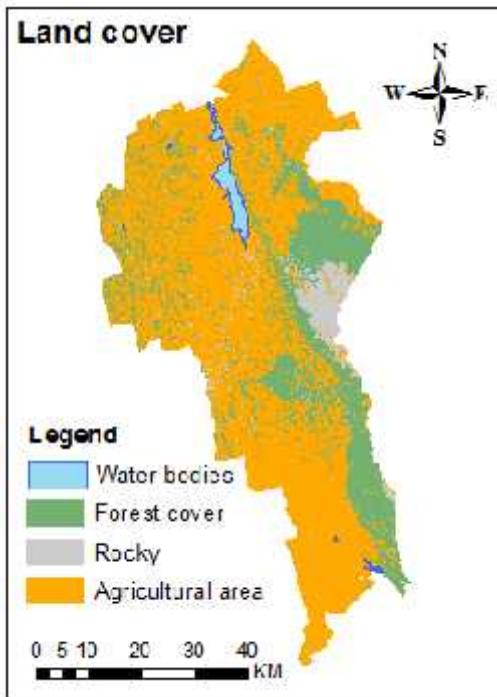


Figure 11: Land cover map

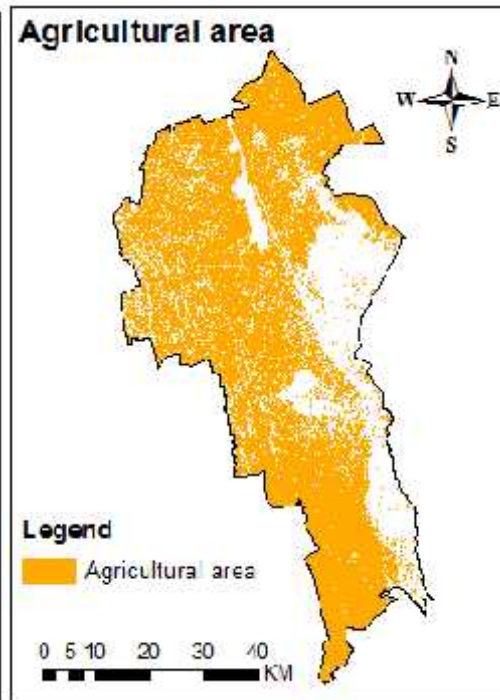


Figure 12: Agricultural area

3.3 Land Suitability for potatoes

The result of land suitability analysis reveals that 37.6% of the agricultural area is highly suitable for potatoes cultivation, 51.5% is moderately suitable and 10.9% is marginally suitable (Figure 13 and Table 17).

Table 17: The area of potatoes suitability classes

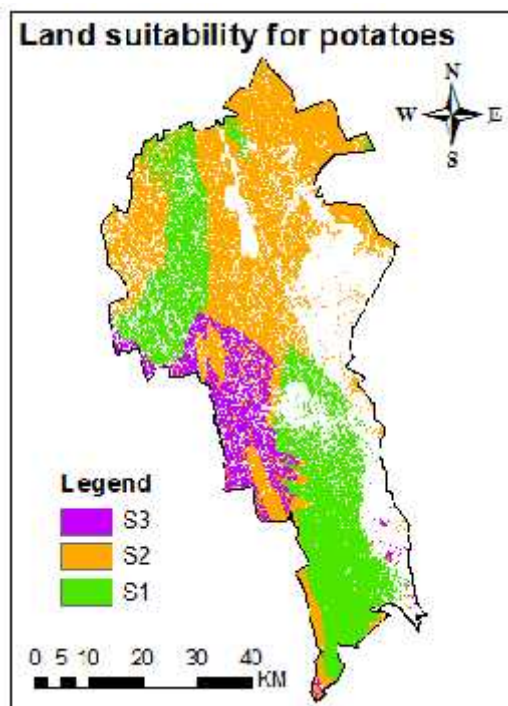


Figure 13: Land suitability map of potatoes

Suitability class	Area (Ha)	Area (%)
S1	84024	37.6
S2	115076	51.5
S3	24313	10.9

According to Nyandarua County integrated development plan 2013-2017 report, 16120 ha is currently under potatoes cultivation, this is only 7.2% of the total agricultural area.

4.0 CONCLUSION AND RECOMMENDATION

All agricultural land in Nyandarua County is suitable for potatoes cultivation in varying degrees of suitability. The agricultural land has been ranked as highly suitable, moderately suitable or marginally suitable, after suitability analysis. Highly suitable area is characterised by well/moderately well drained soil, very deep/deep soil and loamy texture while marginally suitable area is characterised by shallow soil and very clayey texture. Although the county is among the major producer of potatoes in the country, there remain some 206973 hectares that are potentially suitable for potatoes cultivation.

There is no agricultural land having severe limitations that can preclude the cultivation of potatoes, but major limitations for potatoes cultivation in Nyandarua County include very shallow soil (Soil depth less than 30 cm) and very clayey texture (soil with more than 60% clay).

The results of the research are in agreement with the present ground situation based on preliminary evidence of site visits; the two major highly suitable belts constitute the area with the highest potatoes yield.

The county government may use the results of this research to advise the local farmers on the suitable areas for potatoes cultivation. This will ensure food security, increase food production to support the growing population hence alleviating poverty and reducing crime in the county. In the future study this method can be applied for mapping land suitability of other crops in the county and across the country with additional and more refined parameters.

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POTENTIAL OF RAINWATER HARVESTING AS AN ADAPTIVE MECHANISM TO AUGMENT WATER SUPPLY IN KIAMBIU SLUMS, NAIROBI

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Abstract

This study was construed by the erratic rationing of piped water in Nairobi where the daily demand stands at 750,000 cubic meters against the available 525,000 cubic meters. The effect of this deficit is keenly felt in the slums. Lack of water is making the lives of Kiambiu residents even harder due to the risk of water borne diseases. Threat of typhoid and cholera is real. As this happens water vendors make a kill by selling a 20 litre jerrican of water at Kshs. 30.00 against the recommended 40 cents for same quantity. Regrettably, whenever it rains, the water running to waste causes soil erosion and communal infrastructure to collapse. This study therefore sought to make a critical appraisal of the potential of rainwater harvesting (RWH) as an adaptive mechanism to augment water supply in Kiambiu slums, Nairobi. Despite weak policy, high installation cost and simplicity of the technology, the study

concluded that RWH is a potential alternative, capable of supplying more water than what Kiambiu residents currently get from their stand pipes, The study recommends a paradigm shift from theory to the practice of RWH with an aim of transforming the lives of the poor residents of the slums

INTRODUCTION

RWH is amongst the oldest water supply systems. Historical sources mention the use of Rain Water (RW) for domestic supply some 4000 years ago in the Mediterranean region where Roman homes had facilities for RWH (Medina, 2005).

In Sub-Sahara Africa, the growing awareness of the potential for RWH arose following droughts experienced in late 1970s and mid 1980s. This made water to be sourced for everywhere and anywhere.



The search for water

In Kenya, it is estimated that the potential for RWH is equivalent to 5 liters of water per person per day (MOWI, 2008).

Less than 1% of Nairobi households (HHs) utilizes RW yet 60% of its population experience water shortage especially in the slums. It is due to this situation that women and children in Kiambu slums spend time and energy walking to the scattered kiosks in search for water with no guarantee that what they get will be enough to cater for their basic needs. Available data, however, indicate that the average annual rainfall in Kiambu slums is 800mm. This is way above the 200mm threshold suitable for RWH.

This study therefore sought to:-

1. Identify the socio-economic factors related to the practice of RWH in Kiambu Slums.
2. Asses the knowledge for the practice of RWH in Kiambu slums.
3. Examine the technical requirement for the practice of RWH in Kiambu Slums.
4. Establish a model RWH system in Kiambu slums.

METHODOLOGY

A descriptive cross-sectional and analytical survey was carried out. Qualitative data involved focus group discussions (FGD) and key informant interviews (KII). Data on the physical characteristics of the houses were collected through direct observation. Quantitative data was administered through questionnaires using a sample size of 196 derived from the modified Martin (1995) formula.

Kiambu slum was selected purposively based on the fact that it is one of the most recently established slums. Cluster method of sampling was used. A list of all clusters based on the line arrangement of the housing units (HUs) was compiled to form the primary sampling in the area under the stewardship of a village. By summing up the total population for the clusters, the cumulative population for all clusters was determined.

A set of questions targeting respondents' socio-economic status, knowledge of RWH, current state of water supply including the concepts of the practice of RWH were administered. KII and FGD based on the study objectives were considered with an aim of having a paradigm shift from theory to the practice of RWH.

RESULTS AND DISCUSSIONS

Socio Economic Factors

On education, if a baseline is drawn to separate respondents with at most, primary level of education with those having at least secondary level of education, then from the findings it can be alluded that 70.9% of the respondents have at least attained secondary level of education. Education level and water sufficiency were investigated and findings outlines in Table 1.

Table 1: Rainwater harvesting and water sufficiency

Issue	Education level	
	Secondary	Primary

RWH is beneficial	86% agree	61% agree
Water sufficiency	34% agree	44% agree

These findings supports previous studies by Testaya (2009) that adopters of RWH have better education than their counterparts Ifabiyi et al (2009) documents that primary school leavers use less water than secondary school leavers. Turning to this study, with almost three quarters of the respondents having at least attained secondary level of education, a theory can be developed that they would be willing to practice RWH.

On occupation, there is a clear trend, that the economic activity for both the respondents and their partners (where applicable) is business. The findings of a previous study by Amoah (2003) on occupation, documents that those in a form of employment are more likely to express willingness to pay for adopting RWH relative to the unemployed. In a study carried out by Teklehaimanot (2003), it was established that the most constrain for implementing RWH for agricultural use were finances. Granted that the present study is focusing on roof top domestic RWH, first and foremost, what is critical is that in both studies, the concept is the same derived from inadequate water supply.

Lack of water is one of the headline problems in this study area. It therefore follows that the search for solutions will be significant to the community in this slum either through their own initiative and resources or through external participative programs. In a case study in Tamil Nadu state India, the National Water Harvesting Network NWHN (2006) identified and prioritized RWH to reduce problems of lack of water. Initially, the implementing agency was apprehensive whether the slum dwellers would adopt RWH. The practice of RWH not only met their drinking and cooking requirements but also other domestic chores. It can be summarized therefore that in this study, the key challenge is water and the opportunity RWH practice.

Majority of the respondents travel a maximum distance of 50 meters. Women in Punjab travel distances of up to 8km in search of drinking water. Surprisingly in India, the name Punjab stands for abundance of water yet the situation is different as documented by Water Democracy (2013). Granted that distance traveled in this study is not as critical as the case in Punjab, the question that is being asked is; what other tasks might the vulnerables be doing if they did not have to spend time sourcing for water?

In this study, water is mainly transported on foot. The reason for this was investigated. The houses in this study area are constructed with narrow paths between them. Again there is the issue of the un-maintained earth roads which have experienced soil erosion over a period of time mostly from water running to waste. This, makes the use of bicycles and hand carts difficult regardless of how sturdy they are.

An assessment to find out the persons collecting water reveals that in 130 out of 189HHs, women are in charge of this responsibility. It is also interesting to note that the number of HH man and HH child collecting water is each 22. A theory can be developed to support this close relationship; while the man is out of the HH for work during the day, the child is out to

school. Further, in this study, HH woman and HH child make a total of 80.8% of persons collecting water. This study produced results which corroborate the findings of Gulyani *et al* (2000), where they showed that at least 70% of female adults and children spend time and effort to collect water in Nairobi.

Quantities pertaining to daily water consumption are on the basis of liters per HH. From the findings the respondents use an average of 24 liters per HH. Again, if KDHS (2009) statistics of average HH sizes used, then the daily per capita water consumption can be interpreted to be 4.9litres per person. This is rather disappointing because first, it is showing a serious negative trend, where in Nairobi it was estimated at 17.7 liters per person per day in 1998 UN-HABITAT 404 (2007). Second, it is way below the recommended per capita of 20 liters per person per day WHO (2009).

Waiting time in this study is given as short, fair or long. This finding explains little. It does not give a good comparison on how it relates to the recommended maximum time of 5 minutes (WHO, 2009) in order to find out the magnitude of its interplay. Nonetheless, we cannot dismiss this finding since 64% of the respondents queued for long at water points.

If the monthly expense on water is converted to average daily costs, then it translates to 33% for the majority [48%] of the respondents. If this is compared with the daily wage for Kiambiu slums of Kshs. 300 OXFAM (2007), then it can be argued that water expenses for majority of the people is about 10% of the daily wage. This observation supports the UN Human Development Report (2006) which highlights that cost is the biggest factor when it comes to access to usable water. This finding further concurs with the summary of the same report that “in many countries the poor get less, pay more and bear the brunt of human development costs associated with water scarcity.....”

Knowledge and requirements for the Practice of RWH

Only 10% of the respondents have heard of the practice of RWH on their own initiative. Literature by Caribbean Environment Institute (CEHI indicate that 60% of Grenada HHs heard and practiced RWH after experiencing natural disaster including hardships from water supply following hurricanes (CEHI, 2006). Nearer home Tanzania government runs newspaper supplements with information on RWH Gould (2003). It can be concluded that in this study, there is an information gap on the practice of RWH.

On water laws, almost three quarters of the respondents are un- aware of their existence. This finding is also echoed in FGD. Again the findings on who formulates laws and on level of satisfaction of laws are also consistent with the first one. An implication of this finding is that there is lack of information on water laws in general. According to Human Development Report HDR (2006), access to water is compromised by sub-optimal governance system. For example, compared to Ethiopia, Kenya has not yet operationalized policy on RWH Bossio and Gehab (2008). This is despite the fact that the Government of Kenya has enacted laws setting up about 15 semi autonomous agencies to implement the laws. Another important practical implication can be attributed to the many line GoK ministries that constitute the infrastructure sector with overlapping mandates. Funding for different departments in the

sector is allocated mainly to capital projects at the expense of focusing on simple sustainable technology in RWH.

Turning to materials for RWH, it can be demonstrated that cost of installation for RWH is Kshs. 3,000 excluding the tank. This makes the residents perceive the cost as expensive. In a study carried out by sustainable systems (2010), it was established that the cost of RWH would be comparatively less if the system were incorporated during construction of the building itself.

On house ownership, 75% of the respondents are tenants. This is an imperative but tricky finding. The question to ask is this; will the tenants be able to invest in RWH yet they do not own the houses? These are people who only rent the house and see it as a one stop residence on way to either another house within the area or to different slum altogether. We cannot however wish away this finding because of failed ownership yet they are the people who are experiencing the water scarcity. This leaves the remaining 25% who are landlords with the critical issue of space for water storage. Where 72% of the houses lack sufficient space for water storage. During KII, the interviewee had this to say “.....**space is key consideration on establishment of RWH system. Besides the tank, space is also required for circulation and general maneuvering of HH members.....**” As documented by Bhagat (2009), most slums in Bombay are not yet regularized in terms of settlement. No one therefore takes responsibility to ensure that space is left between HUs to accommodate water tanks placed above or below ground.

Technical requirements for RWH

Catchment Unit

In this study no catchment unit is constructed out of reinforced concrete and the roofs are all made out of iron sheets. Further observation reveals that these are pitched roofs ideal for RWH. In a similar study, Barenhoff (2011) found that in slum areas of Hyderabad India the most (66%) used iron sheets as roofing material while the middle class areas it is reinforced concrete (82%) . Barenhoff gives the reason for use of iron sheets due to low construction costs. In this study it can be demonstrated that the estimated cost per square meter of gauge -30 roofing sheets and the cost per square meter of reinforced concrete roofs is in the ratio of 1:2. This confirms Barenhoff assertion on the interplay on cost.

Conveyance Unit

One distressing finding in this study is the number of HHs without gutter .This plays out to 95%. As documented by Baker *et al* (2007), many available materials for gutter construction are dismissed because of cost, efficiency, or difficulty in construction. However, from this study, the more reason for the absence of gutters is the non provision of facility for their maintenance. Observations on gutters installed on buildings reveal that leaves and soil are trapped on them. It is not unusual to see vegetation growing up on them eventually making them fall due to weight as seen in the picture below. This theoretical information can be used to develop and install gutters with interventions for proper maintenance of RWH.



Gutters without provision for maintenance

The absence of down pipes on the few HUs with gutters raises another concern; that of directing harvested water to the narrow openings of containers which are used as storage units. According to Barenhoff (2011) 7% of harvested water is lost on poor alignment of downpipes into storage tanks, 5 % lost as a consequence of rain water overshooting the gutter and another 5 % on gutters without adequate slope of 1:100.

Establishment of a model RWH system

In this study cost of installation of a 10,000- liter capacity water tank can be demonstrated to be approximately Kshs. 125, 000. Granted that very few houses have adequate space for the tank, in K11 the informant voiced cost of the tank as major deciding factor in the desire to install RWH system. According to Thomas (1998) the cost associated with storage is the main disadvantage of RWH practice. In a somewhat related argument, splitting storage between several small tanks (rather than one large communal tank) offers greater security against tank failure.

Storage requirement

- Daily per capita water consumption in Nairobi 17.7 liters WHO (2009)
- Average HHs, Nairobi 4.9 KDHS(2009)

- Per capita water consumption in Nairobi per HH $17.7 \times 4.9 = 86.73$ liters
- Longest Dry period in Nairobi, August to September 90 days
- Storage requirement per HH $= 86.73 \times 90 = 7805$ liters.
- Allow safety factor for contingencies at 20% $= 9,366$ say 10,000 litres.

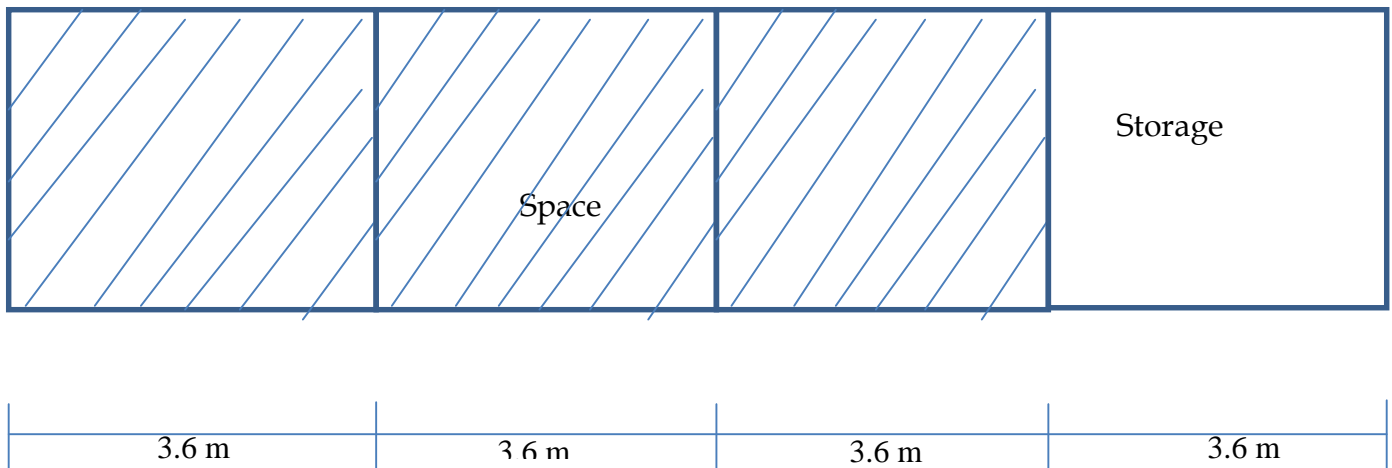
Average Annual Rainfall

The average annual rainfall data were taken from the records adjacent weather station within the neighbourhood. This was established as 867 mm.

Catchment Unit

From the site observations the HUs are in lines and consist of four (4) rooms averagely 3.6 m wide x 3.6 m long as shown below.

Layout of Catchment Unit



Assuming one unit is removed to create space

- Total length of roof $= 3.6 \times 3 = 10.8\text{m}$
- Width of roof $= 3.6\text{ m}$
- Area of roof $= 10.8 \times 3.6 = 38.88$ square meters

Quantity Harvested

- Roof area $= 38.88$ square meters
- Run of coefficient assume 5 % leakage 2.5 % evaporation 2.5 % loss
Due to first flash Total 10% = 90 % efficiency
- Water harvested annually area of roof x efficiency x annual rainfall $= 38.88 \times 0.9 \times 867 = 30,338$ liters
- Daily available water for 3HHs; $30,338 / 365 = 83$ liters
- Potential of RWH per HH; $83 / 3 = 28$ liters

- The present average daily water consumption per HH = 24 liters.
It can be concluded that the potential of RWH per HH is more than the daily available water consumption per HH.

Based on the Kiambu Map and considering the number of HHs is projected to be 10,203 by 2014 KDHS (2009). The potential daily RW harvested can be estimated as follows;

10,203 × 28 = 285 cubic meters:



- i) Restore socio-economic settings that are responsive to slum-based entrepreneurs in the uptake of RWH.
- ii) Incentivize the community in RWH.

- iii) Incorporate micro finance organizations to team up with locals community in RWH practice.

Knowledge and the Practice of RWH.

- i) Carry out advocacy, adopt and scale up knowledge competency and skills on RWH.
- ii) Undertake public education in the local FM radio stations particularly during the period of drought to highlight the benefits of RWH.
- iii) Establish programs that encourage community members to work together and initiate initiatives that focus on the practice of RWH.

Technology of RWH.

- i) Demystify and encourage active pursuit of the appropriate technology of RWH.
- ii) Align the technology to the physical conditions of the site where RWH is being promoted.

Model RWH System

- (i) Set up a pilot project with the slum community in the driver's seat.

Future Research

Two areas of research are hereby recommended. First, research on building maintenance focusing on design to facilitate accessibility of RWH components by the occupants. Secondly, research on opportunity cost to determine the benefits of converting one housing unit into a water storage space.

The potential of RWH as an adaptive mechanism to augment water supply in Kiambiu slum cannot be over emphasized. However by implementing these recommendations it is hoped that RWH will increasingly play an important role in enhancing accessibility of this unique resource, water. It is unique, because it has no close substitute.

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TRACK 3: CHEMICAL SCIENCES

CONCENTRATION OF TITANIUM IN IRON-RICH LATERITES USING IN-SITU CARBONIZED BIOMASS

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Abstract

Increasing demands for the use of titanium and decrease in ore deposit as a source of titanium has resulted into other low grade iron-rich titanium ores to be used. This paper reports on study that was done to concentrate low-grade titanium ores using magnetic separation. Biomass-ore mix in the ratio of 1:10 was heated in a reducing environment. This increased magnetic susceptibility of titanium iron-containing compound in the ore. The magnetic portion of the resulting ore was separated using a strong lab-magnet. This resulted into concentrating the low grade Ti ore from 1.6 – 4.2 % to 4.43 – 8.5 %. The chemical and mineralogical analyses were done using atomic absorption spectrometer and X-ray diffraction techniques respectively.

1.0 INTRODUCTION

Kenya has several geological documented iron-rich minerals that contain titanium [1]. The geological areas include for example, Malindi, Machakos, Mtito Andei, Kitui, Kauro-Merille. Titanium in iron-rich ores has been known in Marimante area that covers an area of 25 miles south of Meru township [1]. In previous study, it has been shown that laterites are fairly distributed all over the country [2].

Titanium is mainly used as Titanium dioxide, a white pigment in paints [3], plastics and paper [4]. It has a wide metallurgical and electronic applications as well as a surface coating material [5]. It also finds use in aerospace industries due to its lightness, strength, corrosion and heat resistance. The main source of titanium is rutile. Due to depletion of this ores, other low grade titanium sources are in demand. Pre-concentration of most mineral ore is inevitable to increase levels of the element/compound of interest to economically viable levels of extraction. Various methods have been used to concentrate ores. The methods have included froth floatation, magnetic separation and density concentration.

The main titanium minerals are the oxide types, such as rutile, ilmenite and leucosene, as well as from titanium slag and synthetic rutile. Rutile is an impure form of titanium dioxide; ilmenite contains titanium combined with iron as oxides. Leucosene is an altered form of ilmenite. Iron-rich minerals are most readily exploited in Australia, the US, India, Mozambique and South Africa. Other titanium minerals with no commercial importance at present are perovskite(CaTiO_3), sphene($\text{CaTi}(\text{SiO}_4)\text{O}$) and anatase(TiO_2)[6, 7]. The main exporters of titanium include China, Australia, India and South Africa.

Magnetic separation is mainly used for concentrating iron ores to be used in a blast furnace. Laterite, commonly called murrum in Kenya contains iron-rich minerals such as goethite ($\text{FeO}\cdot\text{OH}$), haematite (Fe_2O_3) and ilmenite($\text{FeO}\cdot\text{TiO}_2$). The iron in oxidation +2 has a low magnetic susceptibility, but at +3, has a high magnetic susceptibility. Magnetic nature of iron in combined state is increased by heating the sample in a reducing environment in the temperature range of 500 – 700 °C in controlled air flow[8]. The product that is formed can be separated by use of a magnet, thus separating iron-rich component of the ore from the gangue. Currently laterites are used mainly for surfacing the roads. In this study, Iron-rich Ti ores have been treated in a similar manner but in-situ carbonized biomass both as a source or reducing agents (CO , CH_4 , H_2)[9, 10] and heat to increase magnetic susceptibility of Fe-bearing Ti ores.

2.0 METHODOLOGY

Laterites samples were collected randomly from selected localities within Kaharate in Murang'a County and Tharaka Nithi County that include Gitongo and Gitara Kianderi. Sampling was done on already drilled borehole, quarries and river beds. Within sampling site, three samples were collected at different depth. These were done at 30 cm, 50 cm and 100 cm below the ground. About one kilogram of the samples was packed in a plastic bag labeled A to denote 30 cm, B for 50 cm and C for 100 cm. The materials were dried in an oven at 105 °C for two hours then ground to 300 microns using a Pulverizer, Lab Disc Mill Machine. Rock Standards, Syenite(SY-3) and Mount Royal Gabbro (MRG) were used to make standard solutions for Fe and Ti respectively. Atomic absorption spectrometry was used for chemical analysis while X-Ray Diffractometer model Bruker D2 phaser diffractometer was used for mineralogical analysis in the usual manner. Raw and heat treated samples or the ores were subjected to chemical and mineralogical analysis.

Treatment of the sample

Raw ground samples were separately mixed with ground charcoal and biomass in a ratio of 1:10 in clay crucibles. The mixture was then heated in controlled current of air using a charcoal burner at 500 – 800°C for 2.5 – 3 hours. The crucibles were removed and allowed to cool in a desiccator using silica as a desiccator. The cooled sample was then placed in a magnetic separator. The raw and magnet-separated heat treated samples were subjected to chemical and mineralogical analysis as stated above.

3.0 RESULTS AND DISCUSSION

XRD analysis, as shown in figures 1 and table 1. Showed that the sample lateritic ores contain the minerals of ilmenite for Ti/Fe and goethite and haematite for iron

Table 1: Mineralogical composition of raw and heat-treated

Area of the Sample	Mineralogical content in raw sample (%)	Mineralogical content in Heat-treated sample
Kaharata	Goethite (FeO) (34.51%), Ilmenite, FeO TiO ₂ (33.12%), Magnetite (36%), Haematite Fe ₂ O ₃ (51.11%)	Maghemite (33.6%)
Gitong'o	Goethite (21.51%), Ilmenite, FeO TiO ₂ (33.12%), Haematite, Fe ₂ O ₃ (33.51%), 54.11%), Bramantite (Na, H ₂ O) Al ₂ Si ₂ Fe ₂ (Si, Al) ₂ O ₁₀ (OH) ₂ (H ₂ O) (21.51%)	Manganonphreite, K ₂ N ₂ L ₂ Mn ₂ Fe ²⁺ Ti ₂ Si ₂ O ₄ (63.5%), Lindqvistite (Ba, Sr) (Ti, Cr, Fe, Mn) ₂ O ₁₀ (33%), Maghemite (33.6%)

Similar results were found by Mutembei *et.al* (2014) although the researcher's interest was iron. Chemical analysis for raw and heat-treated samples using AAS are summarized in table 2 and 3

Table 2: Chemical composition of raw sample of the same sample

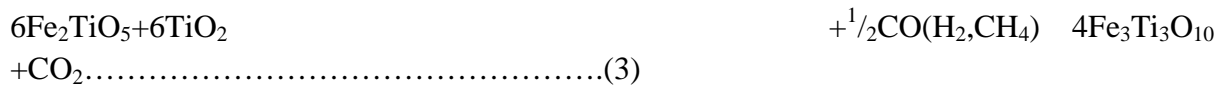
Level A	SiO ₂	Al ₂ O ₃	CaO	MgO	Na ₂ O	K ₂ O	TiO ₂	MnO	Fe ₂ O ₃	LOI
	Mean n=9 ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE
KAHARAT E 1	8.96±0.05	9.41±0.03	0.08±0.00	0.38±0.00	0.10±0.03	0.0±0.01	3.66±0.02	0.41±0.01	50.40±0.10	14.72±0.40
KAHARAT E 2	16.13±0.07	3.24±0.02	0.08±0.00	0.22±0.00	0.34±0.01	0.1±0.00	4.17±0.02	1.01±0.01	52.87±0.25	14.38±0.18
KAHARAT E 3	16.7±0.04	9.8±0.03	0.1±0.01	0.2±0.00	0.1±0.01	0.1±0.00	3.51±0.01	1.86±0.01	53.01±0.26	15.19±0.29
KAHARAT E 4	19.21±0.03	6.87±0.03	0.06±0.01	0.30±0.01	0.24±0.01	0.1±0.00	4.15±0.01	2.01±0.02	50.92±0.14	15.07±0.14
GITONG'O A	19.43±0.06	19.02±0.03	0.07±0.00	0.08±0.00	0.28±0.01	0.0±0.01	1.77±0.01	0.39±0.01	45.61±0.06	13.95±0.04
GITONG'O B	16.24±0.06	13.64±0.03	0.08±0.01	0.27±0.01	0.17±0.01	0.0±0.01	1.63±0.01	0.43±0.01	47.70±0.14	14.31±0.19
GIYARA KIANDEHU	17.53±0.06	15.95±0.03	0.13±0.01	0.36±0.01	0.14±0.01	0.0±0.01	1.60±0.01	1.02±0.01	46.87±0.01	15.52±0.43

Table 3: Chemical composition of heat-treated sample of the same sample

LEVEL A	SiO ₂	Al ₂ O ₃	CrO	MnO	Na ₂ O	K ₂ O	TiO ₂	MnO	Fe ₂ O ₃	LOI
KAHARAT E 1	Mean ±SE	7.36±0.06	3.39±0.06	0.06±0.00	0.31±0.01	0.06±0.01	0.05±0.02	1.74±0.18	0.37±0.01	79.51±0.40
KAHARAT E 2	Mean ±SE	0.52±0.03	2.22±0.01	0.06±0.01	0.33±0.01	0.27±0.01	0.05±0.01	3.83±0.06	0.06±0.01	82.25±0.03
KAHARAT E 3	Mean ±SE	6.17±0.03	7.63±0.06	0.06±0.00	0.16±0.01	0.19±0.01	0.05±0.01	5.93±0.18	0.12±0.01	71.43±0.03
KAHARAT E 4	Mean ±SE	7.71±0.04	3.24±0.07	0.11±0.01	0.23±0.01	0.24±0.01	0.05±0.01	3.48±0.18	0.11±0.01	78.65±0.04
GITONG'O A	Mean ±SE	0.86±0.01	2.77±0.01	0.24±0.01	0.06±0.01	0.16±0.01	0.05±0.01	1.43±0.09	0.17±0.01	76.23±0.12
GITONG'O B	Mean ±SE	3.22±0.01	7.64±0.01	0.24±0.01	0.31±0.01	0.09±0.01	0.06±0.01	3.46±0.11	0.72±0.01	77.91±0.14
GIYARA KIANDEHU	Mean ±SE	4.17±0.06	6.71±0.06	0.11±0.01	0.17±0.01	0.27±0.01	0.17±0.01	4.43±0.10	0.10±0.01	82.91±0.11

Raw sample contained between 1.6 and 4.2 TiO₂ and 45.6 to 62.8 % as oxide of Fe. The results clearly show that the ores are Fe-rich Ti ores. Similar results were observed [8, 11] with laterites from Tunyai Division, Tharaka Nithi County and Kamahuha, Murang'a County.

XRD analysis results of magnet-separated heat treated samples are shown in figure 2 and table 1. The results show that the original goethite, haematite and ilmenite minerals were converted to maghemite. This increased the magnetic susceptibility of Fe-bearing Ti which was separated using the lab-magnet. The separate had higher TiO₂ compared to the raw laterite sample as clearly seen from table 3. [8] though working with Fe in laterite observed that magnetic susceptibility increases when laterites are heated in a reducing environment of Carbon/CO. Similar results were observed [8]. Increase in magnetic susceptibility of iron-Ti containing compound is due to reactions given in equation 1, 2 and 3 [12]



From the equation, presence of Fe^{2+} exhibit antiferromagnetic properties while the pre-oxidation, then reduction using syn-gas lead to formation of Fe^{3+} and Fe^{2+} . The mixture of these ions is highly magnetic.

The chemical analysis of the magnet-separated product showed that it contained Ti in the range 4.43 – 8.5 % as shown in table 3.

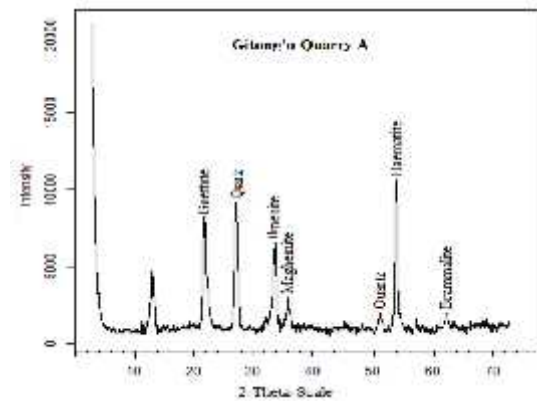


Figure 8: Spectrum of raw samples

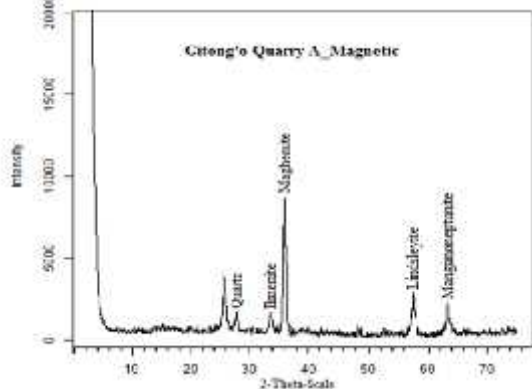


Figure 9: Spectra of heat-treated sample

Biomass was used in this research both as a source of reducing agent and heat. When biomass is heated in an oxygen controlled environment, the gases CH_4 , H_2 and CO are produced [9, 10, 13]. These gases are called syn-gas. The gases are reducing in nature. They were therefore carefully utilized to heat the ore as well as reducing agent to increase the magnetic susceptibility of Fe containing Ti. The resultant product, rich in Fe and Ti was separated using a magnet. This resulted in to a Ti-rich ore that can be commercially exploited for commercial purposes. Elsewhere, ore have been commercially exploited if Ti is above 5 percent [14, 15] In Kwale, Kenya, pre-concentration of the ore is done to achieve a Ti level of above 5 percent, plus Zr which is exported for further extraction [16].

4.0 CONCLUSION

The results show that biomass waste can be used to concentrate the iron-rich titanium bearing ores. This would rid the environment of biomass waste, for example the municipal waste. Further, an upscale of such local technology can help boost the economy of the country.

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CHEMICAL RECYCLING OF VARIOUS TYPES OF POLYURETHANES AND USE OF THE RECYCLING PRODUCTS

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Introduction

Increasing raw material costs and more stringent regulations have led to more pressure on customer oriented recycling processes for polyurethanes. Furthermore, waste disposal runs into more and more costs for the producers while old disposal ways are blocked by new acts both in the US and Europe. One way to solve this problem is to develop for each type of polyurethane product a well-suited process and plant for a customer specialized procedure to re-use the waste material obtained. Based on the previously described simultaneous glycolysis and aminolysis of polyurethanes (1) in this paper we will report on first results on larger scale recycling of some polyurethane products. While first we oriented on the use of the recycling products (recycling polyols) to produce new types of polyurethanes, e. g. from cold moulded foams sealants or coatings (2), the philosophy had to be changed to use the recycling polyols as much as possible to produce the same materials as originally. This route

was consequently developed further to other polyurethane products and the incorporation of the recycling polyols into original premixes to be reacted with isocyanates.

Key words: solvolysis, polyurethanes, recycling polyol, original premixes

1. SHORT REVIEW OF THE PROCESS

The combined glycolysis and aminolysis reaction make use of the re-esterification at the urethane group by the glycols present to liberate the polyetheralcohol originally employed and an amidation reaction with cleavage of the urethane group to produce a trisubstituted urea and the originally present alcohol (1). The polyureas present remain mainly unchanged, only on extended addition or reaction times the cleavage by the glycolic hydroxyl groups to form primary aromatic amines occurs as an undesirable side reaction.

Depending on the type of polyurethane to be treated the glycol is either only a monomer or an oligomer or, as in most cases, is a mixture of several glycols so as to produce optimum product quality and ease the dissolution of the solid particles. As has been shown previously (3) the type of glycol determines the rate of reaction to some extent but more the viscosity of the recycling polyol and the final properties of the new polyurethane produced from it. An additional feature is the particle size of the grafted polymers from grafted polyols used maybe established by proper choice of the glycol mixture (see further chapters).

The recycling polyols maybe produced batch wise or continuously (4). The batch process makes use of jacketed stainless steel reactors with a volume up to 6 metric tons with specially designed periphery equipment and a specially designed dosage unit so as to receive a continuous flow of solid particles with optimum rate into the reactor. The reactor outlet is connected to a filtering unit to filter off any insoluble material and additionally to be able to apply a certain reduced pressure to degas the recycling polyol if necessary. There is no need of further treatment of the recycling polyol, moreover, it is used as produced. In the continuous process typically a twin screw reactor is used where the shafts of the screws and the mantle are both heated to the reaction temperature by a heat transfer medium, typically thermal oil. The feed is made by a screw to densify the material and by dosage pumps and the outlet is again connected to a filtering unit and a suction pump.

2. MATERIALS AND METHODS

2.1 Materials

Diethylene glycol (DEG), dipropylene glycol (DPG), polyethylene glycols (PEG) of molecular weight 200 and 400, and polypropylene glycol (PPG) of molecular weight 400 were obtained by Fluka AG and used without further purification, polypropylene glycol 2000 was a gift of Elastogran AG, Germany, di-n-butyl amine (DBA) was purchased from Merck KGaA, Darmstadt, Germany, and used without further treatment. Catalysts used were Dabco 33 LV as a gift from Air Products and Polycat NP 40 from Performance chemicals GmbH. Stabilizers of various types were generously given by Th. Goldschmidt AG.

The various types of polyurethanes were samples from producers of Germany, Japan, Mexico, Poland, the USA, Bulgaria, or Portugal.

2.2 Methods

First experiments were generally performed in small-scale lab glass ware: a 750 ml four necked glass flask with stirrer, thermometer, reflux and solids inlet. The liquids were placed into the reactor, heated to 180°C, and the solids introduced with stirring as fast as possible while the temperature was slowly increased to the final reaction temperature. At this, the mixture was kept after completion of the addition another 30 to 60 minutes. The reaction mixture was allowed to cool down, filtered, and subjected to analysis.

The next step was the first scale up to a 1.75 kg batch in a 2.5 l glass reactor. The apparatus was as before and so is the process. For filtering, in this case was used a pressurized filter with a 120 mesh screen where the pressure was obtained from compressed nitrogen and applied with up to 25 kp/cm².

The third step in up-scaling was the use of a 100 l stainless steel reactor heated by thermal oil and stirred by a blade stirrer at 60 rpm. The process was the same as before, for filtering a suction filter was directly connected to the bottom outlet and used together with a membrane vacuum pump. The reactor was equipped with a three stage heat exchanger consisting of demister, first heat exchanger adjusted to a predetermined temperature and a second heat exchanger to collect any low boiling liquids.

3. RESULTS

3.1 Recycling polyols from automotive products

From automotive wastes mainly seat cushions, i. e. cold moulded foams, ceiling elements, i. e. rigid reinforced foams, and wheel mould flashes, i. e. microcellular elastomers or flexible integral foams, were reacted to form recycling polyols.

3.1.1 Cold moulded foams

Cold moulded foams were delivered by two main producers of Germany as complete cushions not meeting standards. These were cut to flakes of about 8 cm size by a shredder. The flakes were introduced into the respective reactor without further treatment or separation.

The seats were used in an amount between 50 and 75 % by weight to produce recycling polyols with viscosities ranging from 2,000 to 30,000 mPas (25°C) and hydroxyl numbers of 350 to about 270 mg KOH/g. The aim was to add the recycling polyols to premixes to result in elastic products again. Mainly, the recycling polyols were used as additives with 15 to 25 % by weight in premixes to produce flexible cold moulded foams. Additionally, they were used to produce new types of material, e. g. sealants or steel tank coatings (5) or composites with wood fibers (6). Table 1 depicts some examples of recycling polyols as derived from cold molded foams.

Table 1: Recycling polyols from flexible cold molded foams

Item/No.	191	192	194	198	130
PUR (% by weight)	65,0	70,0	63,0	62,5	75,0
DPG (% by weight)	30,0	25,0	32,0	32,5	23,3
DBA (% by weight)	5,0	5,0	5,0	5,0	1,7
Reaction temperature (°C)	210	210	210	210	200
Reaction time (min)	55	60	55	45	115
Appearance	turbid	viscous	clear	clear	inhomogeneous
OH-No. (mg KOH/g)	299	251	310	303	213
Amine No. (mg KOH/g)	48	15	17	18	21
Viscosity (25°C) (mPas)	11,500	17,800	4,100	3,680	27,000

By the process described from cold moulded flexible foams recycling polyols can be prepared with a viscosity in the range between 3,500 and 27,000 mPas (25°C) with waste loads of the mixture between 60 and 75 % by weight. In the range of about 65 % by weight of solids the viscosity is established in the range between 4,000 and 11,000 mPas with hydroxyl numbers of about 300 mg KOH/g. These recycling polyols maybe used as an additive to commercial premixes or added as an additional feed to the foaming mixture up to 30 % by weight. The resultant foams increase somewhat in hardness but do not suffer a loss in low temperature performance or comfort.

3.1.2 Integral foams

Integral foams processed were polyether based systems used to produce steering wheel shells of which the mould flashes were shredded to pieces of about 5 cm thickness. The flakes were subjected to several investigation of the system in which the amount of solids, the amine content, and the reaction time were systematically investigated.

Table 2: Recycling polyols made with varying the amount of polyurethanes

No.	PUR (% by weight)	Reaction time (min)	OH No. mg KOH/g	Amine No. mg KOH/g	Viscosity (25°C) (mPas)
149	70,0	190	225	29	15,030
158	65,0	110	266	27	6,600

146	63,0	90	310	28	10,800
150	60,0	100	269	22	5,130
143	55,0	105	351	23	4,850
151	50,0	80	336	20	2,020
152	40,0	65	413	16	1,230

As in the case of the cold moulded foams the optimum amount of polyurethane solids is again in the range of 60 to 65 % by weight where the viscosity is of a magnitude allowing the recycling polyol to be added to a premix or processed as one of the components of the foaming mixture. The addition of the secondary amine leads in the lab scale experiments to a rather high amine number. This does not significantly affect the processing times but may in some cases lead to a decrease in the amount of catalyst. The investigation of several amine concentrations is presented in table 3.

Table 3: Systematic variation of the amount of di-n-butyl amine in batches with 60 % by weight polyurethane solids load

No.	DBA (% by weight)	Reaction time (min)	Hydroxyl No. (mg KOH/g)	Amine No. (mg KOH/g)	Viscosity (25°C)(mPas)
153	1,0	95	336	24	6880
154	2,0	95	335	25	7700
155	3,0	95	336	28	5640
156	4,0	95	338	31	5280
157	5,0	95	335	36	5340

As shown in table 3 the amine concentration does not significantly affect the amine number. Only at concentrations beyond 4 % by weight it results in a further increase. This limit is different for any type of polyurethane and depends on the concentration of urethane groups present in the polymer. Most effect is contributed by the reaction time as shown in table 4.

Table 4: Systematic variation of the reaction time in batches with constant polyurethane solids load at 200°C

No.	PUR (% by weight)	Reaction time (min)	Hydroxyl No. (mg KOH/g)	Amine No. (mg KOH/g)	Viscosity (25°C) (mPas)
159	63,2	50	246	17	9650
160	63,2	65	241	20	8360
161	63,2	80	243	25	5900
162	63,2	95	244	26	6600
163	63,2	110	254	24	5500
164	63,2	125	230	20	9610

The reaction time of the mixture after completing the addition of the polyurethane foam flakes increases with increasing the reaction time to reach a limit after about 90 minutes. Shorter reaction times (addition and post reaction) as 50 minutes could not be established under lab conditions with suitable amounts of reactands (i. e. a batch size of 500 g). In continuous production this number maybe decreased further by establishing reaction times of 20 minutes. Shorter reaction times will not be suitable even at temperatures exceeding 250°C as proofed by experiments with a continuous and a semi-continuous reactor as the reaction is not complete.

The experiments performed up to now up to a batch size of 90 kg show the integral foams to be processable to recycling polyols with suitable properties. The somewhat higher viscosity as compared with the polyols received from the cold moulded foams maybe attributed to the different formulation and the load of solids (pigments and fillers).

3.1.3 Rigid glass fibre reinforced foams

The wastes employed were glass fibre reinforced high density foams as used in car ceilings having an estimated density of 65 g/dm³. The glass fibres were of 20 to 48 mm length before the experiment and decreased to 12 to 27 mm length after. The fibres were separated by simple filtration via a Buchner funnel. The unknown formulation of the rigid foam led to lower degrees of solids content in the experiments as shown in table 5.

Table 5: Recycling polyols from reformed rigid foams

Item/No.	166	168	169
Foam (% by weight)	40,1	40,1	40,1

DPG (% by weight)	29,2	29,2	29,2
DEG (% by weight)	35,2	29,2	29,2
DBA (% by weight)	1,5	1,5	1,5
Temperature (°C)	200	220	230
Time (min)	40	45	40
OH-No. (mg KOH/g)	381	387	473
Amine No. (mg KOH/g)	36	32	38
Viscosity (25°C) (mPas)	7,750	28,500	>50,000

The rigid foams were transformed with 40 % by weight into polyols of hydroxyl numbers of about 400 mg KOH/g and viscosities in the range of 8,000 mPas (25°C) when any solids were filtered off. The solids were glass long fibres or solids consisting of other polymers (mainly polyolefins) which had to be separated before they could further processed to give rigid foams without reinforcements under lab scale conditions. The increase of the reaction temperature lead in this case to a tremendous increase in viscosity. The origin of this increase is not yet clear but maybe attributed to finely dispersed solids and fillers of the original foam to produce structural viscous liquids.

3.2 Flexible slabstock foams

Flexible slabstock foams are produced from polyether systems, polyester systems, and mainly based on grafted polyether systems. Each of these types needs a detailed investigation and a specially developed solvolysis mixture and processing technology. Furthermore, the final product properties need to be carefully determined by the customer according to his technology before process development to adjust both viscosity and hydroxyl content.

3.2.1 Polyester based flexible slabstock foams

Flexible slabstock based on polyester systems were solvolysed using a typical mixture to give viscous recycling polyols of light amber colour. They were produced by batch technology in small and 6 kg batches. The results are depicted in table 6.

Table 6: Recycling polyols from polyester slabstock foam

Item / No.	110	111	112	115	113
Foam (% by weight)	53,8	57,7	62,3	65,0	67,5
DPG (% by weight)	44,8	40,9	36,3	33,5	31,0
DBA (% by weight)	1,4	1,3	1,4	1,5	1,5

Temperature (°C)/time (min)	180/60	220/60	220/80	220/85	220/60
Hydroxyl No. (mg KOH/g)	303	331	292	290	275
Amine No. (mg KOH/g)	45	46	46	42	43
Viscosity (25°C) (mPas)	10,530	8,690	19,370	16,880	32,300

With this type of slabstock foam the viscosities of the recycling polyols are generally high as are the original polyester polyols. They maybe processed into the premixes at higher temperature to result in flexible foams again. The limit of application into a typical premix was determined to be 15% by weight at present. Further experiments were performed to reduce the viscosity and to be able to use more than the limiting 15 % by weight in a premix. Some results of such experiments are presented in table 7.

Table 7: Modified recycling polyols from polyester slabstock foam

Item / No.	122	124	130	131	132
Foam (% by weight)	65,0	71,0	75,0	57,7	57,7
DPG (% by weight)	33,5	27,4	23,3	38,9	36,8
Short chain triol(% by weight)	0	0	0	2,0	4,1
DBA (% by weight)	1,5	1,6	1,7	1,3	1,4
Temperature (°C)/time (min)	200/80	220/80	220/80	220/80	220/80
Hydroxyl No. (mg KOH/g)	304	278	213	348	346
Amine No. (mg KOH/g)	42	45	41	42	42
Viscosity (25°C) (mPas)	12,500	32,400	27,000	6,200	7,600

The addition of only a few percent into the reaction mixture reduces clearly the viscosity to values suitable for use in the production. The recycling polyols are clear, amber liquids without any solid side products. The incorporation of these recycling polyols into slabstock foam formulations (free rise under lab conditions) led to a decrease in hardness and a higher degree of softness with lower ball rebound. This maybe attributed to the interference of the short chain triols with phase build up during foaming and polymer formation.

3.2.2 Polyether based flexible slabstock foams

The material used in these experiments were flexible slabstock foam residues from the outer part of the block with densified skins having a determined density of 34.5 g/dm³ of the foam part. Some results are shown in table 8.

Table 8: Recycling polyols from polyether slabstock foam

Item / No.	116	117	119	121
Foam (% by weight)	70,0	57,7	57,7	57,6
DPG (% by weight)	28,3	40,9	40,9	40,9
DBA (% by weight)	1,6	1,4	1,4	1,5
Temperature (°C)/time (min)	200/80	220/80	220/60	220/95
Hydroxyl No. (mg KOH/g)	241	355	361	356
Amine No. (mg KOH/g)	41	41	41	41
Viscosity (25°C) (mPas)	57,750	4,200	3,880	3,780
Appearance	amber, with particles	light amber, clear	yellow, clear	yellow, clear

The results with polyether flexible slabstock foams are similar to those obtained with cold moulded foams, i. e. in a range of solids load to the reaction mixture of a bout 60 % by weight recycling polyols with suitable viscosities are obtained. The increase in the solids content as shown with batch 116 leads to a sharp increase in viscosity while the hydroxyl number accordingly decreases. In application of such recycling polyols an optimum for viscosity and hydroxyl content has to be found to have both a maximum amount of recycling polyol added to the foaming mixture and optimum processing conditions.

3.2.3 Grafted polyether polyol based flexible slabstock foams

Flexible slabstock foams based on grafted polyether polyols are today the main product in this field but present the greatest issue as well. The problem is centered on the solids content which maybe either separated and disposed off or dispersed in the recycling polyol as fine particles. As the reaction temperature typically exceeds the melting temperature of the grafted polymer chains a special technology had to be developed to produce stable dispersions. A further limitation may arise from the polyureas present in the recycling polyol resulting in the combination of both in viscosity problems through the build-up of tixotropy or of a high portion of non Newtonian viscosity (structural viscosity).

When developing a technology to separate the grafts the solvolysis mixture needs to have a well adjusted surface tension which is established by the use of a carefully selected mixture

of short chain glycols. Some examples are presented in table 9 which batches were produced on 1 kg basis to receive the grafts as filterable solids:

Table 9: Solvolysis of grafted polyether based flexible slabstock foam aimed at filterable solids (temperature always 220°C, reaction time 30 minutes)

Item/No.	141	142	145
PUR foam (% by weight)	40,0	40,0	40,0
DPG (% by weight)	43,1	48,1	51,7
Short chain triol (% by weight)	14,4	9,4	5,8
DBA (% by weight)	2,5	2,5	2,5
Appearance	Grey liquid with needle-like solids	Yellow liquid with solid phase	Yellow liquid with solid particles
Hydroxyl No. (mg KOH/g)	445	437	450
Amine No. (mg KOH/g)	44	45	43
Viscosity (25°C) (mPas)	1,480	1,670	1,560

The technology and solvolysis mixture used in these experiments resulted in homogeneous recycling polyols of clear, light amber appearance with a viscosity as low as 1,500 mPas (25°C) due to the low solids content. A precipitate formed of solid needles of about 4 to 6 mm length and 0.5 to 1.5 mm thickness or particles of about 0.2 mm diameter which turned out to be the grafted polymers. The needle-like and the particulate material could be easily filtered off both at room temperature and at 75°C while the latter temperature was preferred because of the much lower viscosity of the recycling polyol. The filtered recycling polyol was used as an additive up to 25 % by weight in a typical formulation to produce polyether slabstock foams again.

When aiming at dispersed solids in the recycling polyols the technology and the solvolysis mixture had to be changed: the rate of the stirrer was increased to about 1200 rpm and the solvolysis mixture adjusted to a higher surface tension by the choice of the glycols. Some results are presented in table 10.

Table 10: Solvolysis of grafted polyether based flexible slabstock foam aimed at homogenous polyols

Item/No.	139	105	195	196	197
Foam (% by weight)	50,0	50,0	60.0	55.0	65.0
DPG (% by weight)	36,0	37,6	29.75	34.85	26.4
DEG (% by weight)	12,0	9,4	5.25	6.15	4.6
DBA (% by weight)	2,0	3,0	5.0	4.0	4.0
Temperature (°C)	200	200	220	220	220
Time (min)	80	60	70	85	60
OH-No. (mg KOH/g)	381	434	329	374	284
Amine No. (mg KOH/g)	-	62	24.4	24.5	44
Viscosity oscillation mode (25°C) (mPas)	-	-	10,600	5020	7050
Viscosity rotation mode (25°C) (mPas)	-	8,100	10,500	4300	6200
Appearance	slurry	homogeneous, amber	homogeneous, dispersion	homogeneous, dispersion	homogeneous, dispersion

As shown in the table, by the process and technology developed recycling polyols with homogeneously dispersed non-settling solids and rather low viscosities could be obtained when applying a solids load between 55 and 70 % by weight. The viscosities as measured by oscillation or rotation mode (Haake Rheostress® 300) possess a difference of roughly 800 mPas at 25°C which shows a high degree of structural viscosity originating from the combined action of the grafted polymers and the oligoureas present in the mixture.

The polyols thus obtained were introduced into a simple flexible foam mixture in the free rise mode (see formulation S1065 for details). In this formulation, part of the polyether polyol Lupranol® 2085 was substituted by the recycling polyols. The composition and some properties of the foams obtained are shown in table 11.

Table 11: Free rise foam composition and properties with the addition of the recycling polyols received from flexible slabstock foam based on grafted polyether alcohols (amounts given in % by weight)

Item/No.	S1040	S1045	S1046	S1042	S1043
Polyol 195	0	15.8	23.1		
Polyol 196	0	0	0	7.85	15.8
Lupranol® 2095	78.8	63.0	53.9	71.0	63.1
Polycat® NP40	0.33	0.33	0.32	0.33	0.33
TEGOSTAB ® 8433	0.06	0.06	0.06	0.06	0.06
Water	1.05	1.06	1.02	1.05	1.05
Lupranat® M20A	19.7	19.7	19.2	19.7	19.7
Start (s)	20	17	21	17	17
Index	90	60	50	70	57

The compression strength of the foam is decreased by only 12% when adding up to 20 % by weight of the recycling polyol while compression set shows no change. When adding larger amounts of the recycling polyols the foams tend to get a higher proportion of closed cells and to shrink. The reason for this phenomenon has not been elucidated but maybe attributed to the cell stabilizers originally present in the foam formulations. The demoulding times turn out to be under lab conditions somewhat shorter than the formulation based on primary polyols.

When using recycling polyols of this type the hardness of the free rise foams is efficiently controlled by the isocyanate index (7). It has to be pointed out that the higher the amount of recycling polyol added the lower the isocyanate index should be formulated so as to produce maximum flexibility of the foams. When employing 30 % by weight of the recycling polyol the index may kept as low as 50 in the total stoichiometric balance (including water). Thus, the formulation is produced more economically by reducing the amount of polymeric MDI necessary for foaming.

3.3 Shoe sole production wastes

Wastes of the shoes sole production are of polyether or polyester type (8). Both types were subjected to solvolysis and introduced into the original systems again. The solvolysis did not need a change in batch technology but in the continuous mode. The following table 12 shows some results obtained with both polyether and polyester shoe soles at various degrees of solids content.

Table 12: Recycling polyols obtained from polyester shoe soles

Item/No.	172	173	174
PUR (% by weight)	65	70	70
DPG (% by weight)	32,5	27,5	26,5
DBA (% by weight)	2,5	2,5	3,5
Reaction temperature (°C)	200	200	200
Reaction time (min)	60	60	60
Hydroxyl No. (mg KOH/g)	296	248	257
Amine No. (mg KOH/g)	23	16	18
Viscosity (25°C) (mPas)	22,370	87,500	66,000

The originally employed polyester diols used in shoe sole production are at room temperature semi solid or solid materials. The viscosity is measured and presented at 25°C while the temperature at working conditions is in the range of 55°C. Hence, the viscosities of the recycling polyols are at 55°C in the range of the original polyesters. Depending on the technology of the customer, the amount of solids in the mixture maybe as high as 80% by weight to give a material being semi solid (paste-like) at room temperature and having a viscosity of about 2500 mPas at 55°C.

Polyether based shoe sole wastes were solvolised in the same way. As in any other case, also with this material the conditions had to be developed and adjusted to the material. Some of the results with higher proportions of solids are depicted in table 13.

Table 13: Recycling polyols obtained from polyether shoe soles

Item/No.	056	057	059	060	061
PUR (% by weight)	60	55	70	63	65
DPG (% by weight)	35,5	40,5	26,5	33,0	30,5

DBA (% by weight)	4,5	4,5	3,5	4,0	4,5
Reaction temperature (°C)	200	200	200	200	200
Reaction time (min)	30	30	30	30	30
Hydroxyl No. (mg KOH/g)	380	383	257	279	254
Amine No. (mg KOH/g)	15	18	27	31	18
Viscosity (25°C) (mPas)	2,720	1,780	11,930	2,430	8,800

Due to the general lower viscosities of the polyether polyols there two choices: either the viscosity can be kept low, e. g. at about 3000 mPas (25°C) having a solids content of about 63 % by weight, or the amount of solids is high, e. g. 70 % by weight, when the viscosity is apt to be processed by the technology employed by the applicant and easily reaches 15,000 mPas (25°C). Even higher percentages of solids are possible. It was shown that even at 85 % by weight of solids a semi solid recycling polyol can be produced showing a viscosity at 25°C of about 80,000 mPas. In any case, the applicant of such recycling polyols has to carefully determine the parameters aimed at which should be completely in concordance with the technology employed.

The recycling polyols were introduced into typical shoe sole systems at rates up to 40% as calculated on the basis of the premix component. If the premixes are changed by the applicant or supplier, especially by eliminating some of the chain extenders ethylene glycol and/or butane-1,4-diol, the glycol of the solvolysis mixture may take over part of their function in establishing a certain phase segregation in the polyurethane and further adding to the rigidity of the material. Such experiments are under way.

5. CONCLUSIONS

The combined glycolysis/aminolysis is the basis of a new polyurethane recycling process well suited to produce recycling polyols of good quality from various polyurethane sources (9). It has been shown by a multitude of lab and semi-technical scale experiments that for each type of polyurethane a special formulation has to be developed, that a formulation fitting for one product cannot be transferred without problems to another product even of the same type but the solvolysis mixture has always to be carefully reformulated and adjusted to the product under consideration. Further, it has been shown that the recycling polyols maybe produced at various scales with identical parameters as shown with the hydroxyl numbers and viscosity. The reaction conditions further influence the quality of the product with respect to homogeneity and colour. The colour of the recycling polyols – in general yellow to dark amber – does not affect the foam properties and is not a result of oxidation during the process but more that of a side reaction of minor contaminants and does not deepen on longer addition or reaction times. Fillers or pigments remain in the recycling polyols, thus leading to products with the colour of the original polyurethane or – in case of mixtures of several

colours – of a mixed colour. In some cases a solids content of the polyurethanes up to 20 % by weight was found and stabilized in the recycling polyol either by the viscosity (where the appearance of tixotropy has to be avoided) or at lower viscosities (e. g. 2000 mPas) with agitation of the polyol in the storage container. The polymers grafted to polyether alcohols as in the grafted polyols may either be formed into a needle-like material and filtered off or finely dispersed and remain in the recycling polyol to be introduced into the new polyurethane again.

The solids content of the recycling polyol is in case of elastic types usually in the range of 60 % by weight to meet viscosity requirements. It maybe increased to up to 85 % by weight but in these cases the viscosity at 25°C exceeds processing conditions so that processing is possible only at elevated temperatures. The latter holds especially in the case of polyester based shoe soles. With rigid foams the amount of solids is limited to about 50 % by weight to meet acceptable viscosities.

The recycling polyols maybe used as single components in the production of composites, coatings, or sealants, i. e. a new type of material. Attempts to introduce them into formulations similar to the original products have shown that depending on the type of polyurethane produced between 15 and 40 % by weight of the premix component maybe substituted by the recycling polyol without detrimental effects on the final product properties.

Thus, the solvolysis by combined aminolysis and glycolysis represents not only a much faster and simpler way to produce recycling polyols from a variety of polyurethane products but also gives recycling polyol with qualities allowing them to be introduced into formulations of the original products as well as in such for completely different products. The process and the apparatus to perform the process are available up to volumes of 6 metric tons thus allowing for an annual production of up to 4,500 metric tons in the three shift system. The process is economical in that way as the production costs at an annual production exceeding 250 metric tons are far below the primary raw materials and usually in the range of 0.50 €

6. LITERATURE

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TRACK 4: AGRICULTURE AND FOOD TECHNOLOGY

EFFECTS OF LONG-TERM APPLICATION OF INORGANIC FERTILIZERS ON SOIL PRIMARY MACRONUTRIENTS IN MAIZE FARM SOILS IN TRANS NZOIA, KENYA

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Abstract

In this study, analysis was carried out to establish how soil total nitrogen, Phosphorous and potassium primary macronutrients accumulates after long term application of chemical fertilizers in Kerita maize farm soils, Trans Nzoia County in Kenya that has seen more than 20 years of fertilizer application. 12 samples of soil were collected from Kerita farm and 2 samples from the control site (Kiptuimet primary school). Nitrogen (N), phosphorus (P) and Potassium (K) in soils were determined using Kjeldahl method for nitrogen analysis, UV-visible spectroscopy and flame photometry respectively. The results revealed that maize farm soils had higher phosphorous levels with mean of 39.33 ± 2.96 ppm and was regarded as adequate for maize growth compared to the control site which had a concentration of 15ppm suggesting that chemical fertilizers had raised soil phosphorous level. However, the concentration of total nitrogen in maize farm soils was at $0.109 \pm 0.01\%$ and was regarded as low for maize growth, a value that was lower than the control site which was at $0.12 \pm 0.00\%$. This indicated that chemical fertilizers alone could not raise soil total nitrogen after long time application. Also maize farm soils had lower potassium mean concentration of $0.5433 \pm 0.08\%$ as compared to the control site that had a mean concentration of $1.15 \pm 0.14\%$ which showed that intensively cropped soils have developed potassium deficiency, in contrast to an old belief that soils in Kenya have sufficient amounts of potassium and would not benefit from potassium fertilizers.

Key Words: Fertilizers, Primary Macronutrients, Farm Soils, Kenya

INTRODUCTION

Maize production in Trans Nzoia is an important factor for food security since it is a major component of diet in Kenya for both human and animals in form of ugali and as animal feed stuff. However, its production trend has been declining for the past years (Onyango et al., 2000) leading to higher market prices. Seed quality and land infertility issues are cited as

major factors leading to its low production (Onyango et al., 2000; Mwangi et al., 1997). This has led to an increase in fertilizer application through government subsidies. The most commonly used fertilizers include; Di-ammonium phosphate (DAP), UREA and Calcium of Ammonium Nitrate (CAN). The main chemical components of these fertilizers are nitrogen, phosphorus and potassium which are essential elements in the growth of plants (Nartey et al., 2012). Unfortunately we have little information about the impact of the long term application of these inorganic fertilizers on the overall soil N, P and K. It has been apprehended that the use of inorganic fertilizer for a long period of time may impair the soil fertility because of imbalanced application of nutrients (Dubey et al 2012) while Tiwari et al. 2002 noted that use of imbalanced nutrients through inorganic fertilizer cannot sustain the desired level of crop production. Application of these fertilizers excessively can also result in environmental and ecological problems such as eutrophication when surface waters become over-enriched with nutrients such as N and P which stimulates plant and algal growth, and subsequently die and decompose. This reduces dissolved oxygen concentrations in water columns, which is detrimental to aquatic life Jeffrey, 1998; Brigden *et al.* 2002.

Quansah, (2010) noted that the immediate short-term effects of chemical fertilizers are often emphasized to the neglect of residual effects. Traditional practices such as recycling organic materials, application of organic resources whose residual effects may last for many years has been abandoned. Yet residual effects of inorganic fertilizer treatments may negatively affect the soil chemical properties and consequently crop yield on a long term continued farmed land. Cooke (1970) indicated that the residues of inorganic nitrogen fertilizers usually last only for a season, but the residual effects of continued manuring with phosphorus, nitrogen and potassium may last for many years.



Figure 2: Location of Trans-Nzoia County (Green)

MATERIALS AND METHODS

Total Nitrogen analysis by Kjeldahl method was performed according to Sherrif et al., 2012. 0.1 gram of the soil samples were measured into a Kjeldahl digestion flask and 3 grams of Devarda's alloy added to the samples to reduce the NO_3^- into NH_3 in an alkaline condition. One tablet of a Kjeldahl catalyst was added and 10 ml of H_2SO_4 then added to the samples

and heated in the digestion unit for two hours at a temperature of 350 °C till samples were totally digested to convert any organic nitrogen into (NH₄)₂SO₄. Distilled water was then added to the digested sample solutions and transferred into 50ml volumetric flasks and made to volume. A 5 ml aliquot was pipetted from the 50 ml solution into a distillation flask and 10mls of 40% sodium hydroxide (NaOH) added to the solution in the flask. The (NH₄)₂SO₄ in the solution was converted to NH₄OH. 5ml of the resulting solution was distilled off into a receiving flask containing 5 ml of 2% boric acid (H₃BO₃) using methylene blue - methyl red indicator until the purple colour of the boric acid changed to blue. At this stage, it was evidence that NH₃ had been trapped.

The blue boric acid- ammonia solution was then titrated against 0.01M HCl solution until the colour of the boric acid solution changed back to purple. The volume was recorded and the process repeated one more time.

The mean titre was calculated and used to determine the total Kjeldahl nitrogen (TKN) as follows:

$$\% N = \left\{ \frac{N \times \text{titre} \times 0.014 \times \text{volume of extract} \times 100}{\text{Weight of sample} \times \text{aliquot taken}} \right\}$$

Where N= molarity of HCl = 0.01; Volume of extract = 50 ml; Weight of sample = 0.1 grams; Aliquot taken = 5 ml; 1 ml of 0.01M HCl = 0.014 grams.

Phosphorous (P₂O₅) was determined using the UV-Visible Spectrophotometer according to Sherrif et al., 2012. Stock solution was prepared by diluting 140 ml of conc. H₂SO₄ with distilled water to 1 litre; 12 grams of ammonium molybdate were dissolved in distilled water to 250ml in a 250 ml volumetric flask; 0.2908 gram of Antimony potassium nitrate was dissolved in 100 ml of distilled water; the three solutions were then mixed together and made to a volume of 2 litres solution with distilled water. 1.056 grams of Ascorbic acid were then dissolved in the 2 litre solution and mixed thoroughly. The sample (0.1 g) was weighed into a digestion tube, 20 ml of HNO₃ and 30 ml of perchloric acid added to the sample in a ratio of 1:1.5. The resulting mixture was then heated in a microwave oven at a temperature of 350 °C for two hours and the digested sample allowed to cool and transferred to a 250 ml volumetric flask and made to volume with distilled water. An aliquot of 2 ml was taken from the 250 ml solution into a 50 ml volumetric flask and 10 ml of distilled water added. A drop of paranitrophenol solution was added and drops of NH₃ solution added until the solution turn yellow; at this point a neutralization point had been reached. 8 ml of stock solution was then added for color development which was read with a UV/visible spectrophotometer. A blank and a standard were prepared in the same way as the sample just that the blank did not contain the analyte of interest. The reading from the blank was used to eliminate background readings.

The calculation for determining phosphorous (P) is:

$$\% P = \left\{ \frac{\text{Reading} \times \text{volume of extract} \times 100}{\text{Weight of sample} \times \text{aliquot} \times 10^6} \right\}$$

The above calculation gives the concentration of the phosphorous in its elemental form. In order to determine the value of phosphorous in the P₂O₅ form, a conversion factor of 2.3 according to the method by McCauley et al. [2009]:

$$\% \text{ P}_2\text{O}_5 = \left\{ \frac{\text{Reading} \times \text{volume of extract} \times 100}{\text{Weight of sample} \times \text{aliquot} \times 10^6} \right\} \times 2.3$$

Where Volume of extract = 250 ml; Aliquot= 2 ml; Weight of sample = 0.1gram; Reading = reading from the UV/Visible spectrophotometer.

Potassium (K₂O) in soil samples was done using the Flame Photometer according to Sherrif et al., 2012. 0.1 gram of the sample was weighed into a digestion tube. 20 ml of conc. HNO₃ to oxidize all the oxidizable matter in the sample and 30 ml of perchloric acid added to the sample. The sample was then covered and heated in the oven for up to 2 hours at a high temperature. The solution was cooled after digestion and transferred into a 250 ml volumetric flask and made up to volume with distilled water. A potassium standard and blank solution was prepared in the same way. The solutions were taken to the flame photometer for reading which were used to calculate the percent K₂O in the sample through the equation:

$$\% \text{ K} = \frac{\text{Reading} \times \text{volume of extract} \times 100}{\text{Weight of sample} \times 10^6}$$

The above calculation gives the concentration of potassium in its elemental K form. In order to calculate potassium in the oxide K₂O form, a conversion factor of 1.2 according to Ann McCauley *et al.* [2009] was used. Thus giving

$$\% \text{ K}_2\text{O} = \left\{ \frac{\text{Reading} \times \text{volume of extract} \times 100}{\text{Weight of sample} \times 10^6} \right\} \times 1.2$$

RESULTS AND DISCUSSIONS

Concentration of phosphorous level in the maize farm soil ranged from 35 ppm to 44 ppm with the highest concentration of 44 ppm at FAS4 and the lowest concentration of 35 ppm at FAS5 while Concentration of phosphorous level in the control site was at 15 ppm. Amounts of Phosphorous required vary from plant to plant [Quansah 2010]. The 35 ppm-44 ppm range was regarded as adequate phosphorous levels in for maize growth.

The significant difference of phosphate in the two study areas was attributed to phosphate fertilizers that have been applied to maize farm soil for more than 20 years. Abo *et al.* [1995] associated the increase in available Phosphorous in the soil to application of phosphate fertilizers. However the effect of the fertilizers on soil phosphorous varied from one soil to another. Once phosphorous is built to a good level after fertilizer application, that level would remain for many years without any additional phosphorous input. The reason is that phosphorous is less soluble in water and leaching is minimal [Hue, 1995]. It is estimated that as much as 90 % of added fertilizer phosphorus is fixed in soils [Potash and Phosphate Institute, 2003] and made unavailable to plants. Quansah, [2010] noted a significant increase in soil phosphorous when measured after crop harvest and before, that is the soil phosphorous

range before the application of treatments was lower than the soil phosphorous range after harvest, indicating an increase in soil available phosphorus after harvest. Addition of Phosphorous to the soil year after year, builds up P in soil. This could be the reason why the concentration of phosphorous was higher in maize farm soils as compared to the control site.

Total Nitrogen in farm soil ranged from 0.11% to 0.12% while in the control site the total nitrogen was 0.12% with an overall mean of 0.109 ± 0.01 and 0.12 ± 0.00 between the farmlands and the control site indicating lower total nitrogen in farm soil as compared to the control site. Total nitrogen percentage concentration in the Kerita farm soil was regarded as low since it fell within the range of 0.05%-0.11%, which is normally regarded as low for maize production [Okalebo et al, 2002]. Values from the control soil samples were regarded as normal since it fell in the normal range of 0.12%-0.25%. Chen et al, 2007 and Fu et al, 2000 obtained similar results where Total Nitrogen contents in the uncultivated farmlands were higher compared to those in the farmland and concluded that Total nitrogen contents could be expected to increase significantly after the farmland had been abandoned for ten years and that application of inorganic fertilizer alone is not sufficient to maintain level of nutrients under conditions of conventional management in which no aboveground crop residues are returned to the soil.

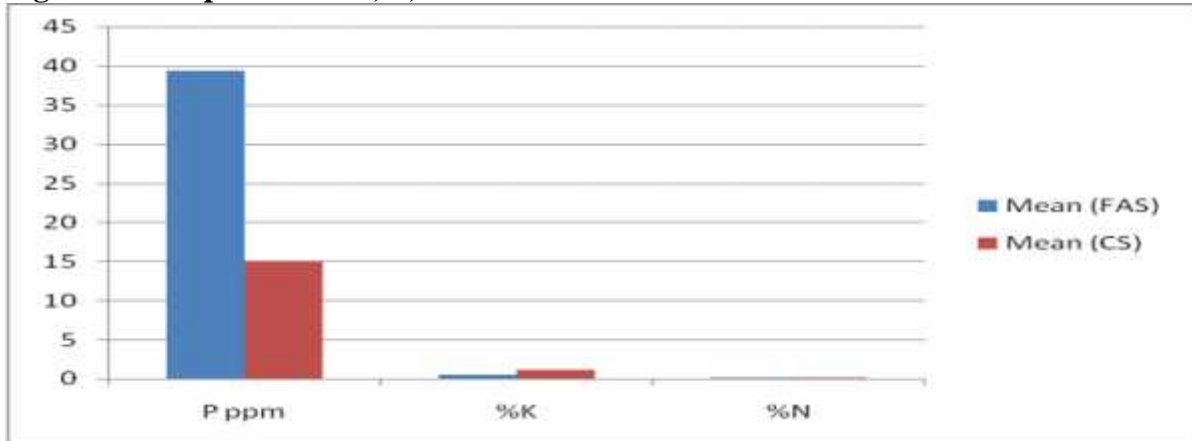
Potassium in farm soil ranged from 0.42% to 0.65%, while in the control site the potassium concentration was between 1.14% and 1.16%. Maize farm had lower mean concentration of $0.5433 \pm 0.08\%$ as compared to the control site that had a mean concentration of $1.15 \pm 0.14\%$. The difference was in agreement with studies by Nandwa, [1988], ICRAF, [1995], and Kanyanjua and Buresh, [1999] which showed that intensively cropped soils have developed potassium deficiency, in contrast to an old belief that soils in Kenya have sufficient amounts of potassium and would not benefit from potassium fertilisers [Hinga and Fom, 1972; Muchena, 1974].

Table 1: N, P and K concentrations (mean \pm SD mg kg⁻¹ of dry weight) in soil samples from Kerita farm and the control site

Site	P ppm	%K	%N
FAS1	40	0.6	0.12
FAS2	36	0.42	0.1
FAS3	41	0.55	0.1
FAS4	44	0.64	0.11
FAS5	35	0.48	0.1
FAS6	38	0.59	0.12
FAS7	42	0.44	0.1
FAS8	35	0.65	0.12
FAS9	39	0.51	0.11
FAS10	40	0.64	0.11
FAS11	39	0.52	0.11
FAS12	43	0.48	0.11
CS1	15	1.16	0.12
CS2	15	1.14	0.12

Mean (FAS)	39.33±2.96	0.54±0.08	0.109±0.01
Mean (CS)	15.00±0.00	1.15±0.01	0.12±0.00

Figure 1: Comparison of N, P, K in Maize farm soils with the control site



CONCLUSIONS

Phosphorus levels in maize farm soil were regarded as adequate for maize growth since they fell within the range of 35ppm-44ppm. Nitrogen levels in farm soil was regarded as low since it fell within the range of 0.05%-0.11 % below 0.12 % which is regarded normal for maize production[Okalebo *et al*,2002]. Potassium in the soil was found deficient for maize production. Overdependence on chemical fertilizers is therefore discouraged and application of organic combined with inorganic fertilizers is recommended to increase in soil nitrogen, phosphorus, and potassium nutrients.

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NUTRITIONAL CHARACTERIZATION OF GOAT MILK FROM KENYA ALPINE DAIRY GOATS REARED IN NYERI COUNTY

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Abstract

The nutritional characterization of goat milk from Kenya alpine dairy goats reared in high potential and semi arid areas of Nyeri County were studied. It was hypothesized that the geographical location does not significantly impact on the milk quality. Milk samples were obtained at weekly intervals from smallholder farmers rearing Kenya Alpine dairy goats in Nyeri County and registered with Dairy Goat association of Kenya (DGAK). The total solids in milk, ash, fat, protein and vitamins, mineral content and fatty acid profile were determined. In Mukurweini region, which is a high potential area, the milk had high significant levels ($p < 0.05$) of fat 4.51% and ash 0.95% as compared to the other two regions. Milk from Kieni West was significantly higher in solids-not-fat, while the protein content was not significantly different in the three areas. Significant levels of ascorbic acid 0.30 mg/100ml and riboflavin 1.07 mg/100ml was found in goat milk from Mukurweini region. Milk produced in Mukurweini contained more saturated fatty acids than milk produced in the semi arid areas. Total monounsaturated fatty acids were high in goat milk produced in Kieni East while the total polyunsaturated fatty acids were not significantly different in the three regions. The study shows that the nutritional quality of milk was significantly affected by the geographical region of goat rearing.

1.0 INTRODUCTION

Goat rearing plays an important socio-economic role in many rural parts of the world in contributing to food and nutrition security. They are a source of income from sale of animals and their products, including skins, meat and milk for home consumption, and manure, besides playing intangible roles like being insurance against emergencies and as an investment in stock (Kosgey 2004; FAOSTAT 2008). Goats are able to adapt to and utilize marginal forage, and survive under harsh conditions, making them a very valuable asset for subsistence farmers. Besides, these animals easily adapt to intensive productive systems and convert their feed into highly nutritious milk and meat very efficiently (Castel et al 2010; Brown 2011). Dairy goats occupy a unique and significant niche in resource-limited

smallholder farming systems in the high potential areas of the tropics and subtropics, and are being increasingly adopted (Ogola et al 2010a). They have potential to improve livelihoods largely through provision of milk for home consumption and surplus for sale to raise income.

Milk is one of the essential products in the human diet, rich in nutritive components. Although the production and consumption of cow milk is the largest throughout the world, one may observe a growing demand for milk of other farm animals, such as goats, which is recognized in developed countries as a niche product [Kanwal *et al.* 2004, Haenlein and Wendorff 2006)

Dairy goat production has been gaining popularity in many regions in Kenya in the recent years and among the small-scale farmers, as it does not require large areas to keep them, as well as the increasing demand for goat milk due to its unique and equally important nutritional value. Smallholder farmers in Kenya are increasingly turning to dairy goat rearing in some regions as a means to grow incomes while improving nutrition in rural areas, as well as commercial benefits of goat dairy products (DGAK, 2009). This is more prevalent in the semi arid areas where they easily adopt and maintain themselves in dry and harsh environments. They do well in partly semi arid and could be essential in tackling very severe food insecurity due to weather changes and scarce resources.

The main feed for dairy goats in Nyeri County are napier grass (*Pennisetum purpureum*) grown on small plots, crop residues, and occasionally grass collected from the roadsides and neighbouring public land. Fodder shortages are mainly experienced during the dry season when the farmers traditionally supplement the grasses with banana pseudostems and indigenous fodder shrubs. Fodder shrubs offer an alternative source of high-protein supplementary feed for dairy animals.

2.0 PROBLEM STATEMENT

In Kenya there are hardly any works studying the effect of the type of system on the yield and chemical composition of goat milk. Although several authors have examined the nutritive value of goat milk taking into consideration various factors [Pilar *et al.* 1998, Andrade and Schmidely 2006, Matsushita *et al.* 2007, Pandya and Ghodke 2007) little is known about its composition in relation to geographical location in a specified area.

The production of goat's milk in Kenya has been increasing steadily over the past few years. However, very little scientific and technical information is available on the quality of milk produced by the different goat breeds raised in Kenya. With the aim of filling this knowledge gap, the nutritional characterization of goat milk will be evaluated with the aim of gaining a better understanding of the relationship that exist between the physico-chemical properties of Kenyan goats' milk and the climatic conditions. The project targeted farmers rearing daily goats especially those who operate on small pieces of land which are less than an acre, and are registered with the Dairy Goat Association of Kenya.

3.0 OBJECTIVES

Overall objective: To investigate the productivity of dairy goats reared in Kenya, their milk nutritional and chemical composition and product development.

Specific Objective: To determine the nutrition and chemical composition of Kenya Alpine dairy goat milk from different geographical areas of Nyeri County

4.0 RESEARCH METHODOLOGY

4.1 Study site

The study comprised farmers who are registered with the Dairy Goat Association of Kenya (DGAK) and have undergone adequate training in dairy goat keeping, practicing good husbandry and producing enough milk in Mukurweini which is a high potential area and Kieni East and West as semi arid areas of Nyeri County.

4.2 Study design

A three-group simple randomized experimental design was used. (C. R. Kothari, 2004), which comprised DGAK registered Kenya Alpine dairy goats from Kieni East, Kieni West and Mukurweini regions of Nyeri County. All the goats were fed on natural pastures that included indigenous fodder shrubs like weeds, shrubs; banana leaves, potato peels, nappier grass, maize stalks, sweet potato vines, green leafy twigs and Calliandra. The farmers mainly used the available material found on the farm.

4.3 Sampling procedure and sample size

The study was carried out on 10 DGAK registered pedigree dairy goats in their second lactation, in each region. Goats were milked once a day, in the morning on weekly basis with milk samples collected aseptically into sterile vials then immediately stored below -20⁰C until laboratory analysis.

The nutritional characterization was carried out comparing goat milk from different geographical areas.

4.4 Milk nutritional analyses

Standard procedures of AOAC 2000 were used to determine the milk total solids, ash, protein (N x 6.38), fat and solids-not-fat. Fatty acid composition was determined by modified Bligh and Dyer method (1959) using a gas chromatography system (GC-9A Shimadzu Co., Tokyo, Japan). Minerals were determined by AOAC 2000 method, using Atomic Absorption Flame Emission Spectrophotometer (Shimadzu Corp., Tokyo Japan, and Model AA 6200). Phosphorus was determined by with the vanadomolybdate colorimetric method (Pearson, 1976). Water soluble vitamins were determined by a reversed-phase HPLC method (Ekinici and Kadakal 2005), while Riboflavin was determined separately using HPLC method (AOAC, 2000).

4.5 Data analysis

The data was analyzed using the Statistical Package for Social Scientists (SPSS) software Version 18 of 2010. General Linear Model (GLM) Univariate procedure was used for computations at 5% significant level.

5.0 RESULTS

Changes observed in the chemical composition of milk from pedigree dairy goats in different geographical locations are shown in Table 1. The total solids differed significantly among the three regions. The high potential region of Mukurweini had significantly higher ash and fat content, as compared to Kieni East and West, which are semi arid areas. Solids-non-fat was significantly high in Kieni West region.

Table 1: Pedigree Dairy Goat Milk Chemical composition

Minerals mg/100ml	Kieni East	Kieni West	Mukurweini
Total solids	12.30±0.54 ^a	13.62±1.00 ^c	13.74±0.99 ^b
Ash	0.21±0.02 ^a	0.22±0.01 ^a	0.95±0.12 ^b
Fat	3.50±0.11 ^b	2.51±0.07 ^a	4.51±1.25 ^c
Protein	3.37±0.06 ^a	3.65±0.23 ^a	3.23±0.87 ^a
Solids-non-fat	8.81±0.49 ^a	11.11±1.07 ^b	9.23±0.37 ^a

a The data are mean value ± standard deviation (SD) of six replicates. Values within a row marked with different superscript are significantly different (p < 0.05).

Changes observed in the mineral composition of milk in the three regions are shown in Table 2. The mineral composition differed clearly among the three regions. In Kieni East the calcium 53.50 mg/100ml, magnesium 4.95 mg/100ml, zinc 0.18 mg/100ml and sodium 18.78 mg/100ml, were significantly higher as compared with the other two regions. Iron content was lowest in Kieni West 0.14 mg/100ml and not significantly different in Kieni East and Mukurweini. Potassium and Phosphorous were lowest in Mukurweini region.

Table 2: Pedigree Dairy Goat Milk Mineral composition

Minerals mg/100ml	Kieni East	Kieni West	Mukurweini
Calcium	53.50±3.31 ^c	44.21±3.35 ^a	48.80±4.81 ^b
Magnesium	4.95±0.56 ^c	4.22±0.31 ^a	4.51±0.57 ^b
Iron	0.16±0.03 ^b	0.14±0.02 ^a	0.17±0.08 ^b
Zinc	0.18±0.02 ^c	0.15±0.02 ^a	0.17±0.03 ^b
Copper	0.04±0.01 ^a	0.03±0.01 ^a	0.05±0.02 ^b
Sodium	18.78±2.36 ^c	15.45±2.03 ^a	17.22±2.72 ^b
Potassium	54.29±6.73 ^b	53.11±3.86 ^b	49.28±6.93 ^a
Phosphorous	1.11±0.01 ^b	1.02±0.07 ^b	0.86±0.02 ^a

a The data are mean value ± standard deviation (SD) of six replicates. Values within a row marked with different superscript are significantly different (p < 0.05).

The vitamin composition of goat's milk and its changes resulting from the geographical area are shown in Table 3. The thiamine content of goat milk was not significantly different in the three regions. Significant levels of ascorbic acid 0.30 mg/100ml and riboflavin 1.07 mg/100ml was found in goat milk from Mukurweini region.

Table 3: Pedigree Dairy Goat Milk Water Soluble Vitamin Composition

Vitamin mg/100ml	Thiamine	Niacin	Ascorbic acid	Riboflavin
Kieni East	0.35±0.02 ^a	0.34±0.18 ^b	0.21±0.09 ^b	0.86±0.07 ^b
Kieni West	0.37±0.00 ^a	0.09±0.01 ^a	0.15±0.01 ^a	0.37±0.10 ^a
Mukurweini	0.36±0.02 ^a	0.21±0.01 ^b	0.30±0.33 ^c	1.07±0.06 ^c

a The data are mean value ± standard deviation (SD) of six replicates. Values within a row marked with different superscript are significantly different (p < 0.05).

The fatty acid profile of goat's milk and its changes resulting from the geographical area are shown in Table 4. An analysis of the results indicated that the concentrations of volatile fatty acids were similar in all the regions. Milk produced during in Mukurweini contained more saturated fatty acids than milk produced in the semi arid areas. As regards particular fatty acids of this group, it was found that goat's milk obtained from Mukurweini contained higher concentrations of such acids as C16:0, C18:0 (Significant differences) and a lower percentage of C12:0, in comparison with milk obtained from semi arid areas. Total monounsaturated fatty acids were high in goat milk produced in Kieni East while the total polyunsaturated fatty acids were not significantly different in the three regions.

Table 4: Pedigree Dairy Goat Milk Fatty acid profile

Fatty acid	Kieni East	Kieni West	Mukurweini
Caproic (6:0)	0.30±0.09 ^a	0.46±0.35 ^a	0.28±0.75 ^a
Caprylic (8:0)	1.56±0.52 ^a	1.72±0.41 ^a	1.65±0.28 ^a
Capric (10:0)	8.99±3.41 ^a	11.81±6.31 ^a	9.67±2.74 ^a
Total volatile fatty acids	10.85	13.99	11.6
Lauric (12:0)	4.46±1.27 ^b	7.41±0.21 ^c	3.66±0.53 ^a
Myristic (14:0)	9.92±0.71 ^a	9.81±3.56 ^a	10.84±0.50 ^a
Pentadecanoic (15:0)	1.04±0.51 ^a	1.11±0.00 ^a	0.89±0.57 ^a
Palmitic (16:0)	21.13±5.71 ^a	17.00±7.29 ^a	28.56±3.11 ^b
Heptadecanoic (17:0)	0.48±0.31 ^a	0.54±0.11 ^a	0.70±0.22 ^a
Stearic (18:0)	15.22±4.34 ^a	17.04±6.52 ^a	22.77±5.65 ^b
Lignoceric (20:0)	0.85±0.16 ^a	1.46±0.38 ^a	1.23±0.09 ^a
Total saturated fatty acids (SFA)	53.1	54.37	68.65
Myristoleic (14:1)	0.41±0.20 ^a	0.31±0.21 ^a	0.31±0.21 ^a
Palmitoleic (16:1)	1.56±0.92 ^a	2.24±1.52 ^a	2.13±0.36 ^a
Oleic (18:1) cis	22.18±3.51 ^a	16.13±9.92 ^a	13.19±8.06 ^a
Elaidic (18:1) trans	2.27±1.06 ^a	3.17±1.60 ^a	3.12±1.51 ^a
Total monounsaturated fatty acids (MUFA)	26.42	21.85	18.75
Linoleic (18:2) cis	1.74±0.41 ^a	2.36±1.00 ^a	1.77±0.47 ^a

Linolelaidic (18:2) trans	1.49±8.19 ^a	1.87±1.68 ^a	1.01±0.60 ^a
Linolenic (18:3)	2.54±0.18 ^a	2.55±3.68 ^a	2.85±1.98 ^a
Arachidonic (20:4)	0.54±0.34 ^a	0.35±3.38 ^a	0.96±0.73 ^a
Total polyunsaturated fatty acids (PUFA)	6.31	7.13	6.59
Total unsaturated fatty acids (UFA)	32.73	28.98	25.34

a The data are mean value ± standard deviation (SD) of six replicates. Values within a row marked with different superscript are significantly different (p < 0.05).

6.0 DISCUSSION

Milk is a major source of dietary energy, protein and fat, contributing on average 134 kcal of energy/capita per day, 8 g of protein/capita per day and 7.3 g of fat/capita per (FAOSTAT, 2012). However, when different geographic regions are considered, the contribution from milk to the various nutritional components varies considerably. According to this study variations were noted in milk composition for dairy goats in semi arid and high potential areas under the study. In the high potential areas of Mukurweini the milk was significantly high in ash and fat with more saturated fatty acids than milk produced in the semi arid areas. Total monounsaturated fatty acids were high in goat milk produced in Kieni East while the total polyunsaturated fatty acids were not significantly different in the three regions. This is in agreement with study carried out by *Stanisawa et al, 2006*, where it was found that cool climate affect milk yields and composition, and both are negatively correlated. Milk C18:0, C18:1, C18:2, C18:3 fatty acids were found to increase in warm climate, while C4 to C16 fatty acids were reduced significantly. Milk composition can have significant differences in major and minor components (Renner, 1982), which are confounded with climate and diet effects. Regardless of genetics, the composition of the daily diet and its amount in relation to production requirements can cause significant changes in milk composition (Moran-Fehr, 1981; Haenlein, 1995). In general terms, 3 percent of bodyweight is a minimum requirement of daily dry matter intake for most goats. In order to cover nutrient needs of high production, the energy and protein density of the daily feed intake must increase, because of the limitation of the rumen in volume capacity. Roughages like grass, hay or silages are mostly low in energy and protein density because of high fiber and/or water contents.

Significant levels of ascorbic acid 0.30 mg/100ml and riboflavin 1.07 mg/100ml was found in goat milk from Mukurweini region. Being a high potential area, there are readily available fodders to feed the daily goats. Results from previous study showed that farmers in this region do not supplement the feed with neither concentrates nor mineral supplements, since the type of fodder used is sufficient to supply the necessary nutrients (Mburu et al, 2014).

In Kieni East the calcium 53.50 mg/100ml, magnesium 4.95 mg/100ml, zinc 0.18 mg/100ml and sodium 18.78 mg/100ml, were significantly higher as compared with the other two

regions. Previous study revealed that in this region farmers use high levels of concentrates and mineral supplements to feed the dairy goats especially during milking (Mburu et al, 2014). In the semi arid areas the dairy do better and are more preferred to daily cow, due to scarcity of fodder and they easily adapt to the harsh climate.

7.0 CONCLUSION

The study has established that the geographical location of the dairy goat rearing affect the quality of milk produced, which is also dependant on the type of fodder available in that region. Dairy goat farming has a potential of improving the small holder well-being through improved family nutrition.

8.0 ACKNOWLEDGMENTS

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TRACK 5: HEALTH SCIENCES

ASSESSMENT OF DOMESTIC WATER SUPPLY IN RELATION TO PREVALENCE OF WATERBORNE DISEASES

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Abstract

This study aimed at determining the relationship between domestic water supply and the prevalence of waterborne diseases in Mbeere North Embu County, Kenya. The accessible population was the population within 7,985 households obtained from 12 locations of Mbeere North. A sample size of 367 was selected. Systematic random sampling was used with population frame of 7,958. Secondary data constituted waterborne diseases reported cases from health facilities, and population statistics. Acquisition of primary data was done using researcher administered questionnaires. Secondary morbidity data was analyzed using Microsoft office excels 2007 and primary household data was analyzed using Statistical Package for Social sciences (SPSS). SPSS was used to generate descriptive statistics, establish correlation among the variables and to test the hypothesis. Pearson product moment correlation coefficient (r) was used to show both direction and the strength of the relationships. Data display was done using charts and figures. The Pearson correlation coefficient linking waterborne diseases infections with domestic water supply source was 0.176 with a significance level of $p < 0.006$. The study hypothesis testing found that chi-square test for independence indicated a strong significant association between those infected with intestinal worms and the source of domestic water, $\chi^2 (1, n = 267) = 102.483, p < 0.0005, \phi = 0.620$. In conclusion, this study therefore showed that water supply source significantly contributed to the prevalence of waterborne diseases in Mbeere North. The study therefore recommended intervention by the government to alleviate the waterborne diseases endemic by ensuring provision of clean water.

Key words: Diseases, Water, Waterborne, Source, Supply,

1.0 INTRODUCTION

1.1 Background

Waterborne diseases are a major cause of illness in developing countries especially Africa and are responsible for sporadic and localized outbreaks of disease in the developed world. Lack of adequate sanitation, adequate and safe water and adequate awareness are major factors contributing to the prevalence of these diseases. Lack of adequate research and ineffective information dissemination hinders the effort to reduce the diseases.

Water safety plans report [1] outlines the objectives of water safety plans as necessary to ensure safe drinking water through good water supply practices which includes preventing contamination of source waters, treating the water to reduce or remove contamination that could be present to the extent necessary to meet the water quality target and preventing re-contamination established during storage, distribution and handling of drinking water. The common waterborne diseases found in the study area include typhoid, diarrhea, dysentery, intestinal worms and gastroenteritis. In Mbeere Embu County, historical data are replete with data on waterborne diseases which impact on human health.

1.2 Water sources or facilities

The water sources in the study area were considered as improved or unimproved. According to the United States Centre for Diseases Control and prevention [2] improved drinking water sources should, but do not always, provide safe drinking water, and include piped household water connection, public standpipe, borehole, protected dug well, protected spring, rainwater collection. Unimproved drinking water sources include among others, unprotected dug well, unprotected spring, surface water (river, dam, lake, pond, stream, canal, and irrigation channel), vendor-provided water (cart with small tank/drum, tanker truck), bottled water etc.

1.3 Problem statement

World Health Organization (WHO) [1] observed that waterborne disease remains one of the major health concerns in the world. A study conducted in Embu County by the Kenya government on the top ten causes of morbidity showed that intestinal worms range number three of all medical cases reported in the health facilities [3]. The data relating to the level of contamination attributed to water supplies in the country and in particular the study area is not available [3].

1.4 Objective of the study

The researcher's overall objective was to establish the relationship between domestic water supplies and sanitation in relation to the prevalence of the waterborne diseases in Mbeere North Embu County. One of the specific objectives of the study and which this report will focus on is:-

To determine the relationship between domestic water supply and prevalence of waterborne diseases in Mbeere, Embu County Kenya.

1.5 Study hypothesis

There is no relationship between domestic water supply and prevalence of water borne diseases in Mbeere, Embu County Kenya.

1.6 Significance of the study

There is very little data relating the linkage between the available domestic water supply and prevalence of waterborne diseases in Kenya. This study is therefore quite significant in;-

Adding new knowledge to understanding how water supply is linked to the outbreak and subsequent spread of waterborne diseases.

Help the community combat the menace on the scourge of the waterborne diseases.

Assist the government authorities and other stakeholders in policy formulation and planning for mitigation against the spread of waterborne diseases.

Assisting government and the public in saving the revenue and hence fostering the country economic growth.

1.7 Some available studies

The concept behind this study is based on the waterborne diseases burden with the main focus on water supply and how it contribute or relate to the prevalence of the common waterborne diseases. The underlying factors which contribute to the state of domestic water supply formed the basis of discussion in the study and subsequent conclusions. Most available studies associate these waterborne diseases with lack of clean water and inadequate sanitation. Choffnes [4] established that water-related factors cause more than 20 percent of deaths of people under age 14. According to the WHO [5], household water treatment and safe storage (HWTS) interventions can lead to dramatic improvements in drinking water quality and reductions in diarrheal disease, making an immediate difference to the lives of those who rely on water from polluted rivers, lakes and, in some cases, unsafe wells or piped water supplies. A systematic review concluded that diarrheal episodes are reduced by 25% through improving water supply [6]

1.8 Interventions to curb spread of water borne diseases

1.8.1 De-worming and hygiene intervention

In Cambodia de-worming programmes for school children were started in some provinces with treatment using mebendazole 500 mg coupled with health education. After treatment, the prevalence of intestinal worms dropped to about one-third of the initial level, [7]. During the research data collection, the researcher established that the Kenya government has been carrying out de-worming of children between 2-5 years twice per year in the study area. The

government is also supplying chlorine water treatment tablets (aqua-tabs), applied as one tab per twenty litres or 40mg/10 litres. The result or the impact showed that the combination of both de-worming and water treatment reduced the prevalence of the waterborne diseases by 80% in the study area.

2.0 MATERIAL AND METHODS

2.1 Study area and population

The study was conducted in Mbeere North, Embu County with a target population of 89,035 according to the Kenya Housing and Population Census [8]. In this study, since everyone in the area is susceptible or at risk of attack by the water borne diseases, the entire population was considered as target population. The accessible population was 7,985 households obtained from 12 locations within Mbeere North sub-County and which was used as sample frame. The choice of this sub-county was based on various factors among them, the extreme weather conditions in the area and the uneven distribution of rainfall and also distribution of various types' of domestic water resources among others.

2.2 Research Design

The variables in the study were domestic water sources, as independent variables and the waterborne diseases as dependent variable. Since this study was looking at the relationships between variables, correlation research design method was used.

2.3 Sampling strategy

The household data of 7,958 formed the population frame. The required sample size of 376 was obtained using Krejcie, Morgan and Daryle [9] chart. The household sample was obtained using systematic sampling from the population frame. The total sample of 376 households was obtained using systematic random sampling method. Although the subject in this sampling appears to have been the household, only one person either the household owner or an elderly family member represented the household.

2.4 Data collection procedure and instruments

The tool used for primary data was the questionnaire which was administered by the researcher. The secondary data mainly on morbidity from various health facilities and demography were obtained from relevant Government offices. Spatial data on water supply source points was acquired using the global positioning system instrument (GPS).

2.5 Data analysis and presentation

Microsoft office Excel 2007 was used to analyze secondary morbidity data and Statistical Package for Social Scientists (SPSS) Version 15.0 was used to analyze primary household data. The presentation of the data was in the form of charts and digital maps for the spatial data on water sources and location of the health facilities collected from the field.

3.0 RESULT ANALYSIS AND DISCUSSIONS

3.1 Instrument return

The researcher issued 367 questionnaires to the respondents in 14 locations within the study area. 267 questionnaires were received back from 12 locations with filled information and the rest were either not filled or were not returned at all translating to about 73 % response.

3.2 Water supply sources within the study area

The spatial data on existing water sources and the health facilities obtain using GPS is shown figure 3.1 below. The figure also shows study area bound by bold line.

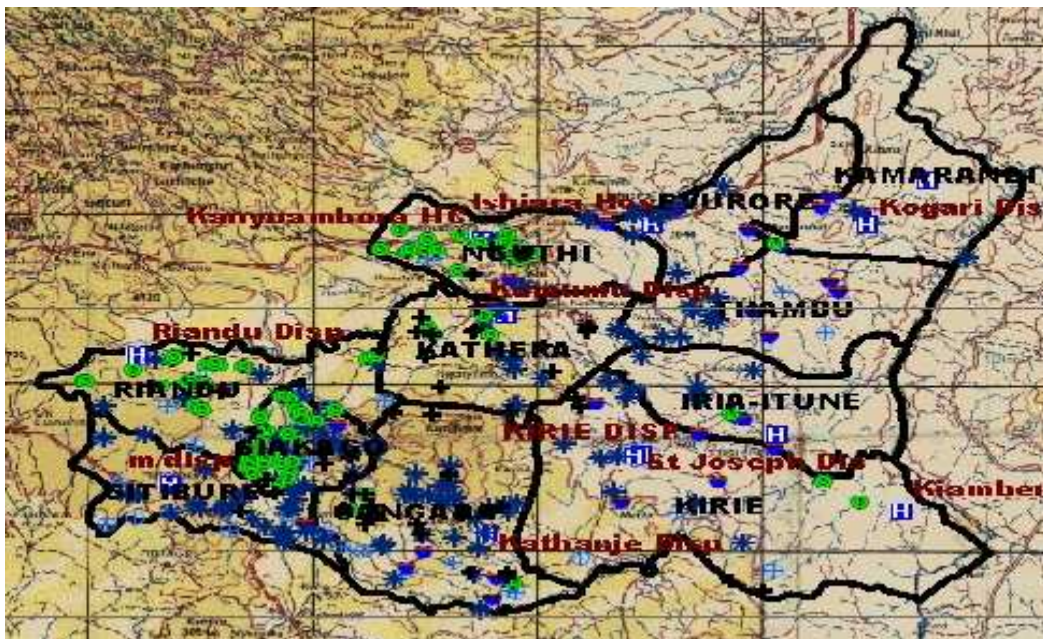


Figure 3.1: Various types of domestic water supply sources and health facilities within the study area.

Legend

- G spring_water_mbeere
- O shallow_well_mbeere
- # rock_catchment_mbeere
- k piped_water_system
- v health_facility_data
- B dams_mbeere
- > borehole_mbeere

Source: Developed from the GIS Kenya shape file layers by the Researcher (2014)

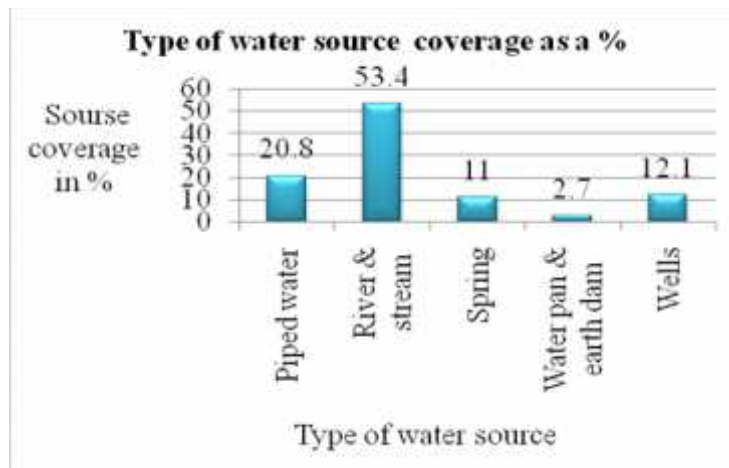


Figure 3.2: Distribution of domestic water supply sources by type Researcher (2014)

Figure 3.2 shows that majority of the interviewees slightly over 53% use water from rivers and streams which are open sources and of low quality. The results of this study agree with that done by UNICEF [10] in Kenya, which showed that only about 46% of the rural area uses improved water sources. Chabalala & Mamo [11] found that Water-borne diseases are “dirty-water” diseases; mainly attributed to water that has been contaminated by human, animals or chemical wastes.

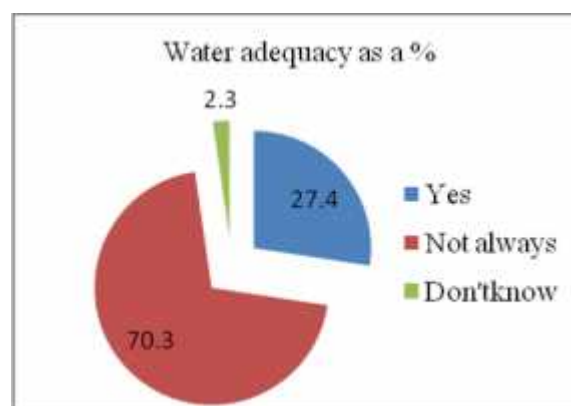


Fig 3.3: Level of domestic water adequacy in the supply area Researcher (2014)

The study shows figure 3.3 that only slightly over 27% of the respondents said that they have adequate water for domestic use. While over 70% of the respondents said that the water they use for domestic use was not always enough.

The results of these studies agree with those of Bateman [12] which estimated that only about one third of the rural population has access to improved water supplies during his study on the ‘comparison of the health effects of water supply and sanitation in urban and rural areas of five African countries’. Keith [13] in his study, analyzed some of the various factors contributing to the spread of the waterborne diseases, found that inadequate water supply for domestic use is one of the factors causing waterborne diseases.

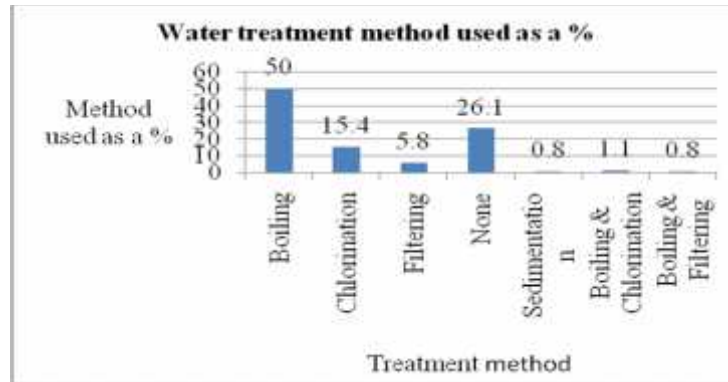


Figure 3.4: Methods of water treatment for domestic use

Source: Researcher (2014)

The study also showed that the community used various methods for treating available water for domestic use (figure 3.4) above with 50 % of those interviewed using boiling as the treatment method. From this study, it can be deduced that the methods used for household water treatment may not completely eliminated the waterborne diseases causing pathogens. However Clasen [14] established that interventions to treat and maintain the microbial quality of water at the household level are among the most promising approaches. A study done in the study area to gather up to date records of existing domestic water source points by the Government of Kenya [15] indicated that only about 14% of the households were seen to be taking water from the sources which could have been said to be clean. From the above analysis, the source of water, the quantity and the method of treatment seem to be contributing to the prevalence of waterborne diseases in the study area.

3.3 Waterborne diseases

The analysis of the secondary morbidity data, when analyzed separately for both over five and under five years put waterborne disease as number three among the top ten common diseases in the study area. The respondents were asked if they have ever been infected with waterborne diseases and 80% said yes while 20% said no. To assess the Knowledge on waterborne diseases transmission, the question was asked if intestinal worms can be transmitted from one person to another and only 22.2 % responded yes and slightly over 49 % did not know the mode of transmission as shown in figure 3.5 below. WHO [5] found that knowledge about the diseases was necessary in order to curb the spread of waterborne diseases.

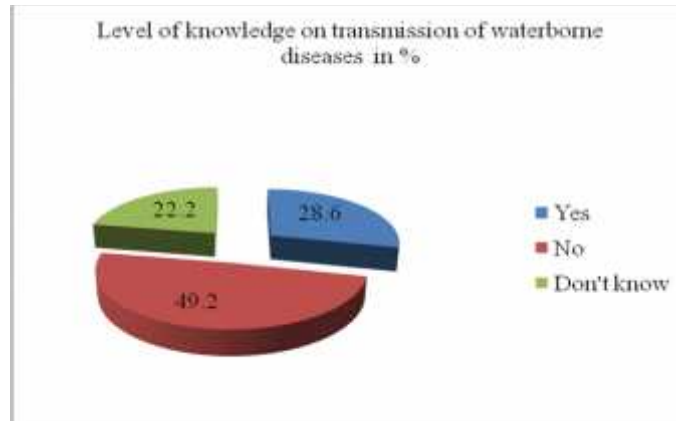


Figure 3.5: level of knowledge on transmission of waterborne diseases
Source: Researcher (2014)

Among those who acknowledged having had attacks from waterborne disease, 80.9 % had confirmed from laboratory test while 19.1% were treated without being tested in the laboratory. The rate of infection from the waterborne diseases per year is shown on figure 3.6 below; with majority being those who were infected twice in a year at 39%.

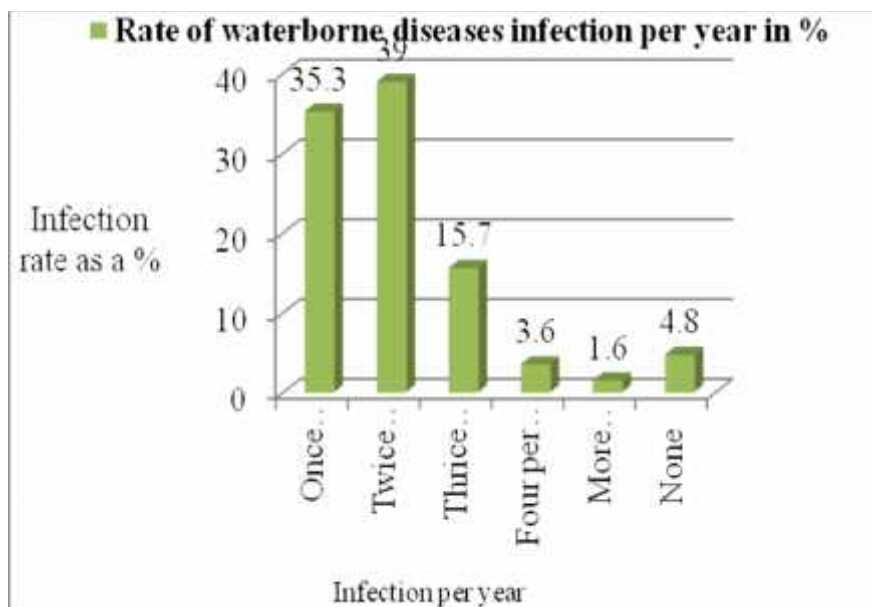


Figure 3.6: Rate of waterborne infection per year
Source: Researcher (2014)

The study showed a slightly higher % of waterborne diseases infections in over five years than that of children under five from the analysis of morbidity data from the ten health facilities. However in general, the output of this analysis showed a high prevalence of waterborne disease infection. In his study, Prüss-Üstün *et al.*, [16] established that waterborne diseases are largely diarrheal diseases, which as a group cause more than 1.5 million deaths per year, of which more than 90 percent occur in children under the age of 14. The discrepancy with this study where the infections of over five years were found to be more was perhaps because of the interventions. The researcher during his study established that the Kenya government had started a programme of de-worming children between 2-5 years and supplying water treatment chlorine tabs (section 1.8). Based on these interventions, it is

therefore prudent to say that the rate of infection of children under five could have been more than that of over five years. The study indicates that 80 % of the respondents within the study area have ever been infected with waterborne diseases at one time. The study further showed varying infection rates as above (figure 3.6). Sharon *et al.* [17] found that the recent estimate suggest that children under 5 years in developing countries have a median of two to three diarrheal episode per person year and children between six and eleven months five diarrheal episode per person year. A study conducted in Embu County by the Government of Kenya on the top ten causes of morbidity between January and December 2007 showed that intestinal worms range number three of all medical cases reported in the health facilities [18].

3.4 Correlation of study variables

Pearson product moment correlation coefficient (r) was used to show both direction and the strength of the relationships. In interpreting the values of correlation coefficients, Pallant [19] suggested $r = 0.01$ to 0.29 as small correlation, $r = 0.3$ to 0.49 as medium correlation and $r = 0.5$ to 1.0 as large correlation. Although a range of bivalent relationships between variables was observed by running the correlation through SPSS, the researcher only took into account output which made statistical sense i.e. $p < 0.05$.

3.5 Establishing the relationship between domestic water supply and prevalence of waterborne diseases.

From table 3.2 below the Pearson correlation coefficient relating to those who have ever been infected with intestinal worms and domestic water source was 0.176. This was a small relationship [18]. The variance or the overlap of the variable was about 3%. The statistical significance of the variables of $p < 0.006$ implies that the relationship was substantially significant. The low level of the relationship could have been due to the interventions to curb the waterborne outbreak in the area through de-worming and provision of chlorine tabs for water treatment by the Kenya government which reduced the prevalence of the waterborne diseases by 80% within the study area. Choffnes *et al.* [4] also found that outbreaks of cholera and other water-related diseases have been frequent occurrences, affecting the health and well-being of thousands of individuals. In sub-Saharan Africa, water resources are scarce and water availability may be seasonal.

Table 3.2: Parametric Correlation

	Pearson	1	2	3	4	5	6	7
Ever infected?	Coef.	1.000	0.465(**)	0.364(**)	0.297(**)	0.167(**)	0.304(**)	0.229(**)
	Sig.	.	0.000	0.000	0.000	0.006	0.000	0.000
Confirmed infect.	Coef.		1.000	0.443(**)	0.532(**)	0.046	0.146(*)	0.093
	Sig.			0.000	0.000	0.455	0.017	0.128
Infection rate	Coef.			1.000	0.331(**)	0.063	0.052	0.092
	Sig.				0.000	0.307	0.398	0.133
Ever admitted	Coef.				1.000	-0.016	0.209(**)	0.033
	Sig.					0.795	0.001	0.596
Water source	Coef.					1.000	0.244(**)	0.096
	Sig.						0.000	0.119

Water adequacy	Coef.						1.000	0.372(**)
	Sig.							0.000
Treatment method	Coef.							1.000

Correlation is significant at the 0.05 level

Source: Researcher (2014)

3.6 Chi-square test

In this study, the researcher used chi-square test for independent to determine the relationship between the variables and also to test the hypothesis. In testing the hypothesis, pallant[18] suggested that if the frequency departs from what is expected, and then we reject the null hypothesis that the two variables are independent of each other. In this study, for the purpose of hypothesis testing, the significant level was set at 0.05. Pallant[18] suggests that if the chi-square value of significant level is greater than the critical value, we reject the null hypothesis. In addressing the objectives and the hypothesis, the variables subjected to the model were; -

- i. *Those that have been infected with intestinal*
- ii. *Source of domestic water*

The Chi-square output for those that have been infected with intestinal worms at any one time and Source of domestic water is shown tables 3.3 and 3.4 below.

Table 3.3 Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	102.483(a)	20	0.000
Likelihood Ratio	27.364	20	0.125
Linear-by-Linear Association	7.430	1	0.006
N of Valid Cases	267		

Table 3.4 Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	0.620	0.000
	Cramer's V	0.438	0.000
N of Valid Cases		267	

3.7 Hypothesis testing that there is no relationship between domestic water supply and prevalence of waterborne diseases.

The chi-square model in this case was testing if there was a relationship between those infected with intestinal worms and the source of domestic water. The outcome of the results is shown in on table 3.3 and 3.4. The interpretation of this outcome showed that a chi-square test for independence indicated a strong significant association between those who have ever been infected with intestinal worms and the source of domestic water; $\chi^2 (1, n = 267) = 102.483, p < 0.0005, \phi = 0.620$. This showed a significant relationship and therefore rejected null hypothesis.

4. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

In determining the relationship between domestic water supply and prevalence of waterborne diseases, the Pearson correlation coefficient relating to those who had ever been infected with intestinal worms and domestic water source was found to be 0.176. However, the significance level of the variables of 0.006 implied that the relationship was substantially significant. From the hypothesis, the chi-square test for independence indicated a strong significant association between those who have ever been infected with intestinal worms and the source of domestic water, $\chi^2 (1, n = 267) = 102.483, p < 0.0005, \Phi = 0.620$. This showed a significant relationship and therefore rejected null hypothesis.

4.2 Recommendations

The government should ensure provision of adequate and clean domestic water supply to the community and also promote household treatment methods and safe storage in areas with limited water supply. There is a need for further research on this area of research covering different localities of Embu County.

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EMERGENCY OBSTETRICS TRAINING IMPROVING SKILLS AMONG HEALTH CARE WORKERS IN MIGORI AND NYERI COUNTIES

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Abstract

Introduction: Utilization of skilled health care has been found to be effective in reduction of maternal and newborn morbidity and mortality. Sufficiently trained health workers can competently handle and manage obstetric complications. Health workers, despite having undergone a formal training, require regular refreshers to keep up to date with new, evidence-based information.

Methods: This is an evaluation report following Emergency Obstetrics and Neonatal Care (EmONC) skills - based training by Maternal and Infant Survival and Healthcare Advancement (MAISHA), a project by Dedan Kimathi University of Technology (DeKUT) and College of The Rockies (COTR), Canada in collaboration with Liverpool School of Tropical Medicine (LSTM) and the Ministry of Health (MOH) among health care workers in Migori and Nyeri sub-County health facilities. A knowledge and skills pre-test was done before the training and a similar post-test was administered after the training to each participant to assess the level of knowledge and skills. Follow up was done to the trained participants four months after the training to assess the level of retention of the skills. Key informant interviews were also conducted to identify success and challenges faced in applying the basic lifesaving skills learned

Findings: The pre-test findings indicated that the health workers were equipped with theoretical knowledge, however the hands on skills were lacking in common procedures such as maternal and newborn resuscitation, breech delivery and use of a partograph in labour. After the training, knowledge was improved and skills were gained, the training being a skill-based training. Despite this, a follow up supervisory visits indicated need for a refresher training to improve further on the skills.

Conclusion: Skill training can enhance quality of obstetric care. A single training appears to be inadequate therefore more frequent skills-based trainings should be organized among health care workers in basic emergency obstetric care facilities.

Key words: Emergency Obstetric care, Training, Health care Workers, Skills

1.0 INTRODUCTION

Maternal and infant health has continued to be the centre of discussion in the international world. Women have a right to life while giving birth, however pregnancy and childbirth in developing countries is marred with challenges. Globally, 15% of women develop complications which can be life threatening if not managed quickly and efficiently (WHO, UNICEF, UNFPA 2012). Maternal and newborn health are closely linked. Every year, an estimated 3 million babies die within the first 24 hours after birth (WHO, 2010). Most of the maternal deaths occur in sub-Saharan Africa resulting mainly due to direct obstetric causes such as haemorrhage, eclampsia, sepsis and obstructed labour. Most of the maternal deaths occur in rural areas where there is limited access to health facilities (Rosmans *et.al*, 2003). The lifetime risk of death for a woman due to pregnancy is 1 in 52 in the less developed countries as compared to 1 in 4,700 in the developed world (WHO, UNICEF, UNFPA, 2012). Maternal and infant mortality is unacceptably high in Kenya, with a current maternal mortality rate (MMR) of 488/100000 and Infant Mortality Rate (IMR) of 52/1000 (KDHS 2008-09).

Improvements in maternal and newborn health are key Millennium Development Goals; strategies to achieve them include ensuring skilled attendance at birth and providing emergency obstetric care (EmOC) for women and infants who need it. Improving the capacity of maternity and newborn health care providers (HCPs) to provide this care is likely to contribute to improved maternal and newborn health. Key indicators to measure progress include the proportion of births attended by skilled health workers and the maternal and infant mortality ratios (UN, 2010).

World Health organization (WHO), United Nation's Children's Fund (UNICEF) and United Nations Population Fund (UNFPA) have advocated for improved access to emergency obstetric care as a way of reducing maternal and infant mortalities. Emergency obstetric care (EmOC) must be provided to all women requiring obstetric care. It is recommended that there should be at least four basic EmOC facilities and one comprehensive EmOC facility for every 500,000 people in the population (UNICEF, WHO, UNFPA, 1997). The services provided in a basic EMONC facility include administration of parenteral antibiotics, parenteral oxytocics, parenteral anticonvulsants, manual removal of a retained placenta, removal of retained products of conception by manual vacuum aspiration, assisted vaginal delivery and neonatal resuscitation. In a comprehensive EmOC facility, the services provided include the seven signal functions offered in a basic facility plus blood transfusion and surgery. In an EmOC facility, 100% of complications should be treated and the case fatality should be less than 1% (UNICEF, WHO, UNFPA, 1997). This therefore calls for staff competency while administering care.

Various efforts have been put in place by the Kenya government to address the issue of concern. One of the ways of addressing the issue is through equipping the health care workers with skills in emergency obstetric care to ensure effective handling and management of emergencies. Currently in Kenya, the Ministry of Health (MOH) in collaboration with Liverpool school of Tropical Medicine (LSTM) is rolling out a programme of training health care workers on emergency obstetric care. This is a skills oriented training where health workers are equipped with skills. The Maternal and Infant Survival and Healthcare Advancement (MAISHA) project is a partner with the LSTM and MOH in training health care workers at basic facilities i.e the dispensaries and health centres. The training encompasses all cadres of clinical staff working in the health facilities, the nurses, clinical officers and doctors. Evidence suggests that team training has better outcomes (Siassakos *et.al*, 2009). Use of traditional methods of training such as event analysis are reactive methods and are not effective as compared to skills training where competency is evaluated (Birch *et.al*, 2007). A recent systematic review of maternal health interventions in resource-limited countries showed that programs integrating multiple interventions—including EmOC training; placement of providers; refurbishment of existing infrastructure; and improved supply of drugs, supplies, and equipment—are likely to have a significant positive impact on maternal and newborn health (Nyamtema, 2011).

2.0 MATERIALS AND METHODS

This is an evaluation report following Emergency obstetrics training by MAISHA project among health care workers in Migori and Nyeri County health facilities. The health facilities supported by the project are Karaba, Kamoko, Gichiche and Njokini health centres and dispensaries in Nyeri County and Nyamaraga, Ogwedhi, Godkwer and Ondong' health centres and dispensaries in Migori County. Staff from all the eight health facilities in the two counties, where the project is currently working attended a one week skills competency training course on emergency obstetrics and infant health. On induction to the training, a pre-test was done which involved both written and practical tests to assess the level of knowledge and skills among the participants. The written test was used to assess the level of knowledge in the common obstetric areas. Management of common obstetric emergencies was evaluated with the use of obstetric mannequins. A similar test was done at the end of the training to assess how much the participants had learned. Observation was made on how the staff carried out the skill systematically and marks were awarded based on their performance. A follow-up was done four months later after the training to assess the level of skill retention. An evaluation visit was made to all the facilities and mannequins were used to assess the specific skill retention among the trained staff. Each staff was given a chance to demonstrate the various skills they had been trained on. Observations were made while the staff carried out the demonstration. In addition, key informant interviews were also conducted to identify success and challenges faced in applying the basic lifesaving skills learned.

3.0 FINDINGS

The training was offered to a total of 58 (80%) clinical staff working in the MAISHA project-supported health facilities. A total of eight facilities were visited where a total of 58 staff from the facilities were assessed on skill retention. Most of the staff reported much improvement on how they carried out the skills after the training as compared to before the training.

3.1 Knowledge assessment

At the start of the training, an evaluation test was done to assess the level of knowledge of the participants before the training. The areas evaluated during the written pre-test were communication and triage, obstetric haemorrhage, management of shock and unconscious patient, management of obstructed labour through use of partograph, management of pre-eclampsia and unsafe abortion. Despite the participants being knowledgeable, there was improvement after the training in most of the trained areas. There was no change in the level of knowledge in communication, triage and referral. There was marked improvement of knowledge in management of shock and unconscious patient from 74 to 90%. The average level of knowledge on obstetric emergencies was low before and after the training at 57 and 61% respectively. The figure below indicates the findings of both the pre and post - tests.

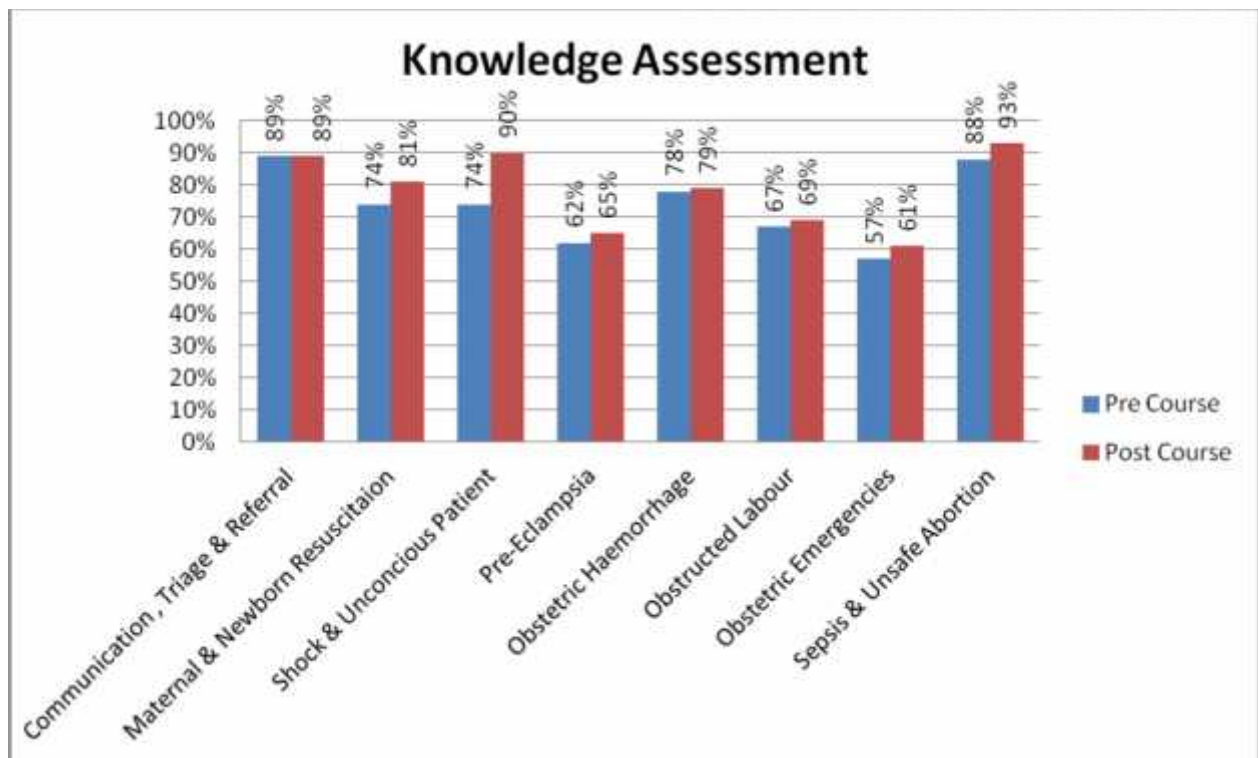


Figure 1: Pre and post – test findings on knowledge assessment

3.2 Practical tests

On the practical tests, skill assessment was done on newborn and maternal resuscitation, assisted vaginal delivery and obstetric complications. The findings indicated that most of the

skills were lacking before the training, however, there was much improvement after the skills training. Despite this improvement, three months after the training, it was found out that competency of some skills still required refresher training to enhance retention.

3.2.1 Maternal resuscitation

Each participant was assessed on each of the steps of maternal resuscitation (call for help, assess ABCs, manage as appropriate with ventilations and chest compressions). In the pre-test, 61% of the participants were not able to shout for help while (49%) could not assess for the patient's response. Also, the resuscitation steps; airway management, ventilation or chest compressions were very poorly done. In the post test, it was evident that learning had taken place since all the participants remembered the initial step of shouting for help, however, there is need to further improve the critical skills of resuscitation such as airway management and chest compression.

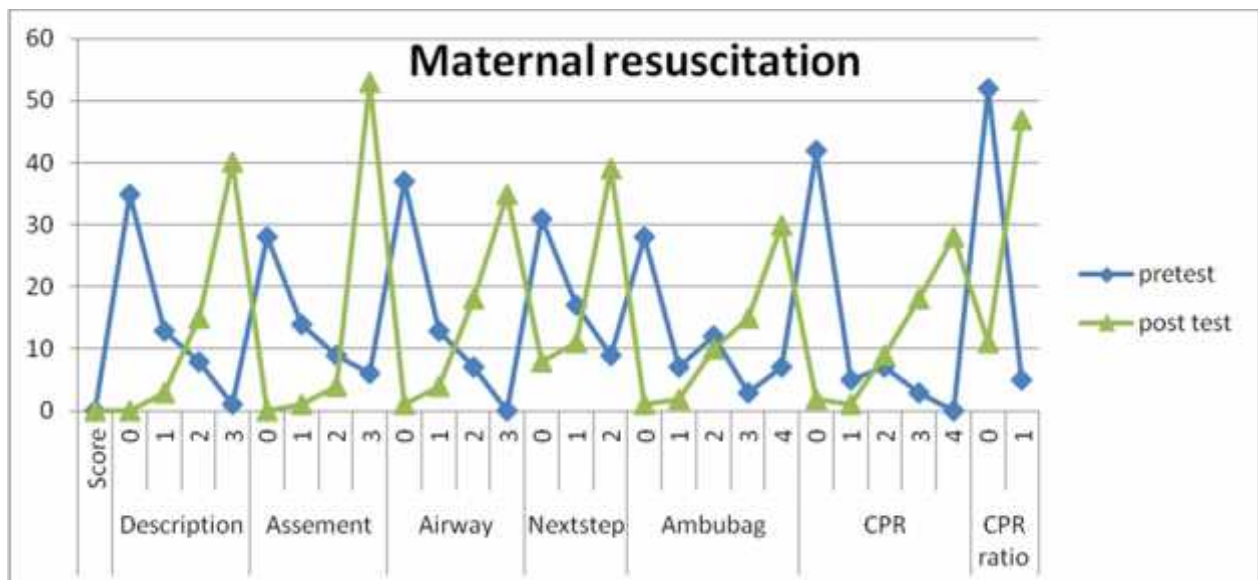


Figure2: Pre and post - test findings on maternal resuscitation

3.2.2 Newborn resuscitation

Newborn resuscitation is a procedure done when a baby fails to establish respirations after birth and it involves various steps. The pretest findings indicated that the participants were well-versed with newborn resuscitation (stimulate and dry, position, assess, ventilate, and provide chest compressions). However many of them were not able to place the baby in a good neutral position, reassess the apex beat or give inflation breaths. During the post test, most of the participants were able to stimulate the baby, place in neutral position and give chest compression. However, it was found out that even after the training, most of the participants could remember how to stimulate the baby, place in neutral position. However, some of them were not able to chronologically carry out the resuscitation procedure. This indicated the need for a follow up training to enhance this skill. The evaluation visit findings

indicated that the participants still required more training to competently carry out the procedure. It was observed that some of the participants as they practiced on the mannequins still had a challenge in ventilation and performing chest compression.

‘We managed to successfully resuscitate one baby after the training, although I feel we still need more refresher training on this because it is very important’. (Nurse, dispensary)

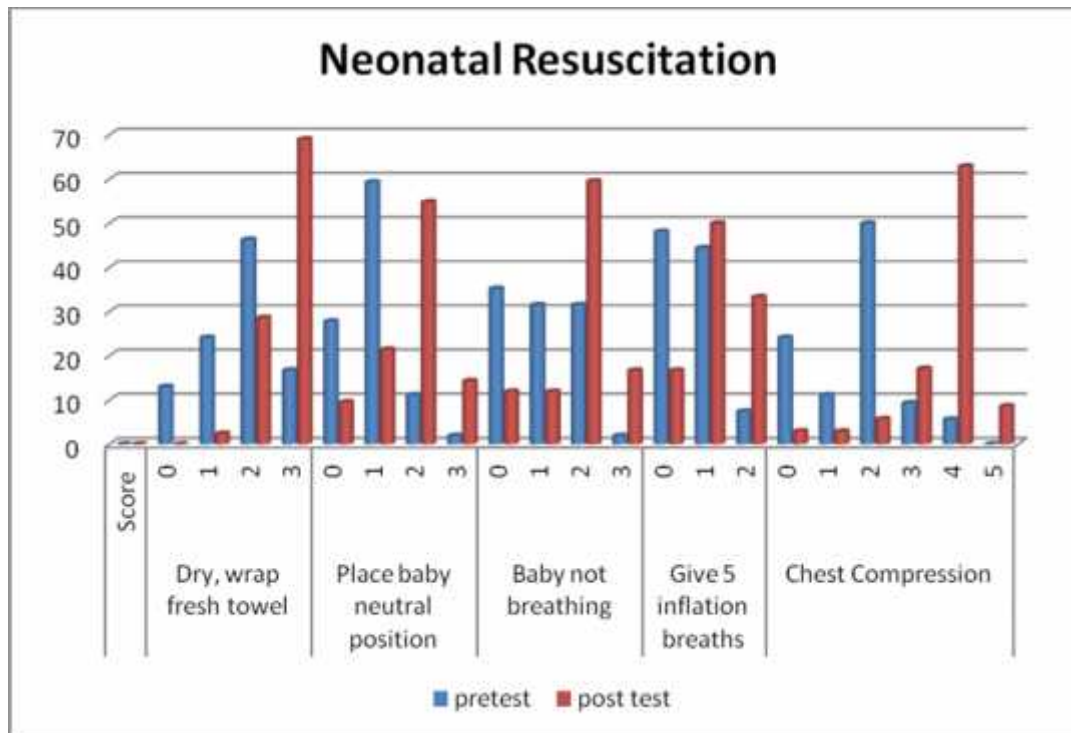


Figure 3: Neonatal resuscitation practical

3.2.3 Vaginal breech delivery

Breech delivery is one of the common abnormal presentations which may present as complete, frank or footling breech. A vaginal delivery in this case is attempted if it is a complete or frank breech if the baby is of average size and once a pelvic adequacy assessment has been done. This is a delivery that is conducted ‘hands off’ when the breech is coming and only interventions are made when the delivery is not spontaneous. During the pre-test, most of the participants were not able to give a description of how to conduct the ‘hands off’ aspect of the delivery. In addition, the skill for conducting the delivery of the arms and legs in complicated breech was lacking. There was notable improvement during the post-test since most of the participants were able to describe the delivery and demonstrate delivery of the arms. However, the delivery of the legs was still a problem since only 20.7% of the participants scored the highest marks. During the evaluation visits, some of the participants had been able to successfully conduct a breech delivery in their facilities although most of them indicated the need for a refresher training.

‘After the training, I have been able to carry out one breech delivery and the baby scored well’ (Clinical officer, dispensary)

Table 1: Breech delivery

		pretest		post test	
Practical questions	Score	n	%	n	%
Delivery Description	0	30	52.6	4	6.9
	1	20	35.1	8	13.8
	2	7	12.3	46	79.3
Total		57	100.0	58	100.0
Leg – Delivery Demonstration	0	9	15.8	0	0.0
	1	35	61.4	24	41.4
	2	13	22.8	34	58.6
Total		57	100.0	58	100.0
Arms - Delivery Demonstration	0	4	7.0	0	0.0
	1	7	12.3	0	0.0
	2	19	33.3	1	1.7
	3	16	28.1	4	6.9
	4	10	17.5	20	34.5
	5	1	1.8	21	36.2
	6	0	0.0	12	20.7
Total		57	100.0	58	100.0

3.2.4. Assisted vaginal delivery

Assisted vaginal delivery is done through the use of a vacuum set in cases where there is delay in second stage of labour with a full descent of the head. In the assisted vaginal delivery station participants were assessed on their knowledge indications for and complications of vacuum extraction and demonstration of its safe use. The pretest findings indicated that only a few participants were aware of the indicators and complications of the assisted vaginal delivery. However, all (100%) of the participants were not skilled on how to carry out the procedure. After the training, 43.1% of the participants were able to correctly demonstrate the procedure of assisted vaginal delivery. Less than half of the participants (48.3%) could

mention correctly the pre-requisites of a vacuum delivery. Most of them could remember the complications that may arise with the procedure.

The in-depth interview findings during the evaluation visits indicated that the participants were ready to embrace the use of the equipment in their facilities although they indicated the need of more practice before competently practicing the procedure in their facilities.

‘Initially, we feared to use the vacuum delivery kits because of the rumour that it can cause brain damage’ (Nurse, health centre).

‘Once we get the vacuum sets, we will be able to practice the delivery but we still need more practice before using the equipment’ (Clinical officer, health centre)

Table 2: Assisted vaginal delivery

	pretest			post test		
Practical questions	marks	n	Percentage (%)	n	Percentage (%)	
AVD Indicators	0	21	36.8	3	5.2	
	1	17	29.8	2	3.4	
	2	16	28.1	18	31.0	
	3	2	3.5	16	27.6	
	4	1	1.8	19	32.8	
Total		57	100	58	100	
AVD pre-requisites	0	20	35.1	1	1.7	
	1	19	33.3	2	3.4	
	2	14	24.6	11	19.0	
	3	4	7.0	16	27.6	
	4	0	0.0	28	48.3	
Total		57	100	58	100	
Vacuum extraction Delivery Demonstration	0	57	100.0	3	5.2	
	1	0	0.0	9	15.5	
	2	0	0.0	21	36.2	

	3	0	0.0	25	43.1
Total		57	100	58	100
Vacuum extraction Complication	0	16	28.1	1	1.7
	1	22	38.6	6	10.3
	2	15	26.3	14	24.1
	3	4	7.0	37	63.8
Total		57	100	58	100

4.0 DISCUSSION

Skills training is a very vital component of health care training. Retention of skills is also an aspect that is critical in patient management. With the ever-changing nature of medical care, frequent refresher courses in skills training are key to enhancing retention.

The study findings indicated that the participants were knowledgeable on the areas that were tested which included communication and triage, obstetric haemorrhage and management of shock and unconscious patient. This could be attributed to continuous professional education where the health care workers get updates on new knowledge. However, for the skill performance, gaps were noted on the skills that were tested. This could be attributed to emphasis on knowledge acquisition rather than skills in most trainings.

Resuscitation of the newborn is an important and frequently required skill in many EmOC facilities. The pre-test findings indicated that the skill of newborn resuscitation was lacking among most of the health workers. This could be attributed to lack of skills training updates. In addition, most of the staff worked in basic facilities where deliveries are fewer compared to the higher level health facilities and also early referral of complications. A skilled health care provider should be able to handle these complications competently, therefore reducing the risks of poor outcomes. A retrospective observational study to assess impact of training on Apgar scores in a tertiary hospital in Bristol found out that there was an association of significant reduction in low 5 –minute Apgar scores with the introduction of obstetric emergencies training courses (Draycott *et.al*, 2006). In another skills training on neonatal resuscitation, improvement of Apgar scores of neonates was significant after the training (Patel *et.al*, 2001).

Maternal resuscitation pre-test findings indicated that the participants were lacking competency in the skill. Most of the leading causes of maternal mortality are preventable including haemorrhage. Through resuscitation, near misses and maternal deaths can be averted. The pre-test study findings indicated that most of the participants were not

competent in carrying out maternal resuscitation. This could be attributed to limited opportunity for practice due to early referral of clients with complications who are referred to higher level facilities. Resuscitation is challenging thus prompt initiation is important to save the life of the mother (Campell and Sanson, 2009). Adequate staff training is important to enable them manage cardiac arrest in emergency obstetric care (Catling, 2011).

Vaginal breech delivery may lead to maternal and neonatal complications if not handled skillfully. The study findings indicated that the skill was lacking for complicated breech in the pre-test but much improvement was noted during the post-test. This could be attributed to lack of practice since breech deliveries are often referred to high level facilities. Vaginal breech delivery can be a safe option which can lead to positive maternal and neonatal outcome if the criteria is met before and during labour (Habib et.al, 2013). A study comparing planned vaginal delivery versus elective caesarean section in singleton term breech presentation in Lyon found out that there was increased risk of neonatal deaths and complications in planned vaginal delivery while elective caesarean section increased the possibility of only minor maternal complications (Golfier *et.al*, 2001).

Assisted vaginal delivery is a procedure which is being rolled out to the lower level facilities in Kenya. Most of the participants were not aware of the procedure during the pre-test. This could be attributed to lack of the assisted vaginal delivery equipment in the facilities. From the findings, most of the participants had misconceptions associated with the use of the equipment. The use of vacuum delivery for assisted vaginal delivery has been found to reduce maternal mortality (Johanson and Menon, 2010). Assisted vacuum delivery has been associated with increased risk for neonatal intracranial hemorrhages (Ekéus et.al, 2014). Studies indicate that the incidence of cephalhematoma decreases with more skilled experience gained with vacuum extraction (Shekar et.al, 2012). This indicates the need for competency among the staff carrying out the procedure.

5.0 CONCLUSION

Obstetric emergencies are sometimes inevitable therefore staff competency in managing the complications is paramount. A one week skills training was found to significantly improve the level of knowledge and skills among the participants comparing the pre- and post-test scores. Suboptimal performance of some common skills like neonatal resuscitation, postpartum haemorrhage management and conducting breech delivery during the post-tests and the assessment visits indicated the need for ongoing refresher training on the specific skills.

Recommendation

As it appears a single training is inadequate to ensure adequate acquisition and retention of many of the complicated skills required in emergency obstetric care, staff need to have refresher trainings and supportive monitoring and supervision.

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TRACK 6: BUSINESS

ARE THE STOCKS IN EMERGING FINANCIAL MARKETS WELL VALUED? EVIDENCE FROM NAIROBI SECURITIES EXCHANGE

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Abstract

The study sought to determine whether the stocks in emerging market are well valued using NSE-20 Share index as the proxy for the market. A latter day valuation model known as Residual income valuation method together with special capital asset pricing model were used. Data was obtained from the audited financial statements of companies contained in NSE handbook and the Central Bank of Kenya annual report from year 1998 to year 2011. A time series regression model was used to forecast returns on equity, earnings per share and book values of equity. The intrinsic values of the stock was computed and compared with the market values. The result shows that the stocks are well valued.

From an academic dimension the paper contributes to the valuation literature. Shareholders and potential investors at local and international level stand a better chance of knowing whether the stocks are correctly priced, undervalued or even overvalued. This will enable them to make an informed decision on whether to dispose (sell) or acquire more (buy) shares in the company.

Keywords: Intrinsic value, residual income model, security exchange.

1. INTRODUCTION

An emerging market is a market that has been or is in the process of globalization thereby opening its borders to the flow of international trade and investment activities, with an end result of a self feeding process which intermingles and increases cross border flow and uniformity of habits in the financial arena both at the individual and corporate level (Pereiro, 2002). The difference between emerging markets and developed market is evident in areas such as governance, transparent financial reporting, liquidity, corruption, volatility, taxes, and transaction costs (Bruner *et al*, 2002). A good number of financial markets: Money market and capital markets in the developing economies especially in Africa are in this stage after going through the process of financial liberalization successfully. Nairobi security exchange is an example of such a market.

Despite the tremendous mutations that have been witnessed in the corporate finance theory, the theory revolves around three decisions that an investor must make: investing, financing and dividends. Investment decision is the fundamental in that the other two decisions can be made and implemented only after the decision is made (Tirole, 2006). Rational and informed investors both at local and international level, finance scholars and practitioners makes an investment decision after assessing the security's intrinsic value with its extrinsic value (Kariuki and Oyugi, 2013). Security's intrinsic value is the true value of the security which is anchored on the internal business drivers whereas the extrinsic value is the fair value assigned to the security by the market, it is the value/ price informed buyers and sellers are willing to trade security without coercion.

Evidence show that developed markets seem to converge on best practices of security valuation: Bruner et al. (1998), Graham and Harvey (2001). The success of a later day security valuation model, the residual income valuation model has been investigated in the developed financial market with researchers concluding that the model is able to value securities accurately, among them being Lee *et al*, (1999, 2012), Frankel and lee (1999) and Higgins (2011). Literature search show that security valuation in emerging markets is inconclusive. The fact of matter is there is no best practice regarding security valuation: Bohm et al. (2000), Pereira (2002). This is evidently shown in text books where the writers reveal substantial disagreement about fundamental issues such cost of capital estimation for discounting cash flows. In Kenya's rudimentary financial market a number of models have been tested and found to be unreliable in determination of security value: among them being dividend discount model (Olweny, 2011), capital asset pricing model and dividend discount model (Omondi, 2003).

Empirical literature review reveal existence of a gap, therefore, the objective of the paper is to address the issue by testing whether the securities in emerging financial market are well valued by combining residual income valuation model with special capital asset pricing model using Nairobi security exchange as the proxy for the market.

2. METHODS/METHODOLOGY

Data was obtained from the firm's audited financial statements contained in NSE handbook and the Central Bank of Kenya annual report from year 2002 to year 2011. The period was considered long enough to provide sufficient data for formulating regression equation. Selection of year 2002 is important because it coincided with the end of the 2000/2001 global recession and also coincided with an important event in Kenya's history: the change of political leadership for the first time since independence to a different political regime that offered hope to common citizen as it was viewed as business friendly. Nairobi security exchange limited twenty share index had twenty firms by the end of year 2011, it comprises of blue chips companies selected on a weighted market performance for a twelve period month. A census study of all the twenty firms listed in the index was done.

Data was analyzed using residual income valuation model shown in equation (1) which was partially borrowed from lee *et al*, (1999). According to ohlson 1995 the true value of security can be written as the reported book value plus an infinite sum of discounted residual income.

$$V_{St} = B_t + \frac{(ROE_t - re)}{(1+re)^i} B_{t+1} + \frac{(ROE_{t+i} + re)}{(1+re)^i} B_{t+2} + TV \quad (1)$$

Where V_{St} = Value of security at time t, B_t = Book value at time t, is the expectation based on information available at time t, re = cost of equity capital ROE_{t+i} = after tax return on the book equity for the period $t + i$. Tv = terminal values. $i = 1, 2, 3, \dots, n$. To determine the cost equity capital special capital asset pricing method, was used, this was achieved by relaxing the assumption of of standard CAPM (Sharpe *et al.*, 1999).

$$(r_{it} = r_z + (rm - r_z)\beta_{it} \quad (2)$$

Where asset z has

$$\beta_z = 0 = COV_{T_z, T_m} = \rho = \frac{COV(z, m)}{\sigma^2} \quad (3)$$

$$R_{it} = (P_{it} - P_{i,t-1})/P_{i,t-1} \quad (4)$$

P_{it} = Closing price of the security i in t period, R_t = required rate of return on security at time t, rm = rate of return on market portfolio, $\beta_{i,t}$ = beta r_z = rate of return on asset z.

Study Area

If the research is undertaken in a specific area, then some mention should be made about the study area. What are its unique features and their relevance to the study?

Data

Data collection approaches should also be discussed if they were involving and/or used novel approaches.

In case you need to add subsections then this is the approach that you should use, appropriately positioning them as need be.

Indicate the approximate location of the figure in the manuscript as shown here for figure 1 and below for table 1. Any figures and tables included in the manuscript should be referenced in the text when explanations on the pieces of information held, e.g. figure 1 shows the seasonal fluctuations of both monthly mean temperature and rainfall. It shows two peaks in rainfall with a peak around May corresponding to the heavy rain season and around October for the light rain season.

3. RESULTS AND ANALYSIS

Cost of capital was estimated for all the twenty companies as shown in table 1 using the special capital asset pricing model. The required rates of return were used to discount the after tax income, book value of equity and the terminal values for each of the company. The security's intrinsic values were computed and compared with the reported market value, this being the decision making criteria. For the purpose of discussion only the computed intrinsic value for year 2011 were presented. The intrinsic values and the reported market values of firm's security in the NSE for year 2011 are presented in table 2.

The security intrinsic value can termed as undervalued, overvalued or correctly valued. From the investor perspective it is the undervalued securities that are of importance and if this information is availed to them, then they stand a better chance of making informed investment decision. From the table, the intrinsic value of seven companies was undervalued. These included East African Breweries Limited, Centum Investment, Rea Vipingo, Kenya Commercial Bank, British American Tobacco, Kengen and Equity bank. These securities were considered good for investment purpose. Intrinsic value of Athi River Mining deviated from its market price by a very big margin; this could be attributed to the indebtedness in the company. The intrinsic values of the other remaining companies were overvalued, difference between the computed and the reported value was however not significant. These findings are in agreement with the studies done this area: Kariuki and Oyugi 2013 conducted a study using residual income and standard capital asset pricing model, the result were positive, however they recommended more research on the residual income valuation model with zero beta capital asset pricing model. The study demonstrated that despite the financial market (Nairobi Security Exchange) being inefficient the security value can indeed be predicted contrary to a number of studies, among them being Olweny (2011).

4. CONCLUSION

The objective of the study was to establish whether the securities in the emerging financial market are well valued. Securities intrinsic's values were determined using residual income valuation method and zero beta capital asset pricing model and compared with market prices. The conclusion was that security values in emerging market are well valued.

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DETERMINANTS OF M-COMMERCE USAGE BY CONSUMERS IN KENYA

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Abstract

The purpose of this study was to examine the factors that influence consumer's usage of m-commerce in Kenya. The purpose was in two folds; to identify the drivers that influence M-commerce usage and to make recommendations for effective adoption of M-commerce in Kenya.

A desktop research was carried out where existing literature will be analyzed locally and globally to ascertain these factors and the most convenient theoretical foundation to be used in this study.

Findings- Technology acceptance model (TAM) was found to be the predominant model in M-commerce studies though many studies acknowledged its weaknesses of being too narrow. Some of the factors widely mentioned in these studies as the drivers of M-commerce usage included; demographic factors ,perceived security risk and perceived benefits, perceived ease of use, social influence and perceived cost.

Practical implications- The result of this study will be important to firms that wish to adopt and use m-commerce in their business strategies and also formulate suitable marketing strategies and products that are attractive to consumers.

Value of the studies- majority of the studies in this area has largely focused on the M-commerce adoption ignoring the important aspect of usage. These applications can only add value to the firms through usage rather than just adoption and penetration.

Keywords: m-commerce, consumers, usage, Technological acceptance model

1. INTRODUCTION

Kenya is a developing country with four main mobile money service providers; M-Pesa, YuCash, Airtel Money and Orange Money. The leading mobile money service M-Pesa processes more transactions domestically within Kenya than Western Union does globally and is currently providing mobile banking facilities to more than 70 per cent of the country's adult population (Jidenma, 2011). In Kenya, the mobile money payments have empowered the local people in transacting businesses and therefore having a source of income. M-commerce is an emerging trend in Kenya and it allows the local people to buy and sell products and services online. Though mobile technology has been available for the last decade there is no standard definition of the term M-commerce. While some researchers have defined it as an extension of E-commerce Ngai & Gunasekaran, (2007), others have argued that m-commerce is more than extended e-commerce due to diverse interaction patterns, usage and value chain (Cho & Lee, 2007). Bakar & Osman, (2005) defined m-commerce as exchange or buying and selling of commodities and services through wireless handheld

devices such as cellular telephones and personal digital assistant (PDAs). Chan & Chong, (2013) also defined m-commerce as any transaction that involves the transfer of rights to use goods and services that is initiated by using mobile access to computer-based networks with the help of mobile devices. It is apparent that the potential and benefit of m-commerce are widely documented. M-commerce has a lot of potential in developing countries as small- and medium-sized companies in remote areas can use them to reach many potential customers while consumers can use them to access various services with ease (United Nations, 2002). In addition, mobile devices are small in size and light in weight hence they are convenient for users to carry around as they go around their daily businesses (Schwidorski-Grosche and Knospe, 2002). Furthermore, given that mobile devices are usually owned by individual and not shared between different users, m-commerce allows the services to be catered towards the users' needs.

Despite this well documented potential, existing literature has revealed that M-commerce actual usage has remained low with majority of users using mobile devices for entertainment purposes such as listening to music and content browsing. In addition studies focusing on this topic have largely been carried out in developed countries as evidenced by (Chan & Chong, 2013; Ngai & Gunasekaran, 2007; Wei, Marthandan, & Chong, 2009). It is therefore important to investigate whether the results found in a developed world context are generalisable even with the apparent demographic, economic and social differences that exist between developing and developed worlds.

Objective

The overall objective of this study was to investigate the factors that influence M-commerce usage by the Kenyan consumers and determine the level of usage.

2. LITERATURE REVIEW

Mobile devices are constantly becoming more readily available in the world (Gartner Research, 2003). Mobile money transfer services (MMT) and electronic Person-to-Person (P2P) payments systems as an alternative to the paper based mechanism like cash are some of the innovation which have been perpetuated by this rapid development in mobile phone technology (Pickens and Richardson, 2007). Common mobile financial services offered via the mobile phone include; bill payment, account transfers, domestic and international P2P transfers, proximity payments at the point of sale and remote payments to purchase goods and services (Juniper, 2009). Various studies have proposed application framework for m-commerce and divided the applications in to the following activities; location based services, mobile advertising, mobile entertainment, financial applications and product locations and searching (Ngai & Gunasekaran, 2007). Chan & Chong, (2013) undertook a confirmatory factor analyses to validate them empirically and classified them in to four categories as; content delivery, transactions, entertainment and location based services. The study revealed that the factors influencing these m-commerce activities varied.

Theoretical foundation

A thorough review of the existing literature revealed that there is a rich stream of theories that has been used in the various studies focussing on adoption, usage and implementation of technological innovations such as: Technological Organisation Environmental (TOE) model developed by (Tornatzky & Fleischer, 1990), Technology Adoption Model (TAM) developed by (Davis,1989) and diffusion of innovation (DOI) model developed by (Rogers, 1983). Technology Adoption Model (TAM) has been widely used by researchers in studies focusing on the usage of new technological innovations such as m-commerce and E-commerce specifically by consumers as evidenced by ; (Chan & Chong, 2013; Litondo & Ntale, 2013; Ngai & Gunasekaran, 2007; Njuguna, 2012). However this model has been criticized by researchers citing its narrow variables as it only analyses the perceived usefulness and perceived ease of use. Chan & Chong, (2013) argued that online usage and m-commerce are used for different activities such as entertainment, information seeking and transaction which have different attributes and different uses and therefore the two TAM indicators may not be adequate. To cater for the model limitations (Chan & Chong, 2013) extended the model and included other factors such as demographic variables (age, gender and education level), motivation variables (perceived enjoyment), and perceived security to make the model more diverse. Isaiah, Omwansa, & Waema, (2012), used TAM in a study investigating the application of the model in M-banking in Kenya and highlighted several model shortcomings that included ; Model design which is more of organisation oriented rather than individual hence not favourable to be used in mobile technology adoption. The model was also said to be limited in variables as there existed other variables that would influence mobile usage. Lastly, it had a limitation in its explanation of other forms of technologies in this case mobile technologies innovations. Isaiah et al., (2012) therefore argued that, for the model to be accepted in mobile innovations studies; it was inevitable to extend it by including variables adopted from Theory of Planned Behaviour (TPB) such as subjective norm, self efficacy, perceived credibility and transactions costs.

3. RESEARCH METHODOLOGY

The study is exploratory in nature. To achieve the research objectives, desk research that used secondary data was employed. This was accomplished through literature review of relevant books, government publications, journals and studies to obtain information on mobile commerce usage and the determinants that influences the usage. Information reviewed was evaluated to draw meaningful conclusions and recommendations.

4. STUDY FINDINGS AND DISCUSSIONS

The importance of Information Communication Technology (ICT) innovations as a driver of economic development and improved organization performance is acknowledged in the most of the reviewed literature. Various factors that affect a consumer intention to use m-commerce have also been revealed in literature reviewed. They include; perceived usefulness, perceived ease of use, security risk, social Influence, trust and perceived cost, demographic factors and motivation variables.

3.1 Perceived usefulness (PU)

PU is defined as the degree of which an individual believes that using a system would improve his or her job performance (Davis, 1989). The effect of PU on IU has been validated in many existing studies; (Lin, & Wang, 2005); (Wei et al., 2009). For example, (Lin, & Wang, 2005) suggested that the usage of m-commerce is strongly driven by the usefulness of the mobile service, which includes ubiquity, personalization, localization, timeliness and network stability. Reviewed literature revealed that perceived usefulness influences mobile technology usage in activities such as content delivery, transactions and entertainment (Chan & Chong, 2013). In Kenya, reviewed literature indicates that perceived usefulness is one of the key factors that influence adoption and usage of internet based technologies (Isaiah et al., 2012; Litondo & Ntale, 2013; Njuguna, 2012).

3.2 Perceived ease of use

Although an individual may believe that an application is useful, he or she might also find that the system is difficult to use (Davis, 1989). PEOU has been considered as an important determinant in adoption of past intranet based technologies (Blanca & Julio, 2009; Njuguna, 2012) and m-commerce (Lin and Wang, 2005; (Chan & Chong, 2013; Litondo & Ntale, 2013; Ngai & Gunasekaran, 2007; Wei et al., 2009). According to Rogers, (1983), complexity of one particular system will become the inhibitor that discourages the adoption of an innovation. Once again borrowing from Davis (1989), PEOU refers to the degree to which an individual believes that using m-commerce would be free of physical and mental effort. For example, someone may find using services on mobile devices tedious and complex due to the constraints of physical features of m-commerce such as its small display screen or difficulty in keying in data. Existing literature from Kenya revealed that perceived ease of use is a key factor that influence internet based technology adoption and usage (Isaiah et al., 2012; Njuguna, 2012). (Chan & Chong, 2013) revealed that perceived ease of use (PEOU) had a great influence in activities such as content delivery, entertainment, transactions and location based services. Empirical study is required to ascertain whether this applies in Kenya.

3.3 Social influence

According to Lu et al. (2003) is equivalent to subjective norm and is defined as an individual's belief about whether significant others think that one should engage in the activity. Subjective norm is studied in both TRA and TPB as the important determinant to explain the adoption of a system. Chang (2004) found that social factor, which is derived from TPB, can enhance the validity of the TAM in intranet usage. Based on DOI theory, SI can be divided into two forms: mass media and interpersonal influence (Rogers, 1983). Mass media influence includes newspapers, magazines, academic journals, television, radio, internet, and other applicable mediums. Interpersonal influence normally comes from social network such as peers, friends, superiors and so on (Rao and Troshani, 2007). Fan et al. (2005) stated that user is more likely to suggest and recommend a service to others, if he or she is satisfied with the service. Their finding also revealed that SI had more impact on user's

acceptance of m-commerce than PU and PEOU. Khalifa and Cheng (2002) also found that SI had strong effect on consumer IU the m-commerce. Social influence only influenced activities such as content delivery and entertainment (Chan & Chong, 2013).

3.4 Trust

Trust is an important element affecting consumer behavior and it determines the success of technologies adoption and usage such as e-commerce (Wei et al., 2009). There are various definitions of trust in existing literatures. (Cho & Lee, 2007) defined trust from the business point of view, as “buyer-seller relationships as the perception by a prospective buyer of credibility and benevolence in the target of trust”. (Chew, 2007) stated that trust in e-commerce is the belief that allows consumers to willingly become vulnerable to the online retailers after having considering the retailers’ characteristics. This definition is consistent with the construct of trust as a salient belief that includes goodwill trust (benevolence) and credibility (honesty, reliability, and integrity) (Chew, 2007). This definition of captured two distinct but inseparable facets of trust in e-commerce. It involves the traditional view of trust in a specific party (online companies) as well as implicitly encompasses trust in the integrity of the transaction medium (internet security technology) (Chew, 2007). Trust is more crucial and complex in environment such as e-commerce and m-commerce than general and traditional commerce due to its uncertain environment and information asymmetry (Cho & Lee, 2007). The buyers and sellers normally complete the transaction through these technologies will not necessary meet each other face to face. The buyers will thus be worried that their personal information and money will be transferred to third party without their knowledge (Lu & Yao, 2003). Sathye (1999) identified security concern as the “biggest obstacle” to adoption of online banking in Australia. According to Lu & Yao, (2003), m-commerce is exposed to greater danger of insecurity than e-commerce and therefore the importance of trust is relatively higher in m-commerce. In addition they found that perceived credibility (security and privacy) has a stronger effect on consumer IU mobile banking than PU and PEOU. In this study, trust is defined as the extent to which an individual believes that using m-commerce is secure and has no privacy threats. Wei, Marthandan, & Chong, (2009) Carried out a study on M-commerce adoption and found out that trust significantly influenced the consumers M-commerce adoption and usage intention. No study was found to have tested this variable in Kenya to ascertain whether the results given were applicable.

3.5 Perceived cost

Price or cost factor is one of the reasons that could slow down the development of m-commerce. Cost factor may consist of initial purchase price (e.g. handset fee), ongoing usage cost (subscription fee, service fee and communication fee), maintenance cost and upgrade cost (Lin, & Wang, 2005) Pagani, (2004) stated that price or cost factor was one of the main determinants of 3G services adoption. Anil et al. (2003) also stated that cost is one of the factors influencing the adoption of m-commerce in Singapore. Sathye (1999) stressed the importance of

Price or cost factors in adoption of innovations. He stated that cost is one of the reasons that prevent consumers from Singapore and Australia to use internet banking. Wei et al., (2009) also found that cost related issues is more important than privacy and security issues when it comes to the adoption of 3G services among users in Finland. In this study, the cost factor is tested in “Perceived cost” construct which is defined as the extent to which individual perceive that using m-commerce is costly. In Kenya studies that tested this variable includes; (Isaiah et al., 2012; Litondo & Ntale, 2013; Njuguna, 2012). All these studies found a positive influence of cost on M-commerce application adoption and usage amongst consumers in Kenya.

Demographic variables

Demographic variables such as age, gender, education level have widely studied and documented in the internet based technology adoption and usage worldwide (Chan & Chong, 2013; Isaiah et al., 2012; Njuguna, 2012). However existing literature indicates that these demographic variables have always been viewed as moderating variables for both PU and PEOU and few studies have focused on the direct relationship between them and consumers technology adoption or usage (Chan & Chong, 2013). Previous studies indicate that demographic variables influence different activities. According to (Chan & Chong, 2013), age has a significant relationship with such activities as entertainment and content delivery while education level influences such activities as location based services and transactions. The study revealed that gender didn't have any influence on either the activities studied. Studies carried out in Kenya indicated that education level influenced M-commerce adoption and usage (Isaiah et al., 2012; Njuguna, 2012) among consumers while age didn't have significant influence on the usage of internet, e-mail and mobile (Isaiah et al., 2012). (Ndung'u & Waema, 2012) found out that age, income, gender, marital status and skills influenced new technologies such as mobile usage, e-commerce and internet in diverse ways.

Perceived security risk

According to Chan & Chong, (2013), M-commerce involves the diffusion of information via a wireless setting. Such diffusion are prone to security threats such as eavesdropping and unauthorized access to the content being transmitted. In his study on determinants of M-commerce consumers activities usage in Malaysia Chan & Chong, (2013), perceived security risk was found to influence activities such as transaction-based M-commerce activities and location based services. In a study carried out in Kenya M-banking adoption on Isaiah et al., (2012) found out that perceived credibility which consisted two elements (privacy and security) influenced M-banking adoption while Njuguna, (2012) found out that perceived risk didn't have any influence on internet banking usage in Kenya.

4. CONCLUSIONS AND DISCUSSIONS

The purpose of this study was to identify the factors that influenced the usage of M-commerce amongst consumers in Kenya. First reviewed literature indicated that studies on m-commerce were still very limited in Kenya and the few available focused on M-banking applications alone. The study also found out that existing literature revealed that m-

commerce usage was still lagging at the infancy stages. Extended Technological Acceptance Model (TAM) was the widely used model though few variables had been tested compared to other studies carried out in other parts of the world? The factors found to have been studied widely in reviewed literature included; perceived usefulness, perceived ease of use, perceived security risk, demographic variables such as age, marital status and education level, social influences, trust and perceived cost. Age, income, gender, education level, skills and marital status influenced usage of the new technologies such as mobile technologies, internet and e-commerce in different ways. The study established that education level is a major determinant of consumers using mobile phones for business or commerce. The study didn't established whether the type of education also serve as a determinant of mobile usage rather than just the level of education as no literature had looked at education in this context. Perceived usefulness of m-commerce was found to have the strongest influence on its usage meaning that consumers were willing to use the technology if useful to their lives. This result support prior research results carried out in other countries. Though not investigated in Kenya, previous studies elsewhere found out that these factors had diverse influences when tested against different activities carried out by the consumers.

Limitation of the study

This study only focused on reviewing the previous studies carried out in Kenya and globally on m-commerce adoption and usage. Future researchers should carry out empirical studies and include some of the variables discussed but not included in this study.

The study only focused on the factors influencing m-commerce usage in general. Future studies should also focus how these factors influences the different M-commerce activities carried out by consumers.

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TECHNOLOGY AND GOVERNANCE: MODERNIZING KENYA CRIMINAL JUSTICE PROCESSES

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Abstract

Forensic science technology, an application of scientific skills, tools and techniques in collecting, analyzing and presenting probative information to resolve legal disputes, is becoming commonly used in criminal justice system. It provides objective and reliable information for multiple phases at different stages of the criminal justice process. Within the Kenya criminal justice system however, the process is characterized by obsolete and reprehensible techniques that lead to inaccurate arrests, prolonged cases, delayed and wrongful convictions and unnecessary exhumations. The adoption, proliferation and maturation of modern forensic techniques in Kenya has been lethargic due to improper regulatory policies, poor procedures and standards, weak legal framework and governance challenges. In a nutshell, the realization of comprehensive modern forensic science benefits is downcast by underdevelopment in Kenya.

Using modernization theory the paper explicates the critical role played by contemporary forensic technology in development and modernization of criminal justice processes, by reviewing various studies and forensic reports. The paper informs policy makers to reexamine application of old methods for adoption of contemporary and advanced scientific techniques in criminal justice governance. Modernization is a progressive and systematic process. It is transformative. For the Kenya criminal justice system to exercise its integral potency it has to, deliberately, move away from old scientific methods and embrace advanced and contemporary forensic routines.

Key words: Modernization; Forensic science; Technology; Criminal justice;

Definition:

Modernization is a continuous and open-ended process. It is the transformation from a traditional society to an industrial society. Meaning, instead of being governed by traditional

or customary structures, the society is governed according to principles formulated specifically for that purpose. It is the creation of new ways of solving society's problems and transiting from old traditions.

Forensic Science is the practical application of science to matters of the law. It is the use of cutting-edge scientific technology to extract, analyze, preserve and examine evidence. Forensic science encompasses many different fields of science, including anthropology, medicine, pathology, chemistry, toxicology, e.t.c. It has been associated with the scientific knowledge and methodology to initiate criminal investigations and solve legal disputes.

1. INTRODUCTION

The evolution of technology directly affects criminal justice system. Science and technology has been associated with a faster, efficient and effective criminal justice system. Its adoption and implementation unswervingly shapes governance; structures, policies and practices of an institution. However, Kenya criminal justice governance is not likely to benefit from numerous advantages brought about by modern technological advancements as long as it continues using old scientific techniques in solving criminal justice disputes. According to McEwen (2011), forensic science has become essential to criminal investigations and prosecutions, world over. Nonetheless, Kenya criminal justice process is still holed up in old scientific procedures such as anthropometry, finger print analysis, latent prints, and handwriting analysis used to identify criminals. This continued rigidity in utilization of old scientific procedures has been detrimental to the Kenya justice process governance leading to inaccurate arrests, prolonged cases, delayed convictions, wrongful convictions and even unnecessary exhumations.

Kenya's snail's pace embrace of modern technology in criminal justice is daunting despite being greatly sensitized by the crimes scene investigation (CSI) phenomena (Peterson, Somers, Johnson, Baskin (2012). Criminal justice personnel and the general public are fully aware of the benefits in application of modern science and technology in solving disputes. However, the application of technology in Kenya, according to Mogire (2011) has been lethargic due to improper regulatory policies, poor procedures and standards and weak legal framework. This has led to challenges in good governance of the criminal justice process (CJP). As such clear standards on application of modern technology need to be addressed if Kenya is to scale the desirable heights in criminal justice governance.

The clamor for good governance in criminal justice system is long overdue. Kenya reforms in the judiciary have been tremendous. However, police reforms which form a key constituent of the criminal justice system have been mired with subjectivity and power struggle. As such, due to poor governance, delivery of justice to both victim and offender has been hampered. Subdued police and prosecutorial processes have led to inaccurate investigations, unlawful arrests, slow court processes, misguided rulings and cold cases. Research shows that modern forensic technology has led to fair criminal justice process through prompt arrest, credible prosecution and accurate conviction of offenders (Corwin, 2003; Lee & Tirnady, 2003; Ramsland, 2004; Snow, 2005) despite Kenya's slow uptake of the new modern scientific

techniques. In principle, therefore, the narrative in application of modern forensic science for good governance should start with the initial stages of criminal justice process. The paper, for that reason, takes the course of examining the application of modern technology in Kenya criminal justice processes of arrest and trial.

2. TECHNOLOGY AND GOVERNANCE

Adoption and implementation of technology directly shapes policies and practices of the justice system. Technology has for a long time been associated with efficiency and effectiveness. It has a long standing significant effect on governing of institutions. Governance is explicated by good and timely service delivery, degree of autonomy from external factors, proper policy formulation and implementation. According to Selian (2002) technology has indeed permeated not only in the market place but also through every organizational structure, often challenging the traditional top-down power hierarchies of governance. In advancing the dialogue, Magno and Serafica (2001) denote that information technology (IT) promotes good governance by increasing transparency, information, and accountability and by enhancing the efficient delivery of public goods and services. Moreover, Kwami (2013) outlines that most countries in the recent years have recorded the use of technologies in management bodies and security agencies to improve the quality of service delivery. As so, governance system should be seen as a more formal part of an integrity system designed to reduce inappropriate behavior and promote ethical temperament. According to Miller (2010), an integrity system is a collection of institutional entities, roles, mechanisms and procedures aimed at good governance.

Kenya criminal justice system has applied technology in different sectors. Notably, the judiciary reforms credited for introduction of a case management system. This system has entrenched confidentiality, integrity and availability of data. It has significantly improved case processing, during trial, record keeping, and generally good tracking of cases. As a result, high quality technological systems affect not only efficiency but also effectiveness of court processes. As such it is essential to examine the significance of modern technology in criminal justice system.

3. FORENSIC IN CRIMINAL JUSTICE PROCESS

Forensic science is one of the advanced technologies used in criminal justice process. This and other ensuing advancements in science and technology have greatly impacted case progression, but also criminal justice credibility. As a key indicator of modernization modern technology has slowly but steadily permeated in criminal justice institutions. Modernization explains application of novel technology in criminal justice that is core to provision of civil liberties and good governance. As such modernization in criminal justice processes would require deliberate integration and application of criminal justice technologies. Criminal justice technology is the use of scientific tools and techniques in conducting of crime investigations, the processing functions of the courts and monitoring functions of correctional facilities. According to Ramsland (2004), good forensic science administration leads to maximization of its contribution to investigation of crime and criminal justice. As such, a

well governed criminal justice process should be anchored on inclusivity of the criminal justice processes supported by modern technology. The inclusivity is delineated by impermeable investigation, strong prosecution, accurate admissible evidence and sound judgment. To achieve this, Kenya justice system needs to address the overall application of modern technology such as case management systems, information technology in trails and forensic evidencing.

This innovative technology has gradually become an integral component of the criminal justice system. It aptly provides facts for conviction as well as exoneration. Modern forensic technology has been credited with application of scientific skills, tools and techniques in collecting, analyzing and presenting probative information to resolve legal disputes (Julian and Kelty, 2012). According to a United Nation Office on Drugs and Crime (UNODC) (2010) evaluation report, forensic services are a means to an effective and fair criminal justice system because they provide objective and timely information for multiple phases at different stages of the criminal justice process. The benefits associated with application of modern forensic in criminal justice are immense. Johnson, et.al (2012) in an analysis of 602 rape cases in United nations found out that forensic evidence was available in almost two-thirds (63.8%) of incidents from inception to disposition. Thirty-three percent of law enforcements agencies in USA estimated that 76–100 percent of both sexual assault and homicide cases used biological evidence (DNA) (Kathy, Cantillion and Clawson (2009).

Despite knowledge of these facts, Kenya has invariably relied on old science techniques. For example, Kenya forensic processes are typically handled by an individual lab, the government chemist, a kind of monopoly that exposes beneficiaries of these scientific techniques to delays, technical incompetence's and unconscious biases (Whitman and Koppl, 2010; Koppl, Kurzban and Kobilinsky, 2008). This has been attributed to improper regulatory policies, poor procedures and standards and weak legal framework (Mogire, 2011). Consequently, it has significantly led to numerous case backlogs and reluctance to new technology. The justice personnel in Kenya have a role to play in legislation, regularization, adoption and oversight of use of forensic science. As a result, new technology for faster and accurate results, reliable and admissible processes should be adopted in all the phases; arrest and trial of criminal justice process.

4. FORENSIC IN ARREST AND TRIAL

The effectiveness of a criminal justice process is delineated by each successive stage; arrest, trial and sentencing. As the first stage in criminal justice process, accurate arrests are vital for credibility of the whole justice process. Its effectiveness is essential in the justice process as a mechanism to identify or confirm the identity of potential perpetrators and link them to the crime scene. It is therefore paramount that reliable tools and accurate procedures are used with minimal, if any, margins of error. According to Johnson et.al (2012) crime scene and forensic lab analysis are both predictive of arrest. They provide crucial data on offender. Without these reliable data and dependable procedures in investigation, police may never have accurate offender profile and this could affect criminal investigation. According to Peterson, et al. (1987) emphasis should be on data collected during crime scene investigation

because it is vital to analyze offender characteristics for exact identification and arrests. The accuracy can be achieved and improved if law enforcement adopts new scientific methods and tools, increasing resources such as establishing the forensic laboratories. In addition to increase resources, technological advancements would be essential to increase effectiveness of “end” to the “front” of the investigative process in the criminal justice system. Since the advent of fingerprints in 1987, dramatic progress has been made in forensic science of identification, including the recent revolution in DNA typing. The scientific knowledge of identifying criminals has grown exponentially. New methods have emerged such as DNA profiling, eyewitness identification, blood spatter analysis, handwriting analysis and polygraph to support identification and arrest of offenders.

According to Peterson et al. (1987) the data collected during crime scene investigation is not only vital to analyze offender characteristics but also in prosecutorial process due to its probative nature. The goal of trial process in criminal justice is to find the truth. Forensic science in return offers objectivity and impartiality in decision making process. According to National Academy of Science (NAS) (2009) scientific techniques offer valuable evidence that contribute to successful prosecution and conviction. As such, continued application of modern forensic science tools and techniques increase credibility and acceptability of judicial outcomes due to their objectivity. UNDOC (2010) underlines the ultimate objective of forensic in criminal justice system as provision of objective evidence aimed at determining the guilt or innocence of an offender. Although the presence of forensic evidence doesn't directly link to sentences it helps in clearance of cases. Mcwen, (2012) reported that of the 47 homicides cases with forensic evidence the clearance rate was 74.6%, compared to clearances rate two of the four homicides without forensic evidence.

5. IMPACT OF FORENSIC

The UNDOC, NAS, US-DoJ, CJS, and other specialized forensic bodies are in agreement that forensic science is beneficial in criminal justice process. The percentage of arrests referred to the prosecutor is significantly different in cases with and without forensic evidence. According to Kathy, Cantillion and Clawson (2009) DNA is a powerful tool to free the innocent as well as identify and convict the guilty. Hays (2008) point out that DNA forensic technology may be law enforcement's most remarkable crime-fighting tool in history. According to Innocence (2007) project report there were over 200 post-conviction DNA exonerations in the United States and 15 of these individuals were serving time on death row.

Still, the influence of forensic evidence is time- and examination-dependent: the collection of crime scene evidence was predictive of arrest, and the examination of evidence was predictive of referral for charges, as well as of charges being filed, conviction at trial, and sentence length. The only decision outcome in which forensic evidence did not have a general effect was with regard to guilty plea arrangements. More studies are needed on the filtering of forensic evidence in different crime categories, from the crime scene to its use by investigators, prosecutors, and fact-finders, and to identify factors that shape decisions to collect evidence, submit it to laboratories, and request examinations.

6. CONCLUSION

A closed up secretive criminal justice system creates a perception of partiality, malfeasance, and denial of justice. In principle, Kenya criminal justice system is characterized by unguided investigation, unlawful arrests, slow court process, misguided rulings and cold cases. It is yet to initiate a forensic lab project (Ombati, 2014) worth 1.5 billion shillings which is expected to assist the police build a crime database. Currently all forensic processes are carried out in the government chemist lab signifying subjectivity. This is a composite indicator of poor governance.

Essentially, criminal justice process should exercise; openness, reliability and neutrality to achieve its objective. The Kenya criminal justice system has been described on one that raises suspicion due to its governance style. To achieve its desired outcome in solving criminal disputes, Kenya criminal justice personnel should adopt modern techniques and new technology in running its processes. Thus, introduction of high-quality case management information systems and application of forensic science in justice process does not only affect efficiency but also effectiveness. Advances in technology have significantly increased the capabilities of forensic science services. The power of forensic technology especially Combined DNA Index System (CODIS) have resulted in an effective crime fighting tool for the law enforcement. CODIS currently contain more than four million DNA profiles from convicted offenders and more than 160,000 DNA profiles obtained from crime scene evidence (Kathy, Cantillion and Clawson, 2009).

Generally, we can conclude that modernizing the Kenya criminal justice system would be beneficial not only to the victims but also to the offender. Equally, application of modern forensic science is a pre requisite to good governance. Modernization, therefore, can only be achieved by deliberate transition from use of old to new scientific skills and technology.

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EVALUATING THE PUBLIC VALUE OF E-GOVERNMENT SERVICES: ACTOR NETWORK THEORY APPROACH

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Abstract

Government all over the world are working on a broad array of e-services, re-designing services as diverse as tax filing, applying and registering for social security, obtaining birth and marriage certificates, procurement for business, government transactions and customs declaration (Kotamraju & van der Geest, 2012). Studies have shown that different stakeholders benefits from e-government services. However, through objectively evaluating e-government services, the benefits between citizens and governments can be successfully understood and improving areas correctly identified. Recently, researchers have shown interest in IS evaluation and the public value perspective segment taking the lead. This is in support of the view that the prime objective of e-government is to produce public value through effective use of ICT (Moore, 1995; Qiang, 2010). Also, research in the field of IS evaluation has begun to recognize the need for grounding evaluation approaches and studies in the ontology and epistemology of relevant paradigms (Lagsten, 2011). The main aim of this article is to develop a understanding of evaluation of the public value of e-government services using Actor-Network Theory (ANT) perspective. This research mainly focus on two aspects: studying the concept of public value and how it is relevant in evaluating e-government services and using ANT, to conceptualise the evaluation of public value of e-government services, that is, using ANT as an ontological foundation to analyse the relations among actors in evaluating the public value of e-government services.

Keywords: Public Value, E-government Services, Evaluation, Actor-Network Theory.

1. INTRODUCTION

During 1970s, the world experienced a wave of reforms in public administration, which led to the end of fruitful age of “welfare state” to a new mode and form of management in public administration referred to as New Public Management (NPM). The cause was due to the global depletion of public resources and reduced quality of public services combined with deep social dissatisfaction (Cordella & Bonina, 2012; Oakley, 2004). Articulated as policy framework, the reforms under NPM agenda were seeking to solve the problem of public administration that was too big, inefficient and expensive, therefore unable to serve public services as is supposed to (Cordella & Bonina, 2012; O’Flynn, 2007). NPM had a clear and dominant focus on results and public managers in this paradigm had goals built around achievement of performance targets (O’Flynn, 2007).

Ever since NPM was first recognized internationally, adoption of information and communication technology (ICT) was conceived to be a powerful tool to help in achieving NPM reform agenda. Indeed, NPM information systems investments were directed towards enhancing efficiency (Cordella & Bonina, 2012). However, for many scholars, NPM was problematic. (Alfold & Hughes, 2008). NPM has been criticized for it likening of public sector to the private sector by reducing the scope of its agenda to business-like and extensive treatment of citizens as customers (Persson & Goldkuhi, 2010; Olsen, 2005).

Heek (2006) articulated that government operations are not business operations, and the views and models from business and e-business can not be implemented without taking the

differences into account. O'Flynn (2007) argues that due to the problems and challenges experienced with NPM, especially during the 1990s, there has been increasing interest in what can be termed a public value (PV) approach in public management. It's an emerging form of management and governance in the public sector which emphasized more collaborative networked or joined up arrangements (Alfold & Hughes, 2008). Cordella & Bonina (2012) suggest that analysis of the effects of ICT on public sector should not solely focus on their impact on the direct economic exchange relationship and individual choices, but rather on the collective preferences as indicated by the public value paradigm.

2. THEORETICAL REVIEW

Meaning of Public Value

In theory and practice, the concept of public value has been attracting growing interest among public policy makers in both developed and developing countries (Bennington, 2011). The original notion of public value was rooted by Mark Moore, in his seminal book 'Creating Public Value: Strategic Management' (1995).

Several authors have sought to define, categorise and distinguish the salient characteristics of public value (Creswell, 2010; Bennington, 2009; Hughes, 2003). Public value is the value which citizens and their representatives seek in relation to strategic outcomes and experiences of public services (Moore, 1995; Kelly, Mulgan, & Muers, 2002). Public value has been described as a multi-dimensional construct – a reflection of collectively expressed, politically mediated preferences consumed by citizenry and created not through 'outcomes' but also through processes which may generate trust or fairness (O'Flynn, 2007). It includes the value attached to the relatively concrete outcomes, such as reduced homelessness or universal access to health care, and to the more intangible, such as increased trust in government and public service providers (Grimsley & Meehans, 2007). Stoker, (2006) describe public value as more than a summation of individual preferences of the users or producers of public services, but as collectively built through deliberation involving elected and appointed officials and key stakeholders.

Moore (2005) suggests that to create public value, and executives must address three key areas; services, outcomes and trust. This model has gained acceptance in both public sector (Kelly et al., 2002) and academics (Bozeman, 2002; Kearns, 2004). Services may be identified as meeting a relatively enduring need and are similar to the private sector (Moore, 1995). Under Public Value theory, successful service delivery supports all elements of public value creation outcomes, services and trust (Try & Radnor, 2007). For example, provisions of education, health care, policing, jointly or severally, services contribute to the achievement of outcomes (Kelly et al., 2002).

Evaluating E-Government Services

E-government is the new wave of the information revolution. The phenomenon hope to reduce costs, improve service delivery and increase effectiveness and efficiency in the public

sector. E-government represents a fundamental change in the whole public sector structure, values, culture and the ways of conducting business. According to the World Market Research Centre (2001), e-government services refer to the delivery of information and services online via the internet. Sharma (2004) similarly Accenture consulting explains e-government services refer to the delivery of information and services online through the Internet or other digital means.

Research conducted in the area of e-government has mostly focused on e-government performance (Chen and Wang 2011, Karunasema and Deng 2012, Bai, 2013), e-government awareness and acceptability (Hussein et al. (2010), e-government implementation (Hermana and Silfianti 2011), e-government policies (Stanimirovic & Vintar, 2013). Little attention has focused on evaluation of e-government (Grimsley & Meehans, 2007; Persson & Goldkuhi, 2010; Kelly, Mulgan, & Muers, 2002).

E-government evaluation refers to assessing and examining the e-government program activities to understand the process and the result of e-government programs (Alhyari, Alazab, & Venkatraman, 2013). E-Government represents an exclusively specific case of IS investment in the public sector and thus its evaluation is likely to be informed by understanding of public sector IS evaluation (Grimsley & Meehans, 2007). According to Tona & Calrsson (2013) IS evaluation is concerned with the evaluation of different aspects of real-life interventions to achieve anticipated goals. The evaluation of public services to citizens in e-government can help government officials understand the development situation of the people-oriented e-government (Zhao, 2010). In additional, e-government evaluation would lead to monitoring changes in e-government environment and also to assess the efficiency of implementing e-government program in order to improve the procedure of service delivery (Alhyari at al., 2013).

Some of the reasons cited for limited research in IS evaluation are problems of identifying and quantifying benefits and opportunity costs, unfamiliarity with evaluation techniques, difficulty in interpreting results, and lack of time, data, information or interest (Alshawi & Alalwany, 2009). Most of the research in the area of IS evaluation indicates that it is a complicated and difficult subject (Serafeimidis & Smithson, 2000; Alshawi & Alalwany, 2009). The complexity is due to multiple perspectives involved and the difficulty in quantifying benefits (Symons & Walsham, 1988). The debate between researchers is not only about the complexity of IS evaluation, but also about the most appropriate evaluation approach to be used for specific IS (Alshawi & Alalwany, 2009). Furthermore, evaluation by its nature, is a very subjective undertaking that cannot be separated from human intellect, history, culture and social organization (Oskan, Hackney, & Bilgen, 2007).

Actor Network Theory

Research in the field of IS evaluation has begun to recognize the need for grounding evaluation approaches and studies in the ontology and epistemology of relevant paradigms (Lagsten, 2011). This section will review the Actor-Network Theory (ANT) theoretical foundations underpinning the evaluation of public value of e-government services.

The seminal works of Bruno Latour (1987, 2005), John Law and Michael Callon (1986, 1995) are recognized as foundations of Actor Network Theory. As its major proponents maintain, ANT is entirely appropriate for socio-technical research (Callon, 1986; Latour, 2005). The basic concept of ANT includes actors (or actants). Both human beings and non-human (e.g. technical) objects are considered as an actor (Thapa, 2011). One important aspect of ANT is the denial of a *priori* dichotomy between the social and the technical; they are considered to be intertwined, in what Law (1987) refers to as heterogeneous networks. Actor-network is a heterogeneous network of aligned interests, including people, organizations and standards (Walsham, 1997). ANT recognizes that technology and people are not distinct pre-existing actors' which influence each other through relationship. Instead, they are considered as the constitutive elements of this relationship, and at the same time, the output of this same relationship (Cordella, 2010).

In ANT, both people and technologies can act and be acted upon (Holmstrom & Robey, 2005). Walsham & Sahay, (1999) summed up and concluded by saying, "the actor-network theory examines the motivations and actions of actors (both human beings and non-humans such as technological artefacts) who form elements, linked by associations, of heterogeneous networks of aligned interests." The view proves to be crucial to the aim of developing of a deeper understanding of the use of an IS evaluation process (Nijland & Willcocks, 2008).

Using this theory as a frame of reference also makes it suitable as a method for analysis (Monteiro, 2000). ANT has successfully been used in the information systems field to examine, for example, the development of information infrastructure (Monteiro, 2000), the standardization process (Hanseth et al 2006) or for understanding IT development within healthcare (Chang et al 2006). In conclusion ANT offers a language of analysis that sensitizes us to new ways of understanding. The difference in opinion between the social and the technical is solved by the perception that both are intertwined.

Actor Network Theory and Evaluating Public Value of E-government Services

Evaluating public value of e-government services is a complex and requires comprehensive understanding of the relationships of the social networks and each actor's relationship to technology and the artifacts' that define the socio-technical network. Actor Network Theory concepts of translation (Callon 1991; Latour, 1987), assemblage (Latour, 2005), and inscription (Akrich, 1992), can be used as unifying concepts of understanding the public value of e-government services where both social and economic value meet.

The translation process enhances the deeper understanding of the interplay among various ICT actors by providing the details of all the strategies through which an actor identifies other actors and arranges them in relation to each other. Through translation the focus is on "processes by which an actor creates lasting symmetries" (Callon, 1986). Translation is concerned with the alignment of interests of different actors, which is necessary for stability in the network. From the outset, actors have a diverse set of interests and aligning these interests causes a network to become stable and durable (Monteiro, 2000).

Clarke (2001) alludes translation bring together complex entities into a single object or idea that can be mobilised and circulated like a branded commodity or a taken-for-granted fact. According to Callon and Latour (1981), “by translating we understand all the negotiations, intrigues, calculations, acts of persuasion and violence, thanks to which an actor or forces takes, or causes to be conferred on itself, authority to speak or act on behalf of another or force”.

Based on ANT, translation modifies an actor’s “program of action” by employing different devices, identified as the “four moment of translation” of problematization, interestment, enrolment and mobilisation (Latour, 1994). *Problematization* involves the definition of the problem and the establishment of an ‘obligatory passage point’ by the focal actor “which renders them indispensable in the network (Callon 1986); *interestment* is a series of processes during which qualities and motivations (roles) are bestowed to other actors according to focal actor’s programme; enrolment is a set of strategies aimed at persuading others to invent in or follow the programme; successful *enrolment* depends on the negotiation and consolidation among actors during *interssement* phase (Thapa, 2011). Finally, *mobilisation* is a series of methods used to ensure that the representatively of spokesmen of collectivities remains uncontested by those collectiveness. All four moments of translation intend to overcome resistance and prevent other actors to follow their predisposition. During successful translation, the network strengthens internally, gains coherence and consistency.

Besides the four stages of translation, the process of inscription is critical to building and stabilising actor-networks, as most artefacts with social systems embody inscriptions of some interest. Inscription refers to the way the technical artefacts embody pattern of use (Monteiro, 2000). For example, technological artefacts can embody a world view that reflects the socio-economic context and rationality in which it was created (Heeks, 2002). In other words, artefacts always embody the beliefs, social and economic relations, the previous pattern of use and assumptions as what the artefact is about (Akrich, 1992). Inscription can also refer to the way technical artefacts embody pattern of use, including user program of action (Monteiro, 2000). In relation to translation, inscription to a large extent take place simultaneously and interrelatedly (Latour, 1991). Indeed, the dynamics of translation reflect different levels of actor’s inscription and alignment rigidity achieved in the actor network (Cordella, 2010).

Assemblage is a moving target that cannot be studied in a complete or comprehensive sense (Latour, 2005). In contrast De Landa (2006) considers that an assemblage is a realistic picture of an agent that can be captured in a given space and time, meaning that causalities could be established between actors. In this study, I rather consider assemblages under the definition given by Latour (2005). Establishing causalities, as De Landa, (2006) proposes becomes more complicated if we do not have a fixed ‘thing’ we are studying. But rather we see progression and process, which may or may not mean the presence of causality.

One of the most key motivations to use the concept of translation in this study is that the evaluation of public value of e-government services can be seen as something emergent. Irani et al. (2005), articulated the IS evaluation should be viewed as a process of experimental

and subjective judgement, grounded in opinion and word views. Latour (2004) propose a combination of values in the translations of facts from what he referred new constitution. Translation describes the process whereby knowledge and values are seen as emerging from concrete situations. Latour argues that values, much like facts become recognised objects only when are constructed and gradually become publicly known.

Public value of e-government services can be studies using a model comprising of four stages of translation. The choice of a specific translation is made following the spirit of ANT where every translation is unique (Latour, 2005). The process start from *problematism* where actors with and around the public domain identify pertinent problems that they face in the communities, organizations and wider society. The next step is *association*, here actors voluntarily associate with spatial settings rather than necessarily accepted an imposed 'interressment' as evident in expert-led processes (Callon, Lacoumes, & Barthe, 2009). Association often emerges at the crossroad of users, workers, experts, public and other interested individuals/groups. Once converges are found both tangible and intangible benefits/costs of e-government services are *enrolled*. Finally, is the stage of evaluation referring to the practice among the public to evaluate the outcomes and impacts of the values that were enrolled. Public value emerges from this process through the on-going processes of assemblage and re-assemblage, rather than fixed.

In addition, using ANT ontological stances, the focus is not on the study of the effects that specific actors have on the black-boxing of inscriptions in a specific actor-network, but on the interplay analysis taking place in the actor-network that result to black-boxed relationship. Latour (1987) argues that science and technology need to be studied in action that focuses on the dynamics of their interaction, rather than on the stability of their relationships. Hence, ANT offers an analytical framework that provided a theoretical and methodological underpinning for the study of public value of e-government services in terms of these dynamic relationships. It permits public value to be conceived as a phenomenon in action that both emerges and affects the interplay of different actors participating in open network relationships.

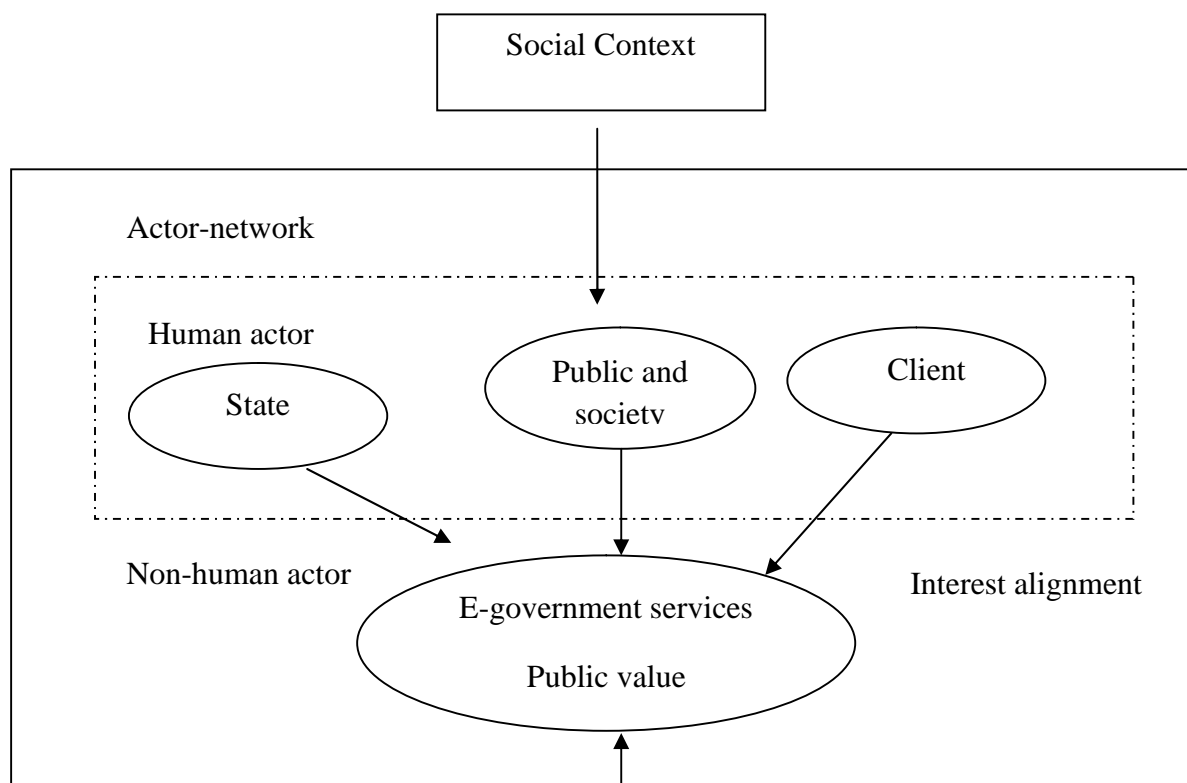


Figure 1: proposed Model of actor-network analysis

CONCLUSION

The objective of this researcher was to promote the use of ANT in understanding the public value of e-government services. According to data presented from literature, ANT not only provides theoretical concepts as ways of viewing elements in the real world, it also suggests that it is exactly these elements which need to be traced in empirical work (Walsham 1997). ANT provides a study of social constructivism by attending to power strategies and networks of human and non-human actors. The glue that holds the actor network of IS together is the power to have strategic control of the IS processes by professionals and the way technological solutions inscribe organizational behaviour. However ANT has critics and carries certain danger, it fails to take into account power structures and their influences on how networks develops and what inscriptions are promoted (MC Bride, 2003), in additional Actor-Networks risk degenerating into endless chains of association. Other research perspectives such as Emergency, Structuration and realistic evaluation may be held to be important alternatives to ANT approaches.

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SERVICE QUALITY STRATEGIES BY PRIVATE SECURITY FIRMS IN KENYA

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Abstract

This study sought to identify service quality strategies by private security firms in Kenya. Descriptive research design was adopted to; evaluate the effects of employee capacity, assess the relationship between service process and service quality, and analyze how relationship with stakeholders influences service quality. The study target 60 managers from the 11 Kenya Industrial Security Association (KSIA) companies within Nyeri County. Self-administered questionnaires were used to collect data. Frequency distributions and measures of central tendency were used to analyze data. The regression model established R^2 value of 0.59 and generated the following coefficients; Service Process 0.371, relationship with stakeholders 0.343 and Employee Capacity 0.190. Results indicated that service process had the greatest influence on service quality. The ... -value from F-test was 0.000, indicating that the model was fit for the study. The study recommends that security firms continue improving their service process to achieve organizational success in the competitive world. In addition, private security firms should create synergy between service process and relationship with stakeholders in order to enjoy economies scale through delivery of quality services.

Keywords: Private Security Companies; Employee Capacity; Relationship with Stakeholders; Service process; and Service Quality

1. INTRODUCTION

According to Asubonteng, McClearly, and Swan (1996), due to intense competition and the hostility of environmental factors, service quality has become a cornerstone marketing strategy for company's in order to survive and grow. Service-based companies are compelled to provide excellent services to their customers in order to have a sustainable competitive advantage by understanding service quality in order to attain their objectives.

According to Freedonia Report (2008), the global security service market was worth \$138.6 billion in 2007 and was estimated at \$152.5 billion in 2009; it will continue to grow at 7.4% annually, reaching \$218.4 billion in 2014. Much of the sector's growth will be stimulated in the leading emerging economies where it is projected that the turnover will increase at double-digit rates. Additionally, the Confederation of European Security Services through the Freedonia Report (2008) estimated in 1999 that more than 500,000 guards were employed by 10,000 Private security companies (PSCs) in the European Union. The report also indicates that over 200,000 private security guards are employed in South Eastern Europe, considerably more than the number of police officers employed in those states. For example in Israel, the United Kingdom, United States and South Africa the number of employees in (PSCs) they employ exceed those of public law enforcement agencies.

In Kenya, the private security industry is one of the fastest growing sectors of the economy and it is a significant employer. In 2004, the industry was valued at 43\$million and provided employment to about 50,000 Kenyans. It is spread across the country, although it is much more visible in urban centers than it is in rural areas. The private security industry fills the gaps that government may be unable to bridge using their security architecture (Mkutu and Sabala, 2007).

Statement of the Problem

Currently there is no specific government oversight body to regulate the private security industry, consequently there are over 2,000 security companies operating in Kenya. Approximately 30 PSCs are members of the Kenya Security Industry Association (KSIA). This means that majority fall outside the ambit of the industry self regulation mechanisms. Besides, a sizeable number of locally owned security companies operate illegally, since they are not registered with government authorities. As a consequence, many companies pay little attention to service standards .To bridge the gap KSIA was formed by companies in need to comply with the set standards which are drawn from the Laws of Kenya, internationally accepted technical and systems specifications, and the professional experience of all member companies, to establish a set of benchmarks. The study therefore evaluated the extent of implementation of set service standards to enhance service quality by private security firms so as to advice relevant bodies on the same.

Research Objectives

- i. To evaluate the effects of employee capacity on service quality by private security firms in Kenya.
- ii. To assess the relationship between service process and service quality by private security firms in Kenya.

- iii. To analyze how the relationship with stakeholders influences service quality by private security firms in Kenya.

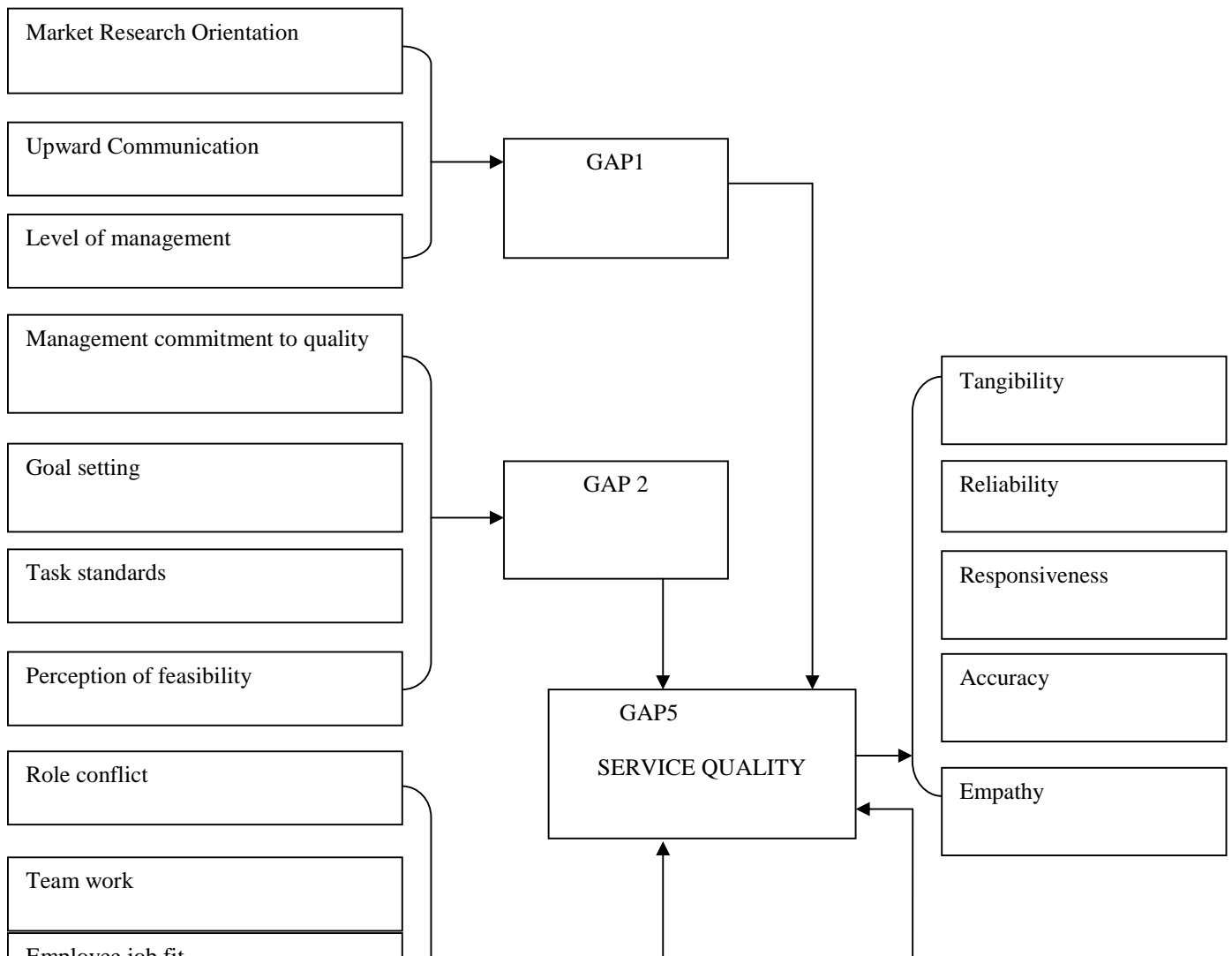
2. LITERATURE REVIEW

In the study by Looy and Dierdonck (2003) asserted that quality holds the key to competing in today's global market by assisting in clear development of marketing strategies by building strong brand names,. Despite the fact that quality management practices are primarily embraced in the manufacturing sector, quality management in the service industries has been gaining momentum over the past decade through Total Quality Management (TQM).

The main theoretical framework by Zeithmal, Berry and Parasuraman (1988) is a combination of Gap theory and SERVQUAL theory (Figure 1). It is relevant to this research study as private security service requires high consumer involvement in the consumption process; hence, the attainment of quality service relies significantly on the co-contribution of the employees to the service delivery process.

EMPLOYEE CAPACITY

Figure 1: Extended Service Model by Zeithmal, Berry and Parasuraman (1988)



Employee Capacity

Tornow and Wiley (2004) found a positive correlation between the capacity of employees and service quality. They also found that customer satisfaction is directly related to the attitude and perceptions of employees, which relates to the organization and its management practices. To improve effectiveness in service quality, organizations must build the capacity to retain, attract and employ an adequate number of high-quality employees' in order to adapt to circumstances that are constantly changing.

According to a study by Schneider, Russell, Beatty and Baird (2003), asserted that to provide high quality service, employees need to get enough training in the necessary technical skills and knowledge, and interactive skills. Interactive skills help employees to provide courteous, caring, responsive and empathetic service. Successful companies invest heavily in training and make sure that the training fits their business goals and strategies.

Despite the size of the private security sector, there are no specific regulations or requirements in terms of the training and vetting of guards, and the quality of training and services vary considerably from company to company. Most companies provide some training for their guard force, but some PSCs place guards on duty with little or no knowledge of basic security provision, while others provide fairly extensive courses. Given the unevenness of training and standards, concerns are frequently raised about the quality and integrity of security staff, with allegations that guards are in collusion with criminals (Thuranira and Munanye, 2013).

According to Luecke (2006), discontent is unlikely to be derived solely from remuneration or working hours and that work enhancement is required for essential motivation and that it is a constant process for the management to ensure that the work should have an adequate assessment to exploit the full capability of employees. Additionally, certain factors such as opportunity for advancement, gaining recognition, responsibility, challenging or stimulating work, sense of personal achievement ought to be taken into consideration in order for employees to render efficient services to attain customer satisfaction and loyalty.

According to Abrahamsen and William (2005), working conditions for guards are not conducive, some guards report of lack of overtime payment, annual leave, insurance and social benefits. Additionally guards are not well armed issued only with a baton and a whistle, whereas criminals often carry firearms, machetes and other weapons .As a result attacks and violence towards security guards are common and sources within the sector estimate that between 5 to 10 security guards are killed each month mostly in Nairobi and Mombasa.

It is the duty of management to recruit the right personnel to fill the required positions within the organization in order to ensure that stated objectives are achieved. Therefore the main objective of recruiting is the need to attract and retain the right employee for the right work within the organization. In this regard service organizations tend to engage employees for their service competencies and preference (Luecke, 2006).

A survey by Wairagu, Kamenju, and Singo (2004), cited that employees of the private security companies are often young, incompetent, inadequately trained and equipped, and lack the motivation to deliver quality services additionally the majority of the workforce in the private security industry comprises young school leavers aged between 18 and 30 years.

As part of their effort to ensure higher quality and standards, KSIA requires all its members to subscribe to Staff Check, a database that contains information on employees.

Service Process

According to Goldstein, Johnston, Duffy and Rao, J (2002), service process leads to an outcome resulting in the customer being either satisfied or dissatisfied with the service experience it is of paramount importance that service organizations pay attention to designing the system by which service concepts are produced and delivered to customers .It is the role of delivery to ensure that the expected service outcome is received by the customer.

A study by Zhu and Nakata (2007) argues that customer orientation is driven by service quality and impacts significantly on business performance. Furthermore, the study argues that the relationship between customer orientation and business performance can be positively influenced by IT capability. The impact of IT capability on customer orientation is the result of enhanced service quality driven by technological changes that results to increased automation and better connectivity. This then leads to the facilitation of customer related activities such as the sharing of customer knowledge within the organization, gathering customer information, analyzing customer information and behavior, making decisions and planning customer initiatives.

Koufteros, Vonderembse, and Jayaram (2005), provides empirical evidence about the relationship between organizational structure and internal communication since organizational structure facilitates processing and flow of information. However, as organizational structure has many dimensions which affect communication, the organization need to realize the value of Total Quality Management (TQM) implementation, by building internal organizational structure. Organizational structure should be capable of fully

supporting the implementation of the preferred structure by providing control and flexibility of activities in order to adapt quickly to the changing marketplace. It is thus important to assess organizational structures when evaluating an organization's TQM implementation.

On research study by Guo, Duff and Hair (2008) on the impact of process variation on financial performance in financial service institutions sheds further light on the dynamics of the impact of process orientation on customer satisfaction. They identify lack of rigorous policies and processes as one important factor that contributes to the substantial variation in service delivery. An improvement in processes can reduce the apparent variation in the process, and can have an indirect effect on business results through increased customer satisfaction. Hence process orientation, like employee management, supports a firm's customer orientation and has a direct effect on customer satisfaction.

Relationship with Stakeholders

The manner in which complaints are received and addressed demonstrates an important measure of organizational commitment to quality care and customer satisfaction. A well structured complaint and grievance policy is one of the foundations of good customer care service when clearly communicated to all parties involved (Legge, 1995).

According KSIA (2005), lack of information sharing, mistrust, and misinformation are the primary barriers to effective collaboration between PSC's and public security which has an adverse effect on operations of PSC's. Police officers feel that private security personnel generally lack education and training and are threats to their policing domain of professionals versus non professionals. PSCs on the other hand believe that public law enforcement officers have limited knowledge about the private security industry and do not appreciate the important role they play in solving and preventing crimes.

Industrial Relations involves all aspects of legal compliance that are required to be met by any organization, it includes changes in the Employment Relations Act, Health and Safety Legislation, Workers Accident Compensation and other obligations and developments specific to the act. In order to maintain businesses those are competitive and successful in a fast-changing global economy. Organizations must keep up with issues and trends that affect employment relationships and regulations ,labour market and economics and analyze contemporary employment issues to create healthy industrial relations (Victoria University, 2010),

Research Gap

According to a study by Hill, Collier, Froehle, Goodale, Metters, and Verma (2002) , argues that much have been done on service quality issues based on consumer perspective compared to service quality issues based on management perspective hence the study intends to shed more light on the issue.

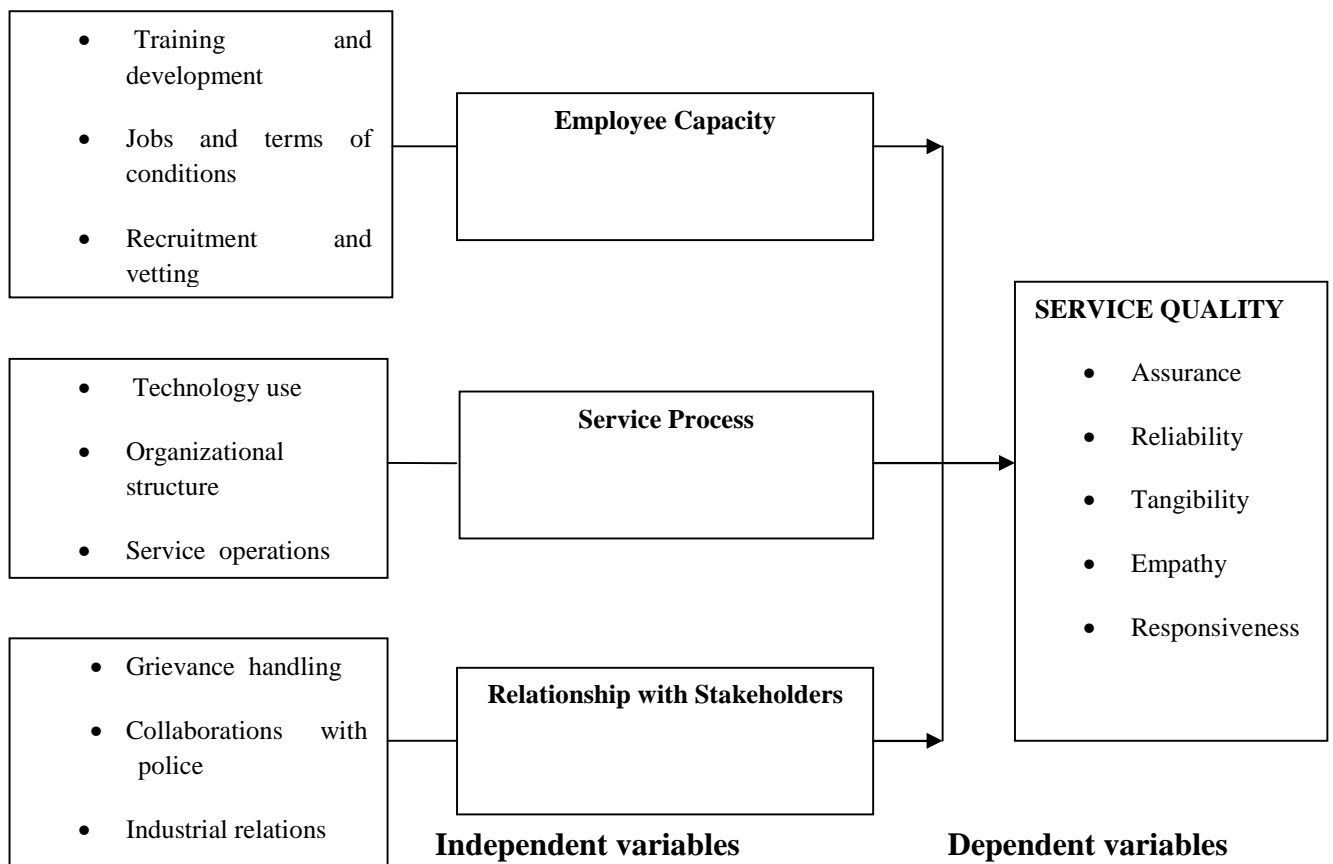
A study by Amin and Isa (2008) on the role of employee capacity in service quality in retail settings in a number of Arab countries, concluded that employees in those regions are unique in many ways and that more studies should be conducted to understand service quality in

different cultures and sectors hence study aims to evaluate the effects of employee capacity on service quality by private security companies in Kenya.

Operational Framework

The Operational Framework (Figure 2) showed the dependent, independent and parameters of the study.

Figure 2: Operational Framework



3. METHODOLOGY

Descriptive research design was used, the population of the study consisted of 11 companies operating in Nyeri County representing 39% of the total members under KSIA. The study involved a complete census of branch managers, operations managers, base commanders, and supervisors of PSCs' all the selected employees of registered companies under KSIA summing to 60 respondents.

Questionnaires were used to gather data from the field. Descriptive statistics in the form of mean, frequency, standard deviation and percentages were employed. Inferential statistics was conducted using T-test to determine whether there is a significant difference between the means of dependent and independent variables. F-test was used in order to ascertain whether the model used best fits the population used. To test significance of the variable *p*-Value was used with acceptable significance level of $p \geq 0.05$.

The analysis was carried out in SPSS version 20 at a 95% confidence level. A regression model in the following form was used.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + e$$

Where: Y= Service quality
 β_0 = Autonomous factors
 X_1 = Employee Capacity
 X_2 = Service Process
 X_3 = Relationship with stakeholders.
 β_i = Coefficient for variables
 e = Error term

4. FINDINGS

Table Regression output

Variable	Unstandardized coefficients	Standardized Coefficients	T-test	Sig	R2	Adjusted R2	F	Sig.F
	0.280		2.166	0.0031	0.592	0.581	34.4	0.0000
Employee capacity	0.190	0.199	2.058	0.103				
Service process	0.371	0.402	3.521	0.043				
Relationship with stakeholder	0.343	0.357	2.710	0.0459				

From the ANOVAs results, the probability value obtained was less than $\alpha=5\%$, which implied that the regression model was significant in predicting the relationship between service quality and the predictor variables. The F calculated at 5% level of significance was 34.4. Since F calculated is greater than the F critical = 4.05058, this shows that the overall model was significant.

Service process *P*-value ($P = 0.043$) and Relationship with stakeholders *P*-value ($P = 0.045$) was statistically significant at 95% confidence level. There was no significant relationship between employee capacity *P*-value ($P=0.103$). This implies that service quality and relationship with stakeholders affected the service quality in private firms.

R^2 which is referred as the coefficient of determination shows the variation in the dependent variable that is due to change in the independent variables. According to the table above the value of R^2 was found to be 0.592, this shows that variation of 59.2% in the service quality in private security firms is caused by employee capacity, service process and relationship with stakeholders. Substituting the beta values in the model with the unstandardized coefficients, the specific model was estimated as follows:

$$Y=0.28+0.91 X_1 +0.371 X_2 +0.343 X_3 + 0.0004$$

Where: 0.28 =Represent service quality that is constant despite the variations of independent variable. According to the regression equation taking all factors employee capacity, service process and relationship with stakeholders constant at zero, the service private firms would achieve 0.28 service quality.

Employee Capacity (X_1) indicates that one unit of change in employee capacity would lead to 0.190 increase in service quality. Service Process (X_2) indicates that one unit of change in service process would lead to 0.371 increase in service quality. Relationship with stakeholders (X_3) indicates that one unit of change in relationship with stakeholder would lead to 0.343 increase in service quality. The error value 0.0004 represents other variables that have not been considered by the study but affect service quality by private security firms. Such factors include cost, response strategies and customer relationship management.

The model indicates that service process has the highest value of 0.371; relationship with stakeholder is the second highest variable with value of 0.343 and employee capacity is the least variable with value of 0.190. This implies that service process had the highest influence to service quality in comparison to employee capacity and relationship with stakeholders.

The study established that the PSCs implemented service process as a strategy to enhance service quality in terms of use of technology, fitness between organizational structure and strategy and customization of service procedures and techniques but there was shortage of facilities necessary in service delivery. From the findings in the study service process was found to have a significance level of ($P=0.043$) at 95% confidence level indicating that it was statistically significant.

The study found out that the PSCs had effective readdressal of grievance although collaboration with public security was ineffective. From the findings in the study relationship with stakeholders was found to have a significance level of ($P=0.045$) at 95% confidence level indicating it was statistically significant.

The study found out that although the PSCs emphasized in the recruitment process, they had not well implemented employee capacity as service quality strategy in terms of training, employee appraisal, working conditions and career development. From the findings in the study employee capacity was found to have a significance level of ($P=0.103$) at 95% confidence level indicating that it was not statistically significant.

CONCLUSION

Well implemented service processes are responsible for the quality services delivered by PSCs. Use of technology and fitness between organizational structures and strategies are their main strengths.

Prompt redress of grievances, ease in communicating grievances are the strengths of these companies. However, delayed response by police to emergencies is an obstacle hindering effective collaboration between public and private security providers.

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ROLE OF INTERNAL CONTROL SYSTEMS IN MANAGEMENT OF REVENUE BY NYERI COUNTY GOVERNMENT

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Abstract

The purpose of this was to evaluate the role of internal control systems in revenue management of Nyeri County, Kenya. Specifically, the researcher wished to investigate the role internal control environment on the revenue management; examine the role of risk management on the revenue management; investigate the role of information and communication on the revenue management and assess the role of monitoring on the revenue management in Nyeri County. The study adopted a survey design and will targeted 97 personnel from the accounts, audit and revenue collection departments in the Nyeri county government offices. The researcher used census method to include 97 personnel in the study. In the study questionnaires were used to collect data. Data analysis involved descriptive (frequencies, percentages, means and standard deviation) and inferential (regression) statistics. SPSS was employed in analysis of data. Findings were presented in form of figures and tables. The study found that control environment ($P=0.03$) and monitoring ($P=0.11$) were statistically significant in revenue management. The researcher concluded that that revenue management was promoted by a well-structured control environment and efficient monitoring of control activities and hampered by poor risk management and poor information and communication. The researcher recommended that the general public including the staff at the county government should be made aware of revenue management information. Appropriate and sufficient reports should be produced for the proper management and control of the county government and financial reports should be made easily accessible to all staff.

Keywords: Internal controls, Revenue management, Control environment, County Governments

1. INTRODUCTION

The effective implementation and monitoring of a sound internal control system helps ensure that organizations meet their objectives, such as providing services to the community professionally, while utilizing resources efficiently and minimizing the risk of fraud, mismanagement or error. Good internal controls will help align the performance of the organization with the overall objectives through continuous monitoring of the performance

and activities carried out by the organizations, encourage good management by allowing management to receive timely and relevant information on performance against targets, as well as key figures that can indicate variances from targets (Webber, 2004). Ensure proper financial reporting maintaining accurate and complete reports required by legislation and management, minimizing time lost correcting errors and ensuring resources are correctly and efficiently allocated. Good controls also safeguard assets by ensuring the organization's physical, intellectual property and monetary assets are protected from fraud, theft and errors, deter and detect fraud and error by ensuring the systems quickly identify errors and fraud if and when they occur. Good control systems also reduce exposure to risks by minimizing the chance of unexpected events.

The type of revenue affects the processes and controls needed to manage it. For example, license fees require inventory controls over the actual license documents in order to ensure that fees are collected for all licenses issued. According to Theofanias et al., (2011) taxes do not require any inventory controls. The amount of revenue is also important in determining the process to manage collections. The primary objective of any revenue management process is to collect what is owed. As with any process, accomplishing this in an effective and efficient manner is important so that resources are not wasted. Also there will be an efficient revenue management process, improved cash management, more accurate cash forecasting ability, greater budgetary control and ability to complete projects timely as noted earlier, the type of revenue will have an impact on the nature of the internal controls.

Mismanagement of public funds is a common phenomenon in developing countries (El-Nafabi, 2011). According to Jokipii(2010) embezzlement and mismanagement of public funds is the biggest obstacle to achieving the millennium development goals in developing countries. Heald and McLeod (2002) define public money as all money received by a public body from whatever source. Webber (2004) indicates that, managing public funds should focus on public expectations since the public is concerned about the purpose for what money is allocated, the way it is spent and the benefits realized. According to Miller (2003) the single most important reason leading to asset misappropriations, corruption, organizational fraud and fraudulent financial statements is poor internal control systems.

According to the office of the controller of budget (2013) the former local authorities in the county had projected to collect a total of Ksh 192,739,274 for the 4 months under review (April, May, June and July). The revenue collecting units were Nyeri municipal council, Nyeri county council, Karatina municipal council and Othaya town council. Actual revenues for the four months to June 2013 amounted to Ksh 175,265,226. This represented a shortfall of Ksh 17,474,048 (or 9% of estimated revenue). Going ahead, the report recommended that is critical for the county government to find new and innovative ways to increase revenue from local sources. The review also identified a need to realign the local tax system to the county structure, seal any leakages, improve tax compliance, enact requisite tax laws and widen the tax base.

Nyeri County in Kenya has had a problem in managing its revenue due to inappropriate internal controls. According to a report from the office of the auditor general; Nyeri County

experienced several challenges in revenue management in the 2012-2013 fiscal years (RoK, 2013). The report indicated that there was low revenue collection and temptation to spend local revenue without paying it into the county revenue fund as required by law. To remedy the situation, the office of the auditor general recommended adoption of some internal controls such as hastening of Integrated Finance Management Information System (IFMIS) and development of requisite legal framework to support revenue growth.

Consequently, internal controls have been put in place and some are in the process of being implemented to ensure safe custody of all county assets, to avoid misuse or misappropriation of the assets and to detect and safeguard against probable frauds. One of the controls that the Nyeri County is in the process of adopting is the automation of revenue collection and management. The purpose of this study therefore was to investigate the role of internal control systems in revenue management of Nyeri County Kenya

2. RESEARCH OBJECTIVES

General Objective

To find out the role of internal control systems in revenue management of Nyeri County Kenya.

Specific Objectives of the study

- (i) To investigate the role internal control environment on the revenue management in Nyeri County.
- (ii) To examine the role of risk management on the revenue management in Nyeri county.
- (iii) To investigate the role of information and communication on the revenue management in Nyeri County.
- (iv) To assess the role of monitoring on the revenue management in Nyeri County.

3. THEORETICAL BACKGROUND AND INFORMING LITERATURE

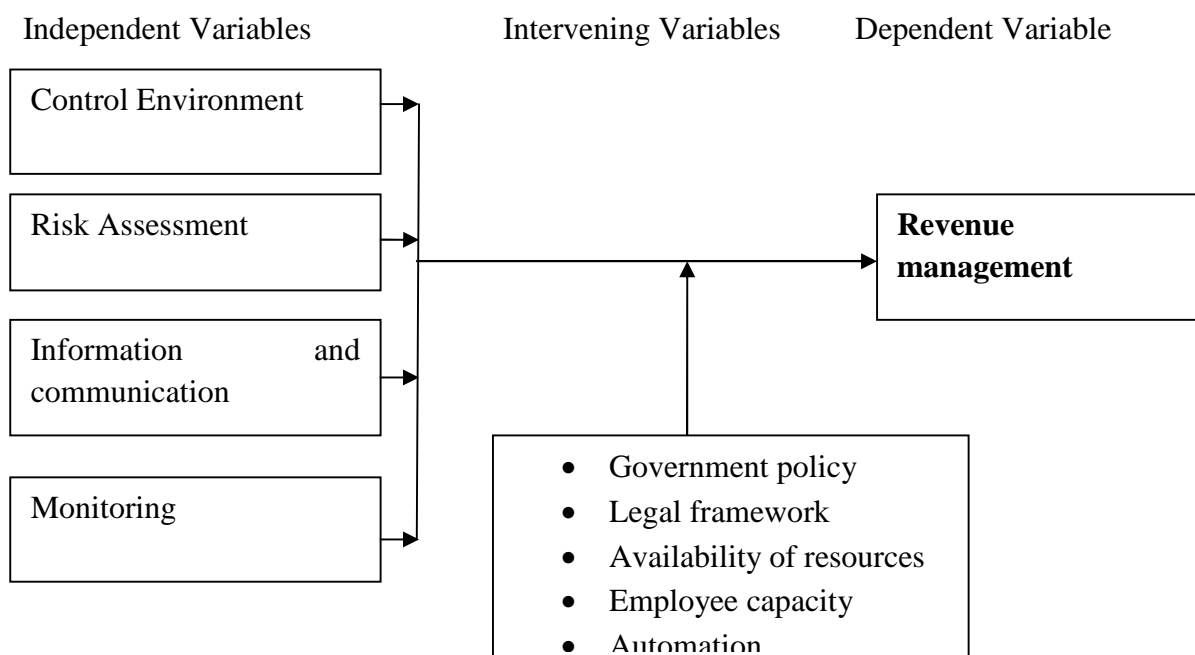
Agency Theory describes firms as necessary structures to maintain contracts, and through firms, it is possible to exercise control which minimizes opportunistic behavior of agents, Adams (1994). Accordingly Gerit (2010) point out that in order to harmonize the interests of the agent and the principal, a comprehensive contract is written to address the interest of both the agent and the principal. They further explain that the relationship is further strengthened by the principal employing an expert to monitor the agent. This position is also supported by Jokipii(2010) who maintains that the contract provides for conflict resolution between the agent and principal, the principal determines the work and agent undertakes the work. He however, proposes that the principal suffers shirking which deprives him or her from benefiting from the work of the agent.

According to Aldrige and colbert (1994) effectiveness of internal controls strengthens transparency in the management of public funds. Apart from transparency, effectiveness of internal controls further strengthens accountability, investments in viable projects and helps to meet the wealth maximization objective. Risk can be defined as the combination of the probability of an event and its consequences (Amudo, 2009). According to Chung et al. (1997) risk is defined as real or potential events which can reduce the likelihood of achieving business objectives. Risk has also been defined as the uncertain future events which could influence the achievement of the organization’s strategic, operational and financial objectives (Gay, 1992). Risk is all about events and their consequences which can happen in the future (Schaefer ,2010).

Information and communication involves the process of identifying, capturing, and communicating of relevant information in an appropriate manner and within a given timeframe in order to accomplish the financial reporting objectives (Aldridre& Colbert ,1994). For effective communication information should flow within and without the various sections of the organization (Theofanis et al.,2011). Information and communication is one of the most important internal control system components, since it influences the working relationship within the organization at all levels (Amudo&Inanga, 2009). Hence, such information must be communicated throughout the entire organization in order to permit personnel to carry out their responsibilities with regard to objective achievement.

Internal control systems need to be adequately monitored in order to assess the quality and the effectiveness of the system’s performance over time. Monitoring provides assurance that the findings of audits and other reviews are promptly acted upon (Theofanis et al, 2011). Monitoring of operations also ensures effective functioning of internal controls system (Amudo&Inanga, 2009). Hence, monitoring determines whether or not policies and procedures designed are being carried out effectively by employees.

4. CONCEPTUAL FRAMEWORK



(Researcher, 2014)

The control environment, as established by the organization's administration, sets the tone of an institution and influences the control consciousness of its people improving the effectiveness of the internal control system. The risk assessment is critical since every entity faces a variety of risks from external and internal sources that must be assessed and forms a basis for determining how the risks should be managed (Theofanias et al., 2011)

The information and communication will be measured by establishing the management awareness of their control responsibilities, personnel awareness of problems to be reported and whether personnel are encouraged to report suspected improprieties. The monitoring measurable includes whether the management reviews supporting documentation, approve accounting system and perform follow up actions. Further, the study will seek to establish the budget preparation and communication system and budget variances reporting. The conceptual framework provides the relationship between the independent and dependent variables. The independent variables consist of control environment, risk assessment, information and communications and monitoring. These elements are critical for effectiveness of internal control.

5. METHODOLOGY

The study adopted a survey design to investigate the role of internal control in revenue management County government. The target population of the study consisted of 97 personnel from the accounts, audit and revenue collection departments in the county offices. The researcher used census method to include all 97 personnel in the study. Questionnaires were used to collect data.

Data analysis involved preparation of the collected data, coding, editing and cleaning of data in readiness for processing using statistical package for social sciences (SPSS). To establish the relationship between, control management, risk management, information and communication and monitoring with role of internal control regression analysis will be conducted. The regression model was in the form below.

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + e$$

Where:

Y= Role of internal control in management of revenue

α = Autonomous factors

X₁= Control Environment

X₂= Risk Management

X_3 = Information and communication

X_4 = Monitoring

e = Error term

6. FINDINGS AND CONCLUSION

Revenue Management

The researcher sought to find out from the respondents on how they felt about the effectiveness of revenue management in the county government of Nyeri. Findings indicate that 49% felt that revenue management was effective while 31% felt revenue was not well management; 20% were undecided.

Effectiveness of revenue management

Response	Frequency	Percentage
Very effective	11	12%
Effective	34	37%
Neutral	18	20%
Not effective	15	16%
Not effective at all	14	15%
Total	92	100%

Control environment

Findings indicate that there is a well and elaborate organization structure in the county of Nyeri (Mean = 4.2). The findings indicate that the county government management is committed to the operation of the internal controls (Mean=3.8). The findings also indicate that policies on staff ethics or codes of conduct exist (Mean = 4.0) and that policies and procedures are periodically reviewed (Mean = 3.2) also, specific lines of authority and responsibility have been established to ensure compliance with the policies and procedures (0.564). However the findings indicate that management does not provide feedback to the junior officers about the operation of the system (Mean=0.931) however, a standard deviation (SD) of 0.931 indicates a significant variation in responses.

Control environment	Min	Max	Mean	SD
There is a well elaborate Organization Structure in NCG	1	5	4.2	0.432
County government Management is committed to the operation of the internal controls	2	5	3.8	0.543
Policies on staff ethics or codes of conduct exist	1	5	4.0	0.690
Policies and procedures are periodically reviewed	2	5	3.2	0.723
Specific lines of authority and responsibility have been established to ensure compliance with the policies and procedures	2	5	3.8	0.564
Management provides feedback to the junior officers about the operation of the internal control systems	1	5	2.9	0.931

Risk management

The county government carries out a comprehensive and systematic identification of its risks relating to each of its declared aims and objectives (Mean = 3.9), the county government appropriately evaluate risks when the organization is planning and approving new products or activities (Mean = 4.1) and that county revenue management can be improved by effective risk management (Mean =4.3). However, the findings indicate that staff are not involved in discussions about appropriate controls when the organization is developing new products and activities (Mean = 1.8) and that the county government risk management policy is not made known to all staff (Mean = 2.3)

Risk management	Min	Max	Mean	SD
The county government carries out a comprehensive and systematic identification of its risks relating to each of its declared aims and objectives.	1	5	3.9	0.673
The county government appropriately evaluate risks when the organization is planning and approving new products or activities	1	5	4.1	1.09
Staff are involved in discussions about appropriate controls when the organization is developing new products and activities	1	5	1.8	0.660
County revenue management can be improved by effective risk	1	5	4.3	0.472

management.				
County government risk management policy is made known to all staff	1	5	2.3	0.381

Information and communication

Duties and roles of staff are clearly outlined (mean = 3.6), the county government's accounting systems properly manage and report transactions in accordance with the proper accounting standards (mean 3.6). However the results suggest that staff are not made aware of revenue management information (Mean = 2.2), appropriate and sufficient reports are not produced for the proper management and control of the county government (Mean=1.9) and financial reports are not easily accessible to all staff (mean =1.5).

Information and communication	Min	Max	Mean	SD
Duties and roles of staff are clearly outlined	1	5	3.6	0.635
Staff are made aware of revenue management information	1	5	2.2	0.754
County government's accounting systems properly manage and report transactions in accordance with the proper accounting standards	2	5	3.6	1.12
Appropriate and sufficient reports are produced for the proper management and control of the county government	1	5	1.9	0.937
Financial reports are easily accessible to all staff	1	5	1.5	0.540

Monitoring

The study found that there was a monitoring system in the county government to determine compliance with internal controls (Mean = 3.9), the county government takes appropriate follow-up action in instances of noncompliance that are reported to it (Mean = 3.6), internal auditors periodically assess the adequacy of the organization's internal control systems (Mean = 4.2), the county government reviews the qualifications and the independence of external auditors (Mean = 3.6) and that the auditing procedures comply with ISA standards (Mean = 3.4). The findings also indicate that there is insufficient detail in audit reports, or other control assessment reports, for the county government to understand the situation as regards internal controls (Mean = 2.1) and that audit reports, or other control assessment reports are not timely enough so that the county government is able to take appropriate action (Mean = 1.9).

<i>Monitoring</i>	<i>Min</i>	<i>Max</i>	<i>Mean</i>	<i>SD</i>
There is a monitoring system in the county government to determine compliance with internal controls	1	5	3.9	0.654
The county government takes appropriate follow-up action in instances of noncompliance that are reported to it	1	5	3.6	0.663
Internal auditors periodically assess the adequacy of the organization's internal control systems	2	5	4.2	0.437
The county government reviews the qualifications and the independence of external auditors	1	5	3.6	0.745
The auditing procedures comply with ISA standards	1	5	3.4	0.932
There is sufficient detail in audit reports, or other control assessment reports, for the county government to understand the situation as regards internal controls	2	5	2.1	0.346
Audit reports, or other control assessment reports are timely enough so that the county government is able to take appropriate action	2	5	1.9	0.357

To establish the relationship between, control management, risk management, information and communication and monitoring with role of internal control regression analysis was conducted using SPSS at 95% confidence level. The findings are presented in this section.

Regression model summary output

Model Summary

Model	R	R Square	Adjusted Square	Std. Error of the Estimate
1	.912 ^a	.663	.443	0.040

Regression ANOVA output

ANOVA^s

Model	Sum of Squares	df	Mean Square	F	Sig.

	Regression	6.793	4	1.698	.819	.014 ^b
1	Residual	535.161	258	2.074		
	Total	541.954	262			

Regression coefficients output

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.092	.735		4.207	.000
	Control environment	.298	.187	.234	.525	.030
	Risk management	.091	.164	.036	.554	.580
	Information and communication	.071	.058	.076	1.221	.223
	Monitoring	.308	.090	.275	1.201	.011

The r square = 0.663. This means that control environment, risk management, information and communication and monitoring explain 66.3% the role of internal controls in revenue management. The P-value (P=0.014) is less than the critical value (P=0.05) this means that the model adopted by this study is significant and ideal in explaining the role of internal control systems in revenue management of Nyeri County, Kenya. Results show the coefficients for the model adopted by the study. The findings indicate that control environment (P=0.03) and Monitoring (P=0.11) are statistically significant, Substituting the coefficients in the model, the model is as follows

$$Y=3.09+0.298x_1+0.091x_2+0.071x_3+0.308x_4+ 0.014$$

According to the regression equation established, taking all factors into account with constant at zero, revenue management will be 3.09. The model shows that monitoring affects revenue management the most followed by internal control environment, risk assessment and information and communication. According to the model, a unit increase in control

environment would result in a 29.8% increase in revenue management whereas a unit change in monitoring would result in 30.8% increase in revenue management.

7. CONCLUSION

The researcher concludes that there is a significant relationship between internal controls and revenue management. In the context of the county government of Nyeri the researcher concludes that revenue management has been promoted by a well-structured control environment and efficient monitoring of control activities. However revenue management is hampered by poor risk management and poor information and communication.

8. RECOMMENDATIONS

County government management should provide feedback to the junior officers about the operation of the system so that they know what is expected of them in enhancing revenue management. Staff should be involved in discussions about appropriate controls when the organization is developing new products and activities and the county government risk management policy should be made known to all staff.

The general public including the staff at the county government should be made aware of revenue management information. Appropriate and sufficient reports should be produced for the proper management and control of the county government and financial reports should be made easily accessible to all staff. The county government auditors should ensure sufficient detail in audit reports, or other control assessment reports, for the county government to understand the situation as regards internal controls. The audit reports, or other control assessment reports should be timely enough so that the county government is able to take appropriate action.

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EFFECT OF MANAGEMENT CONTROL SYSTEMS ON OCCUPATIONAL FRAUD RISK IN COMMERCIAL BANKS IN KENYA

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Abstract

Globally, a typical organization loses at least 5% its annual revenue loss through occupational fraud. Further statistics indicate that occupational fraud risk is highest in commercial banks than any other industry globally. Occupational fraud risk is therefore a global problem. When the percentage annual loss statistics is applied to the consolidated commercial banks revenue

for the year 2012, the loss translates to approximately Kshs 15 Billion. The problem is that Kenya has the highest incidences of fraud in East Africa. The study set to determine the effect of management control systems on occupational fraud risk in commercial banks in Kenya. A representative sample of 30 banks out of the 43 commercial banks licensed by Central Bank of Kenya by June 30, 2012 was used in this study. Multiple linear regression was used to test the null hypothesis; There is no relationship between management control systems and occupational fraud risk in commercial banks in Kenya. The findings from this study are, a Cronbach's alpha of 0.830 for the drivers of management control systems, a moderate positive correlation between management control systems and moderate influence on occupational fraud risk in commercial banks in Kenya. These results provide insights into the occupational fraud risk management and the regulatory authorities in the design of deterrents of fraud in Kenya and developing countries.

Keywords: Occupational Fraud Risk, Management Control systems, Factor analysis, Multiple Linear Regression.

1.0 INTRODUCTION

1.1 Background of the Study

Fraud is an international phenomenon affecting all countries in the world. Specifically, occupational fraud risk is a global problem and its frequency is highest in banks than any other industry globally (Kroll, 2011, ACFE, 2012, Waterhouse Coopers, 2007). Global fraud study report to the Nations, a publication of the Association of Certified Fraud Examiners (ACFE, 2012) on occupational fraud and abuse indicate that a typical organisation losses over 5% of its annual revenue to fraud. Applied to the consolidated Commercial Banks revenue for the year 2012, (CBK, 2011) the loss translates to over KShs 15 Billion loss to fraud. Occupational Fraud loss is not unique to Kenya and is on the rise globally (Kroll, 2011). Occupational fraud prevalence remains high with the estimated prevalence levels as; North America (23%), Canada (16%), Europe (16%), Mexico (23%), Latin America (18%), Middle East(19%), India (23%), China (20%), South East Asia(24%) and Africa 33%. Further statistics show that Africa has not only the highest fraud prevalence (33%), but also the fastest growing exposure levels of 84% (2011) up from 70% (2010). Globally, occupational fraud is highest in Africa compared to other regions globally. The vice continues to threaten the expansion of businesses globally. In another global fraud survey, PricewaterhouseCoopers indicate that Kenya has the highest incidences of fraud in the world, based on a global ranking of 78 countries surveyed way ahead of other more developed economies like South Africa, UK, New Zealand, Spain and Australia PricewaterhouseCoopers (PwC, 2011).

1.2 Occupational Fraud in Kenya

Fraud is unique to East Africa in that it ranks number 2 out of 25 risks when ranked in order of severity (PWC 2011) while the global ranking of fraud in commercial banks is number 15 out of 25 risks in order of perceived severity. Kenyan banking sector is the most affected by the vice compared to Uganda, Tanzania, Rwanda and Zambia (PWC, 2011, World Economic Forum, 2010). Government of Kenya statistics report an alarming 45% annual average increase in number of economic crimes (RoK, 2012). Kenya has the highest incidences of fraud in the world, based on a global ranking of 78 Countries surveyed (PwC, 2011). Fraud statistics are nearly double the global average of 34 per cent and significantly higher than the fraud incidence average in Africa of 57 per cent. The vice threatens a unique sector which occupies a unique position within the Kenyan economy because of the special role in financial intermediation (CBK, 2011). The banking sector maintain over 16 million deposits accounts with gross Kshs 1.5 trillion and over 2 million loan accounts worth over Khs 950 billion (CBK, 2011).

1.2 *Statement of the Problem*

Fraud is a global phenomenon and it is on the rise. Kenya is not isolated from the growing wave of frauds. Financial Services survey report that commercial banks in Kenya are more susceptible to fraud risk than banks in her neighbouring countries in Eastern Africa (PWC, 2011). Despite the significant 84% (36) of commercial banks in Kenya complying with risk management guidelines issued by Central bank of Kenya for over half a decade (2005-2010), an alarming proportion 95% (41) commercial banks are concerned with fraud risk (CBK, 2010). The concern is principally due to the rising losses from fraud to their employees and customers. Rising rate of the vice can erode investor and consumer confidence and pose a great threat to potential investors in Kenya (PWC, 2011). Empirical studies; Duffield & Grabosky (2001), Zahra, Priem & Rasheed (2005), Mustafa & Youssef, (2010) have concentrated on the causes and motivations to defrauding by staff. Other scholars, Alleyne and Howard (2005), Bakre (2007), Brazel, Carpentre & Jenkins (2007), Hamersley, Bamber & Carpenter (2007), Lange (2008), Owusu & Ansah (2002), studied the role of external auditors in fraud, detection and prevention and they produced conflicting findings. Some of the fraud risk studies that incorporated technology and its role in fraud risk management include; Baker (2003), Graziolo & Jarvempaa (2003), Haugen & Selin (1999), MacInnes, Musgrave & Laska (2005) and Nikitkor & Bay, (2008). From empirical literature, it is evident that there is hardly any empirical study on effect of management control systems on occupational fraud in Kenya. The study aim was therefore to find out the effect of management control systems on occupational fraud risk in commercial banks in Kenya.

2.0 LITERATURE REVIEW

2.1 *Concept of fraud*

Occupational fraud has generally been viewed as the use of one's occupation for personal enrichment through the deliberate misuse of or misapplication of the employing organizations resources or assets (ACFE, 2012; Duffield and Grabosky, 2001; Levi ,2008).

2.2 *Theoretical Literature Review*

Theories of fraud point that occupational frauds constitute a crime and those frauds are not random occurrences (Bagnoli & Watts, 2010, Gillett and Uddin, 2005, Carpenter and Reimers, 2005). Various factors contribute to the likelihood of their occurrence, and the form of the occurrence (ACFE, 2012, Langenderfer & Shimp, 2001, Zahra, 2005, Bakre 2007). Many theories have been put forward in an attempt to explain the concept of fraud. On the other hand physiological theories of fraud explains that criminality is inborn and not radon (Oluwadare, 1993; Laombrose ,1876; Rosenthal ,1972). Clarke (1990) in what is known as the sociological theory of fraud explains that if it can be ascertained that certain groups or certain individuals are more likely than others to commit fraud, then they may be the likelihood to reduce the amount of frauds by removing the factors which predisposed these individuals towards perpetrating frauds. Cressey's fraud triangle theory describes a triangular relationship between opportunity, pressure, and rationalization (Wells, 2001; Wilson, 2004). Wilson (2004) describes "opportunity" as the ability to bypass or override controls meant to prevent manipulation, "pressure" the motivation to commit the fraudulent act, and "rationalization" as referring to the moral and ethical argument used to justify the act. What constitutes the key driver of frauds has been is an empirical question among scholars but research point that the same is not random.

2.3.4 *Management Control Systems*

Fraud triangle theory suggests that in circumstances where fraud opportunity is low, fraud occurrence is lower than otherwise. Research indicates that one of the means of reducing fraud opportunity is by institution of strong and effective management controls (ACFE, 2010; Lange, 2008; Nikitkov & Bay, 2008; Alleyne & Howard, 2005). The necessary level of control (in the sense of severity versus laxity) depends on the circumstances and attitude of the organization as to how much occupational fraud it is prepared to accept. In selected studies of occupational fraud, Albretch (2001), Leatherwood & Spector (1991), Alleyne and Howard (2005), Lange (2008) and Mustafa (2010) also found that the rigorous enforcement of management controls reduced not only employee misconduct, but also occupational fraud.

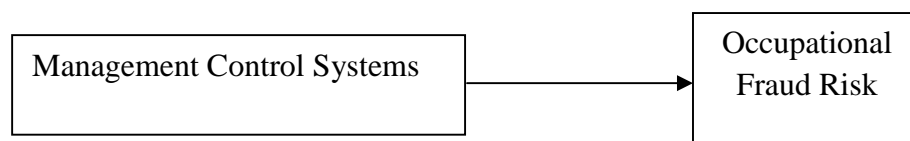
It has also been found that lax management attitudes (Holmes & Holmes, 2002) and ineffective written policies may contribute to its incidence (Turner & Stephenson, 1993; Hooks, Kaplan, Schultz & Ponemon, 1994; Bell, Knechel, Payne & Willingham, 1998; ACFE, 2010). The ACFE Fraud Examiners' Manual in the USA (ACFE, 2008; ACFE, 2010;ACFE, 2012) goes the nearest to providing a list of the main forms of management controls to combat occupational fraud. Alternatively, it may not be particular management controls which are of importance but rather the combination of various policies and procedures which make up those controls which are critical.

A common reason for the breakdown or failure of management controls is organizational change, whether it is due to growth or technological or environmental developments. This is documented in a number of the Wells (2001) cases where it is not the failure of a single control that is to blame for the fraud incidences but rather the failure of a number of the controls which have not adapted to organizational changes. It is an interesting question, therefore, which may be answered empirically, whether differences between an organization's control system (and its constituent components) and those employed in commercial banks in Kenya are the principal reason for their relative effectiveness (or ineffectiveness) in countering occupational fraud in Kenya. The following hypothesis is therefore proposed:

H₀₂: There is no relationship between management control systems and occupational fraud risk in commercial banks in Kenya.

2.3 *Conceptual Framework*

The conceptual framework is based on (management control systems) as the stimulus variable and occupational fraud risk (amount of fraud, number of frauds and frequency of frauds) as the response variable.



Stimulus Variables (SV)

Response Variable (RV)

Figure 1: Conceptual Framework for the effect of management control systems on occupational fraud risk in commercial banks in Kenya.

2.4 *Empirical Literature Review*

2.5 *Research gaps*

From reviewed empirical literature, it is evident that research on the effect of management control systems on occupational fraud risk in commercial banks in Kenya not been done in a comprehensive approach. Literature reviewed indicate that many scholars have concentrated on antecedents of fraud, Dunn & Albrecht (2001), Erickson & Maydew (2006), Ball (2009), Hochberg, Sapienza & Jorgensen (2009), Miller (2006). Other researchers, Knapp and Knapp (2001), Cullinan and Sutton (2002), Ramos (2003) Alleyne and Howard (2005), Bakre (2007) Lange (2008), Hoffman and Zimbelman (2009), Mustafa and Youssef (2010) have studied the role of internal audit in fraud risk management. Baker (2002), Chua and Wareham (2004), Vasiu and Vasiu (2004), Gregg and Scott (2006) studied the role on Information technology in fraud risk management. Idowu (2010) concentrated on fraud assessment in commercial banks. This aim of the study was to provide insight “if management control

systems influence occupational fraud risk in commercial banks in Kenya” and provide pertinent recommendations based on the findings.

3.0 METHODOLOGY OF THE RESEARCH PAPER

The study assessed the bivariate relationship between management control systems and occupational fraud in commercial banks in Kenya. The target population was all the 43 commercial banks operating in Kenya 30th June 2013. These banks are classified by the Central Bank of Kenya using Market Share Index (MSI) as; 6 large banks operating in 546 branches, 15 medium banks operating in 310 branches and 22 small banks with 199 branches. The study used multi -stage sampling process in the selection of a stratified sample of 30 commercial banks and 258 respondents in total; 68 “management”, 54 “section heads” and 136 “clerks”. This sampling method is strongly supported in some social research studies (Oladipo & Adenkule, 2009). The sample size determination is presented in **Table 1**.

Table 1: Sample size determination per “Bank category” from Bank’s Head Office Staff

Bank category	Total	Management	Section heads	Clerks
Large Banks (4)	44	12	8	24
Medium Banks(10)	150	40	30	80
Small Banks (16)	64	16	16	32
Total	258	68	54	136

Self-administered questionnaire was used to collect primary data and a secondary data collection sheet was on the other hand used to obtain secondary data from Central bank of Kenya reports, banking anti-fraud unit reports for the years 2008-2012. Approximately 80% of the commercial banks in Kenya have centralized risk management model (CBK, 2012) and each is head quartered in Nairobi (the capital city). This study focused on the head offices of each bank because branches will generally reflect technologies by the head office. Questionnaires’ reliability of 0.809 was achieved using Cronbach Alpha prior to validity tests using Confirmatory Factor Analysis (CFA). The results of reliability test are presented in **Table 2**. This measure was considered adequate for the study (Cooper & Schindler, 2011). The questionnaire was also subjected to thorough examination by two independent resource persons, from the Certified Fraud Examiners, Kenya Chapter to enhance content validity and final questionnaire was refined before subjecting it to the final data collection exercise. Management control systems as a variable was measured using three constructs “ antifraud control measures”, “fraud detection measures” and “fraud detection measures” using 10 items each, for the first two constructs and 8 in the case of fraud detection measures. Management controls systems items used to construct the questionnaire were Likert-type scale that ranged from 1 to 5 with the following equivalences, “1”: “strongly

disagree”; “2”: “disagree”; “3”: “neutral”; “4”: “agree”; and “5”: “strongly agree”. Likert scale is useful in measuring attitudes and perception (Chimi & Russel, 2009; Charandrakandan, Venkatapirabu, Sekar, Anandakumar, 2011).

Table 2: Reliability of Drivers of Management Control Systems

Scale Item	Number of Items	Cronbach’s alpha	Number of Items	Cronbach’s alpha
	Before Factor Analysis		After Factor Analysis	
Anti- fraud environment methods	10	0.778	8	0.786
Fraud detection methods	10	0.679	14	0.886
Fraud reporting Methods	8	0.787		
Management Control Systems	28	0.809	22	0.830

Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was used to assess the item constructs suitability for factor analysis. The results of sampling adequacy test are presented in **Table 3**. The results show that KMO test had a score of 0.794, which was well above 0.50 levels, indicating an acceptable degrees of sampling adequacy for the variable (Malhotra, 2004; Tabachnick & Fidell, 2007; Brett, Ted & Andrys, 2010). The results also showed that the Bartlett’s test of Sphericity had a Chi-Square value of 2276.004 with a significant value of $0.000 < 0.001$, again supporting use of Confirmatory Factor Analysis as a data reduction technique and a measure of construct validity for management control systems constructs.

Table 3: Test of Sampling Adequacy- Management Control systems

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.794
	Approx. Chi-Square	2276.004
Bartlett's Test of Sphericity	Degrees of freedom	153
	Significance	.000

4.0 DISCUSSIONS AND RESULTS

4.1 *Response Rate*

Response rate was approximately 92% with 78%, 95% and 100% among the small banks, medium size banks and large banks respectively. Overall the response rate in this study was higher compared to other similar previous studies. For example, Voon and Pua (2009) reported a response rate of 70% in their study on the determinants of corporate crime in Nigeria. The high response rate was attributed to anonymity among respondents. Auta (2010) used anonymity in his study on development of e-banking in Nigeria. Response distribution of the 236 respondents in terms of age was categorized between the age of 21 – 30 (28%), 31- 40 years (40%), 41-50 years (32%), over 50 years (2%). This is a pointer that the respondents had reasonably sufficient knowledge on the subject of the study within the banking sector in Kenya. Among the sampled banks, 11% were from local public commercial banks, 75% from locally private banks and 14% from foreign commercial banks. The findings imply that the sample used in this study included all categories of commercial banks in Kenya in terms of ownership structure and therefore representative of all banks in Kenya. A significant 206 (87%) of the respondents had banking sector experience between 1 and 10 years and therefore likely to have had reasonable exposure to the subject of this study; occupational frauds in commercial banks.

4.2 *Drivers of management controls systems*

When the 28 statements on management control systems were subjected to factor analysis, 22 items loaded between 0.416 and 0.958 and were thus retained for analysis. This study used statements with factor loadings above 0.4 which is recommended (Tabachnick & Fidell, 2007; Montgomery, Peck and Vining, 2001). Principle Component Analysis is an important tool for data reduction (Bhattacharyya, 2011). The reliability of the composite measure for the 22 items was re-assessed and a Cronbach alpha coefficient of 0.830 was achieved.

4.3 *Test of Assumptions*

Durbin –Watson d statistic test of univariate independence for management control systems resulted a coefficient of $d=2.160$, well within the range of 1.5 and 2.5 for independent observations (Garson, 2012; Porter & Gujarat, 2009). Effiok, Ojong and Usang (2012) used Durbin Watson's d Statistic to test autocorrelation of predictor variables in their study which examined the implication of occupational fraud and financial abuse on the performance of Nigerian companies. The Gaussian test results are presented in **Table 4**. The table shows that normality test statistics computed for occupational fraud risk using both Kolmogorov-Smirnov (K-S) and Shapiro-Wilk tests are insignificant with p-value of .200* and .423 respectively, both greater than 0.05 in both measures, an indication of held normality assumption based on both numerical methods (Shapiro & Wilk 1965; Park, 2008),

Table 4: Normality Test for Study Variables

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
Occupational Fraud Risk	0.088	30	.200*	0.965	30	0.423

a. Lilliefors Significance Correction

*. This is a lower bound of the true significance.

4.4 Statistical Model

Aggregate weighted scores of management control systems were regressed against the weighted scores of occupational fraud risk. Results of curve estimation using SPSS Version 17.0 indicated that a linear mathematical model was adequate for the testing of hypothesis. Linear relationship between determinants of fraud and fraud risk is expected based on the results of above tests of assumptions (Shevlin & Miles, 2010). The mathematical relationship between the variables was hypothesized as “OFR= + MCS” where OFR is occupational fraud risk (regressand) and MCS is management controls systems (regressor). The model summary is presented in **Table 5**.

Table 5: Model Summary of OFR/ Management Control Systems

Model	R	R Square	Std. Error of the Estimate	Durbin-Watson
1	.425 ^a	.181	.2384872	2.160

a. Predictors: (Constant), Management Controls Systems

b. Dependent Variable: Occupational Fraud Risk

The linear regression analysis shows that there is a relationship, $R = .425$ and $R^2 = .181$ which means that approximately 18.1% of the corresponding variations in occupational fraud risk are explained by a unit change in management control systems measure. **Table 6** shows significance of the model predictor in the hypothesized model.

Table 6: Regression Model Significance

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	0.352	1	0.352	6.180	.019 ^a
	Residual	1.593	28	0.057		
	Total	1.944	29			

a. Predictors: (Constant), Management Control Systems

b. Dependent Variable: Occupational Fraud Risk

Regression analysis is Table 6; shows that the linear relationship between occupational fraud risk and MCS has an F value $F=6.180$ which is significant with p value $p=.019 < p=.05$ meaning that the overall model is significant in the prediction of occupational fraud risk in commercial banks in Kenya. We therefore fail to reject the null hypothesis and confirm that indeed, there is a positive and significant effect of management control systems on occupational fraud risk in commercial banks in Kenya. These study results corroborate findings by (ACFE, 2012; ACFE, 2010; Lange, 2008; Nikitov & Bay, 2008; Alleyne & Howard, 2005) who found that one of the means of reducing fraud opportunity by an institution was by institution of strong and effective management controls. Similarly, Mustafa & Youssef (2010) found that rigorous enforcement of management of management controls reduced employee misconduct and occupational fraud. Idolor (2010) found that that failure of management controls contributed significantly to the occurrence of fraud in Nigeria commercial banks. While there may be nothing as absolute control, there is a necessary level of control (Mustafa & Youssef, 2010). The acceptable level of control is determined by consideration of “that level of control which would keep occupational fraud to tolerance level” if not absolute deterrence of the same.

Table 7: Regression Coefficients of Management Control Systems and Occupational Fraud Risk

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-0.007	.447		-.016	.987
	Technology Adoption	.975	.392	.425	2.486	.019

a. Dependent Variable: Occupational Fraud Risk

Table 7 shows; test on the beta coefficient of the resulting model, the constant = -0.007 is insignificant with p value $p= 0.987 > p=0.05$. The coefficient = 0.975, has a p value, $p=.019$ which is less than $p= 0.05$. This means it is significant in the regression model.

The model residuals normal P-P plot presented in **Figure 2** shows that the standardized residuals plot a lot the 45 degree straight line from origin, an indication that the residuals are normally distributed. Normality of the residuals indicates the linear regression was adequate for the analysis of the relationship between occupational fraud risk and management control systems.

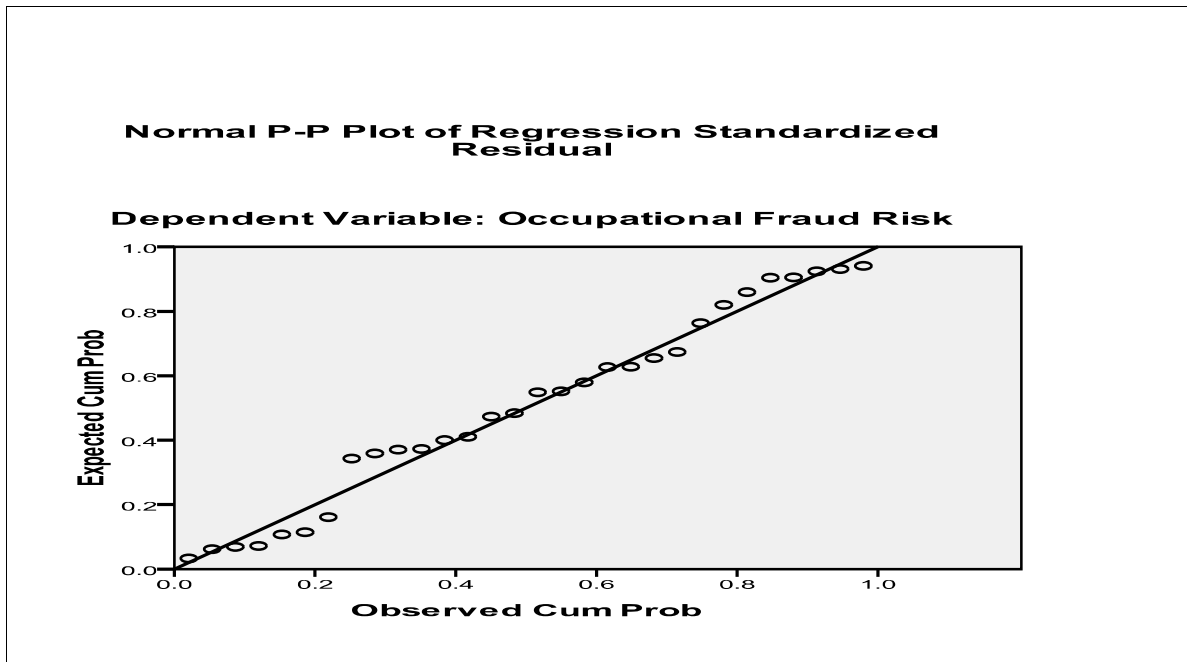


Figure 2: Normal P-P Plot of Regression Standardized Residual of occupational fraud risk and management controls systems

5.0 CONCLUSION AND RECOMMENDATIONS

There is a positive and significant relationship between management control systems and occupational fraud risk in commercial banks in Kenya. Weak fraud management controls appear to create opportunities for occupational fraudsters as indicated by the statistically significant beta values. Fraud triangle theory appear quite important in explaining effect of weak fraud management controls and occupational frauds in that staffs who are potential perpetrators of fraud find opportunity in the weak controls systems. Conclusively, this study confirms that the number of frauds, frequency and amount of fraud loss experienced in commercial banks in Kenya are influenced partly by weak if not failing fraud controls. The inherent fraud risk exposure was found to be statistically insignificant as explained by the p values of 0.987. Commercial banks should employ effective fraud controls to deter fraud incidences. The controls should cut across anti fraud controls, fraud detection controls and fraud reporting controls. Weak management controls are associated with more opportunities and incidences of fraud. Important too is the fact when controls are weak, trusted staff

automatically become trusted violators and therefore banks should also practice and maintain high ethical standards in performance of the duties as well as ensure tight tone on the top for occupational frauds.

6.0 LIMITATIONS AND FUTURE WORK

The major drawback to this study is that it used likert scaled measures of perception of the bank staff on the effect of management controls systems on occupational fraud in commercial banks. Further, the study is limited to commercial banks in Kenya and excludes other financial market players such as the forex bureaus, mortgage banks, micro finance institutions, savings and credit cooperatives (SACCO's) and pension funds. An improved and more informative study could be achieved in future by using secondary data on a multi-sector study in order to generalize the fraud situation in the Kenyan context.

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EFFECTIVENESS OF OPEN TENDERING SYSTEM ON PROCUREMENT PROCESS AMONG PUBLIC SECONDARY SCHOOLS IN NYERI CENTRAL DISTRICT, KENYA

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Abstract

The study sought to investigate the effects of open tendering on procurement of goods and services by Public Secondary Schools in Nyeri Central District of Nyeri County in Kenya. Four objectives were proposed namely to; Analyze the effect of Open tendering system on the quality of goods and services procured: Examine the influence of Open tendering system on the cost of goods and services procured: Assess the effectiveness of Open tendering on the accountability in procurement of goods; Evaluate the influence of Open tendering on the suppliers' confidence in the procurement system of Public Secondary Schools in Nyeri central. The study adopted the descriptive survey design. The population of the study was the tendering committee members of the 14 public secondary schools in the district and the registered suppliers in the district. From a population of 288 consisting of 112 committee members and 176 registered suppliers, snowballing was used to draw a sample of 122 suppliers. A census was carried out on the committee members. Data analysis was done using descriptive and inferential statistics. SPSS was used to generate frequencies, percentage and mean to present the measuring parameters of each objective. A regression model was computed to establish the relationship between each independent variable with the dependent

variable. It was found out that open tendering ensures that schools purchase quality of goods and services; it helps in reducing cost of goods and services procured; The system also enhances accountability in the procurement process and suppliers' confidence. However, though the public secondary schools are using open tendering, all the laid down procedures are not being followed as required. Therefore the study recommends a more vigorous supervision and auditing systems.

Keywords: Open tendering, quality of goods and services, accountability, suppliers' confidence, procurement, tendering committee.

1. INTRODUCTION

In the heart of the procurement reforms is the Open tendering system. Open tendering as per the Kenya Gazette Supplement No. 92, 2006, involves invitation of prospective suppliers to compete for an advertised contract where the lowest tenderer in terms of price will be accepted. The lowest bidder should nevertheless be deemed qualified to perform the contract. The Public Procurement Regulations of 2006 (part IV) states that 'for each procurement, the procuring entity shall use open tendering or an alternative procurement procedure under Part VI' (National Council for Law Reporting, 2010. P.20). In spite of this, alternate procurements are subject to written approval by the tendering committees and documented reasons should be provided (Kenyan *et al.*, 2010).

The Public Procurement and Disposal Act decentralize procurement activities to various public entities which include government departments, courts, public schools, colleges and public Universities among others. For Public Secondary Schools, the Act has granted teachers and subordinate staff the power to control the tendering and procurement process by setting of Tendering Committees to oversee the whole process of procurement. This is a departure from the previous process where procurement was solely performed by Principals.

This procurement system for Secondary Schools is particularly useful with introduction of Free Day Secondary Education (FDSE). FDSE have resulted in a surge of students seeking after secondary education. As such enrolment has risen from 860,000 students in 2003 to over 1 million in 2006 (Munavu *et al.*, 2008). In addition, the number of secondary schools has also increased from a total of 6,566 in 2008 to 7,308 in 2010 and the existing ones have undergone expansion (*ibid*). To cater for the expansion of these Secondary Schools, enormous amount of public funds is being used to procure necessary goods and services.

To ensure the schools obtain quality goods and services in a timely manner, the tendering committee is supposed to use Open tendering system. This requires that the schools should, among other things advertise the tender. The advert should provide the name and address of the procuring entity, indicate where to obtain and submit the tenders. The advert should provide enough information to allow fair competition among the participants (National Council for Law Reporting, 2010).

A study by Kenyan *et al.*, (2011) observes that although the Act has strengthened the Public Procurement System in Secondary Schools, weaknesses still exist in practice.

The open tendering has inherent weaknesses prone to abuse by procuring entities and therefore the Public Secondary Schools fails to achieve the intended benefits. For example, a tender may be openly advertised as required but eligibility rules manipulated to fit a given supplier in exclusion of other suppliers. In Nyeri Central district though most Public Secondary Schools using open tendering to procure goods and services they have stalled projects, some immediately after commencement while others while nearing completion. Research done reveals the major reasons for non-completion of the projects is nonpayment to the suppliers, the lengthy procurement procedure and lack of honesty among the suppliers.

Specific objectives

- i. To analyze the effectiveness of open tendering on the quality of goods and services procured by Public Secondary Schools in Nyeri Central District.
- ii. To examine the influence of Open tendering system on the cost of goods and services procured by Public Secondary Schools by secondary schools in Nyeri Central District.
- iii. To assess the effectiveness of open tendering in ensures accountability in procurement of goods and services by Public Secondary Schools in Nyeri Central District.
- iv. To evaluate the suppliers' confidence in the Open tendering procurement system used by of Public Secondary Schools in Nyeri Central District.

2. LITERATURE REVIEW

Open tendering and Accountability

According to Thai (2001), the basic principles of good procurement practice include accountability. This is where effective mechanisms must be in place in order to enable procuring entities spend the limited resources carefully, knowing clearly that they are accountable to members of the public. Accountability shows how the public interest has been protected in the expenditure of public funds. Maintaining integrity in public procurement is one of the most important pillars of modern national procurement systems (Barrett, 2000). The accountability of procurement officials is not only important from a public or administrative law perspective, but also has economic implications.

Secondary schools in Kenya are bound by the Procurement Act to be accountable in their procurement activities. However, according to Transparency International (2007), single sourcing of goods, services and works remains a common practice among some schools; while in others, school heads collude with their Boards and political leaders to subvert procurement and tendering procedures. As such it is not clear about the extent to which the new procurement regulations have taken root in public secondary especially on the accountability of the procurement activities.

Open Tendering and Cost of Goods and Services

One of the basic rules of procurement is that in the end, it is important to think in terms of the total cost of goods and services. This includes not only the purchase price, but also time and resources that are expended in the pursuit of the ownership of goods and services. By understanding the steps involved in procurement, it is possible to get a better understanding of the real cost involved in attaining any good or service (Baily et al, 2004).

While Mutahi (2005) noted that little was known about the extent to which many schools had integrated procurement reforms in their systems, the study conducted by IPAR (2007) underscored the inadequacy of literature and documentation on weaknesses in the expenditure management in Public Secondary Schools especially cost management.

Open tendering system and the quality of goods and services

Open tendering allows the procuring entity to invite a variety of suppliers and select those who can offer quality goods and services at the lowest price. However, an Open tendering system, which can provide more transparent procedures and has better objectivity with little room for the ordering party's discretion, also has some disadvantages (Odhiambo and Kamau 2003). A study by Kanemoto and Kidokoro(1999) in the procurement of building services in Japan revealed that it is difficult to prevent low-quality and disqualified builders from tendering, and as a result, it can be difficult to maintain a high quality level of tendering parties. The study revealed that builders with lower tender prices perform poor quality work or additional charges for design changes might be charged to the procurer too frequently.

While several studies (Onsongo, Okioga, Otieno and Mongare, 2012) have looked into the effects of procurement on financial management in Secondary Schools and the challenges faced in implementation of open tendering, the effects of open tendering specifically on the quality of goods and services have not received any attention.

Open tendering and Suppliers confidence

The private sector is mainly the supplier of goods and services to the government institutions thus their confidence in public procurements process is critical. Their confidence can be affected by unfamiliar regulations, unfavorable conditions set for participation among others. For example Public Procurement Oversight Authority (2007), reveals that 'limited private sector training supply remains a major constraint to the unfolding of the procurement market potential, as many private bidders lack adequate procurement knowledge to take part in procurements' (P. 20). Further, some contracts require huge financial resources, but small and medium enterprises faces difficulties in obtaining credit a situation that is worsened by delays in payment of contracts PPOA (2007).

3. METHODOLOGY

Research Design

Descriptive survey research design was used. This design was ideal as it enabled an in-depth study of the relevant variables in order to establish existing conditions in the schools

procurement systems (Orodho, 2009). Studies that are concerned with what people think and what they do can utilize this research design. The population of the study was the tendering committee members of the 14 Public Secondary Schools in the district and the registered suppliers in the district. There were 8 members of the tendering committee in each Public Secondary school. Therefore there were 112 tendering committee members in the district. On the other hand there were 176 registered suppliers in the district according to the Nyeri County tendering committee. In total, therefore, the population of the study was 288 individuals consisting of 112 tendering committee members and 176 suppliers. The study conducted a census of the committee members in all the 14 public secondary schools in the district. Thus 112 committee members participated in the study. On the other hand snowballing method was used to pick on the suppliers that participated in the study. The sample size was therefore 234 individuals. A questionnaire was used to collect data in this study. The self-administered questionnaire had both close ended and open ended questions.

4. DATA ANALYSIS AND PRESENTATION

The study sought to investigate the effect of open tendering on the cost of goods and services procured by secondary schools. The committee members were supposed to indicate whether, they always accept the lowest bidder in the procurement process. As shown in Figure 1 20% of the respondents indicated that they do not always accept the lowest bidder while 80% of the respondents indicated that they do always accept the lowest bidder.

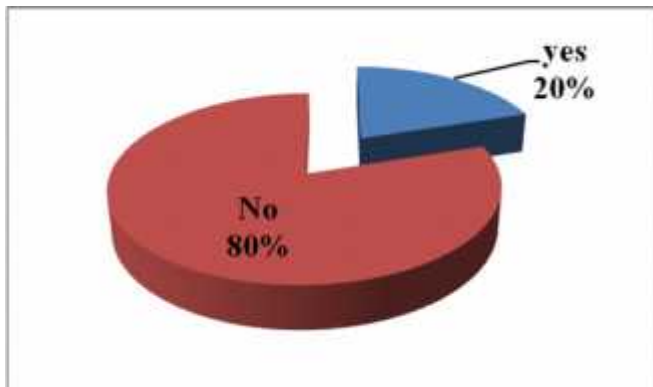


Figure 1 Lowest bidder acceptability

Accountability

As shown in Figure 2 the committee members were required to indicate whether the undertake procedures to ensure accountability. Market survey was the one of the accountability procedure undertaken by most schools. Market survey had mean score of 1.7. The second most carried out procedure was formation of a panel to evaluate suppliers with a mean score of 1.5. The least accountability procedure carried out by schools was documenting the evaluations. These findings reveal therefore that schools mostly use market survey to update the members of the tendering committee on the prevailing prices so that they make informed decisions.

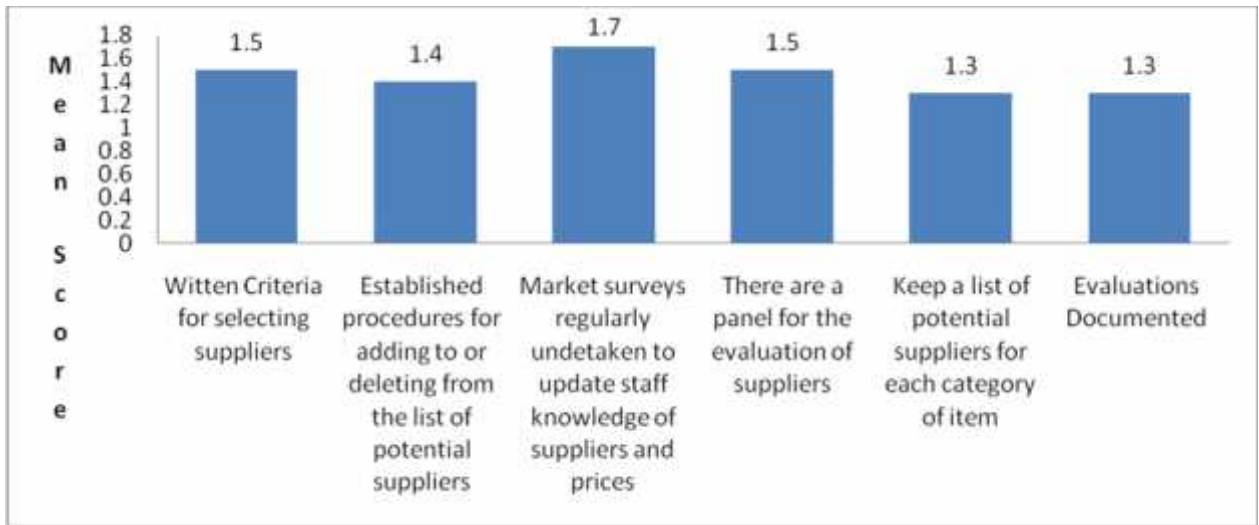


Figure 2 Accountability Responses

Quality of Goods and Services

The effect of open tendering on the quality of goods and services procured by the secondary schools was measured in terms of the practices used by schools to ensure the quality of goods procured conforms to the requirement. As shown in Figure the schools ensure they have manual of procedures of equipments bought by the schools. This was the commonly used methods of ensuring quality of goods by secondary school and had the highest mean score of 1.6. The respondent also indicated that goods and services are supplied as per the specifications as per letter of award all accessories and spare parts are provided. The least performed procedure was always ensuring quality and quantity are correct.

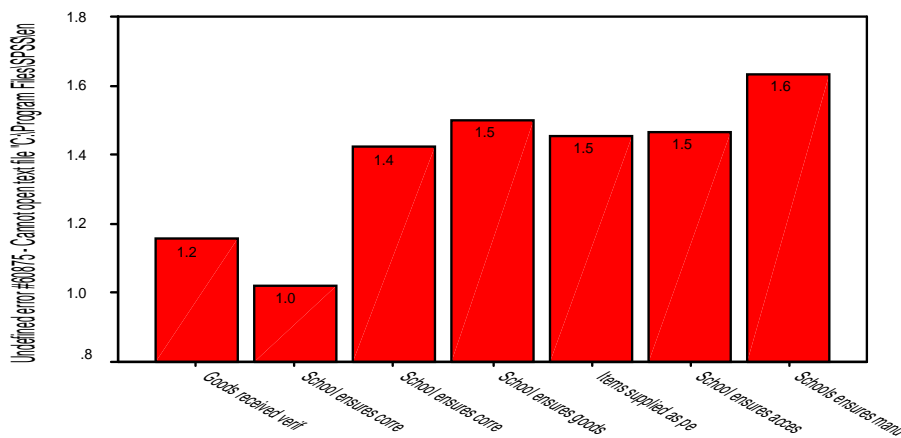


Figure 3 Quality of goods Responses

Suppliers Confidence

The suppliers' confidence was measured by how suppliers come to learn about the information about secondary schools' tenders. As shown in the Table 2, 32% of the suppliers indicated that they learn about secondary school tenders through local newspaper. However, the most important source of information was other publically available tender sources such as the Ministry of Education. Such information is normally available on the notice boards within the premises of the ministry of education. The least source of information was through engagement with secondary procurement committees where only 8% of the respondents indicated the committees' members as the source of information for secondary schools tenders. The findings therefore reveal that information of secondary schools' tenders are fairly publicly available thus reducing chances of corruption which in turn boosts the suppliers' confidence.

Sources of tender information	Frequency	%
Through local newspapers	24	32
Through other publically available tender sources (e.g Ministry of Education)	34	45
Through a network of other suppliers	12	16
Through direct engagement with secondary procurement committees	6	8
Total	76	100

Table 2 Sources of tender information

The suppliers' confidence was also measured by the ease with which information on tenders is user friendly. The suppliers were asked whether the tender information provided by the secondary schools target specific suppliers or brands. Further, the respondents were to indicate whether the tender information contains enough detail in terms of technical specifications to enable suppliers provide required goods and services. According to the findings, suppliers indicated that there was no enough provision of enough technical specification that may allow them provide required goods and services. This particular item had the highest mean score of 2.5. However, the respondents indicated that tenders were not necessarily in favor of a certain brand. This particular item had a mean score of 2.1. Further, the suppliers indicated some of the tenders were in favor of specific suppliers as shown in Figure 4. The findings therefore reveals that the suppliers' confidence is to the procurement process was mostly affected by the technical information provided by the schools. Lack of enough information makes it difficult for the suppliers to source and provided the required goods and services.

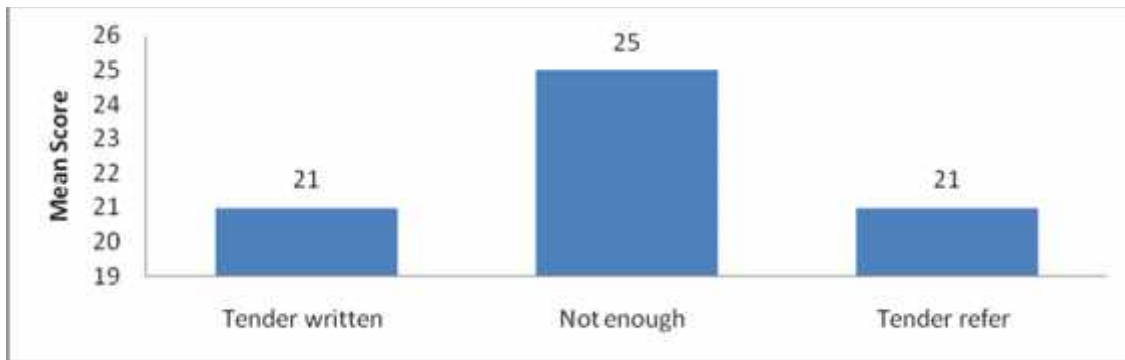


Figure 4 Tender Information

Multi-regression

The multi-regression model of all the variables considered together was computed. The multi-regression of the study was given as shown in the Table 4 the model shows that 95.7% of effectiveness of the procurement process was accounted for by the quality of goods and services practices used by secondary schools, costing practices, accountability practices and suppliers' confidence.

Table 4 Multi-regression 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	.978 ^a	.957	.955	.523	.957	601.822	4	109	.000

a. Predictors: (Constant) Quality of goods and services, Cost of good and services, Accountability, supplier confidence

The model shows that quality of goods practices, cost of goods practices, suppliers' confidence and accountability practices were important factors of the open tendering that influence the effectiveness of the procurement process. The model had significance value of 0.00 which indicates that these are important practices as far as effectiveness of the procurement process is concerned. As shown in the Table 5, accountability had the highest value of 0.177, which implies that ensuring that practices that bring about accountability are used was critical as far as effectiveness of the procurement process is concerned. The cost of goods and services had a value of .036 and had the least influence on the effectiveness of procurement in secondary schools while cost of goods and services had a value of .086.

Table 5 correlation coefficient of multi-regression

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.447	.176		3.101	.002
	Quality of goods	.086	.023	.217	3.777	.000
	Cost of goods	.036	.013	.132	2.685	.008
	Suppliers Confidence	.067	.019	.207	3.524	.001
	Accountability	.177	.023	.462	7.760	.000

a. Dependent Variable: Procurement process

Thus the study's model was as follows

$$Y = 0.447 + 0.086 X_1 + 0.036 X_2 + 0.067 X_3 + 0.177 X_4 + 0.176$$

Where;

Y=Effectiveness of procurement process

0.447= Effectiveness of procurement process practiced by secondary schools without considering open tendering.

X_1 = quality of goods and services

X_2 = Cost of goods and services

X_3 = Suppliers confidence

X_4 = Accountability

Secondary schools in Nyeri central district practice Open tendering as required by the Procurement Act 2010. However, the schools fail to observe critical procedures as required such as advertisement of tender, documentation of the evaluation process and failure to justify rejection of the lowest bidder. This confirm Transparency International (2007) observation that single sourcing of goods, services and works remains a common practice among some schools; while in others, school heads collude with their Boards and political leaders to subvert procurement and tendering procedures.

In terms of cost schools always accept lowest bidder, however some schools indicated they do not necessarily accept the lowest bid. While the Kenya Gazette Supplement No. 92, 2006, state that procuring entities should advertise contracts where the lowest bidder in terms of price will be accepted. Reddy and Berger (1983) observes that the lowest bidder should not always be deemed qualified to perform the contract. Though rejection of the lowest bidder should be justified, the findings reviewed that most schools do not justify such action.

Gaining suppliers confidence to the procurement process is one of the intention of open tendering. Participating suppliers in Nyeri secondary schools were found to supply food stuff stationeries laboratory chemicals and building materials. The major concern of the suppliers is lack of enough technical specification information that may allow them provide required goods and services. As such the suppliers have to refer to the schools for more information. This confirms that Public Procurement Oversight Authority (2007) observation that suppliers' confidence can be affected by unfamiliar regulations, unfavorable conditions set for participation among others.

5. CONCLUSION

Secondary school in Nyeri practice Open tendering in procuring goods. However they do not necessarily follow the laid down procedure as required by the Procurement Act 2010. While the schools avail information through advertisement, use of informal means such notice boards or consulting the tender committee is still being used by the schools. The quality of goods and services is also not always confirmed as required. It therefore follows that introduction of the Open tendering have not adequately improved accountability or improved the quality of goods and services.

Recommendation for further study

The school committee should be trained on the procedures of open tendering to ensure that they follow all the laid procedures so that open tendering can be effective. There should be regular auditing of the procurement procedures with an intention to ensure open tendering is practiced by secondary schools. The Open tendering should made less tedious to make it easier for schools to practice it as their main procurement method.

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INTERGROUP CONFLICTS AND PERFORMANCE OF PUBLIC UNIVERSITIES IN KENYA

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Abstract

The central theme of the research was to investigate the effect of intergroup conflicts on the performance of public universities in Kenya. With a sample size of 150 respondents (n=150), the study used both primary and secondary data collection instruments. Primary instruments included the use of questionnaires while secondary instruments involved acquiring information from the already existing records from the public universities. Both content and construct validity was achieved through citation of literature and expert involvement in preparation of the research instruments respectively. Both descriptive and inferential statistics were used in data analysis using SPSS version 20 software. Cronbach's Alpha of coefficient was found to be 0.890 which was way above the recommended 0.7 in non clinical research

work, meant that the research instruments were reliable. Pearson Product Moment Correlation was used to determine the direction and strength of the relationship between intergroup conflicts and performance of public universities in Kenya. Intergroup conflicts and performance of public universities was expected to follow a regression model of the nature $P = \beta_0 + \beta_1 IC + e$. The findings were presented using tables and crossbar tabulations. The outcome was positive correlation between intergroup conflicts and performance of public universities in Kenya. The findings are of importance to the Government of Kenya, shareholders, employees and interested parties of public universities and it forms a basis for future reference.

Key words: Intergroup conflicts, performance, public universities

1. INTRODUCTION

Public universities are charged with the responsibility of generating and disseminating knowledge for the benefit of the wider society. Nakhone (2004) shares a similar view regarding the nature of universities: A university is a place for the pursuit and dissemination of knowledge. It is a social institution that enjoys a high degree of autonomy and academic freedom. A university is generally perceived as a social, cultural, technological and economic agent of change. They are therefore expected to be in the forefront in the generation of new ideas and new ways of doing things. In Kenya, a university is regarded as the highest institution of learning in the land (Nakhone 2004).

Globally, conflict is a necessary and useful part of organizational life. It is inevitable and an integral part of the process of change. Indeed, it is an aid to cooperation, not an obstacle, (Albert 2001). There are productive and destructive conflicts: a conflict is said to be productive or positive when it is constructively discussed by the parties and the parties solve the conflict amicably. When warring parties solve their conflict in a constructive manner, the outcome is likely to generate a positive employee's performance and build sustainable relationship among employees. Poorly managed conflict heats up the environment to bring about dislocation of the entire group and polarization and reduced productivity on employee's work performance.

It also results into psychological and physical injury, emotional distress and inability to sleep, interference with problem activities, escalation of differences into antagonistic position and malice and increased hostility among members of a group in an organization that eventually affects the ones work performance, (Akaniji, 2005). Through conflict management, a cooperative atmosphere is created for promoting opportunities and directing movement toward non-violent reconciliation of basic clashing interest. However, no matter how one looks at conflict, it is important to realize that conflict is one of the best ways in the world to turn the tide and improve unsatisfactory conditions. As a matter of fact, sometimes there may be no real dispute to be managed, but there may be need for greater understanding, cooperation and team work to promote interpersonal harmony and good organizational climate for teaching and learning. Therefore, conflict should not always be seen as something undesirable but rather as a necessary impetus that can bring positive consequences, if

properly managed. It is against this background that it becomes pertinent to examine effect of intergroup conflicts on the performance of public universities in Kenya.

Conflict emerges in an organization when an individual: perceives that s/he is insecure, his/her performance is threatened or is ineffectively performing his/her duties because s/he is hindered by the activities of another person. One of the major objectives of resolving conflict in organizations is to enhance organizational learning that involves knowledge acquisition, knowledge distribution, information interpretation, and organizational memorization (i.e., preserving information for future access and use). This enables organizational members to collectively engage in the process of diagnosis of and intervention in problems. Rahim (2002) define learning as "detection and correction of error".

Main sources of conflict in the organization relate to perception and value problems. According to Kehinde (2011), the specific issues that bother employees are compensation and welfare while managers prefer the compromise, problem solving and dominating strategies to minimizing the incidences of organizational conflicts on one hand and working people on the other. Conflict can create negative impact to group but may also lead to positive effects depending on the nature of the conflict. It is against this view that the study establishes the effect of intergroup conflicts on the performance of Public Universities in Kenya.

Study Objective

The general objective of this study was to establish the effect of intergroup conflict on the performance of public universities in Kenya. The findings of the research study will be useful to the management of public universities in Kenya. Further, the findings will be of importance to the stakeholders of the Public Universities in Kenya namely students, employees, shareholders and the community at large. The study will also contribute to extant literature on conflict resolution strategies. The study was carried out in Public Universities. The study covered time frame of three years: from 2011 to 2013. The period was chosen due to the availability of information that was to be used in the study. The employees of the public universities were targeted as the study respondents.

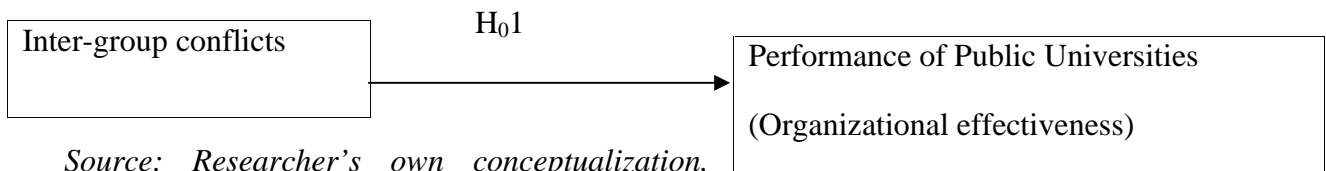
Conceptual Framework

The variables were intergroup conflicts as the independent variable while performance of Public Universities was the dependent variable.

Figure 10.1: Conceptual Framework

Independent variable

Dependent variable



Source: Researcher's own conceptualization, 2014

2. RESEARCH METHODOLOGY

A descriptive research design that involved qualitative method was used. Best and Kahn (1986) viewed descriptive design as conditions or relationship that exists, opinions that are held, processes that are going on, effects that are evident or trends that are developing. According to Mugenda and Mugenda (2003), descriptive survey design is a way of collecting information by interviewing or issuing questionnaires to sampled individuals. The survey design is preferred as it is used to explain the existing status of the two variables. It will enable the researcher to generate information directly from the respondents in public Universities.

Study Area

The study was carried out at Masinde Muliro University of Science and Technology (MMUST), Jaramogi Oginga Odinga University of Science and Technology (JOOUST) and Kisii University. The universities were identified based on their age and origin. MMUST grew out of Moi University before getting its charter in 2003. Kisii University started as a constituent college of Egerton University in 2009 before becoming a chartered university in 2013. JOOUST on its part started as a constituent college of Maseno university in 2009 before becoming chartered in 2013. All these three Universities therefore started as offshoots of older Kenyan public universities hence intergroup management were derived from the mother universities with modifications based on the prevailing business environment. As a result, the study considered them ideal institutions for this study.

Study population and sampling technique.

According to Kombo and Delno, (2006) target population is a group of individuals, objects or items from which samples are taken for measurement. The population that was of interest to this study was the teaching staff of MMUST, Kisii University, and JOOUST who stood at 1,500 members of staff. The teaching staffs were ideal for this study because they are affiliated to different departments which appear to be groups in their making.

Data Collection instruments

Primary data was obtained from the questionnaires and interview schedules as research instruments. Self-administered questionnaire were administrated by the researcher and filled by the members of staff of Public Universities. The questionnaire contained closed-ended questions. The questions offered will be based on a Likert-scale rating to ask the respondent how strongly he/she agreed or disagreed with a statement or series of statements. As (Kothari, 2004) states structured questionnaires are used as the main instrument of primary data

collection because this study covers a number of subjects and the nature of the research which has both quantitative and qualitative data.

The interview guide was used for interviewing key informants who were knowledgeable and experienced about the subject matter as recommended by Oppenheim (2001). These were the Deans and Heads of department. Open-ended questions in the interview guide allowed the researcher to get the required answers that are unanticipated and potentially helpful in avoiding issues later in the process. These questions will develop trust and are perceived as less threatening, allowing for an unrestrained or free response. However, they were time-consuming and this led to difficulty in developing general statements or assumptions (Musaazi, 2006).

Reliability and Validity of Research Instruments

Golafshani (2003) states that the extent to which results are consistent over time and an accurate representation of the total population under study is referred to as reliability and if the results of a study can be reproduced under similar methodology, then the research instrument is considered to be reliable. The reliability of a study has to do with the degree to which the measuring instruments used in the study yield consistent results or data after repeated trials Mugenda and Mugenda (2003). A test -retest technique was used to measure reliability of the data. According to Mugenda (2003) this involved the administering the same instrument twice to the same group or subject and after keeping the initial conditions constant, administer the same test to the same subject after few weeks and then correlate the scores to obtain correlation coefficient . If the correlation coefficient is high the instrument is said to yield data that have test – retest reliability.

Table 1.3: Reliability test

Reliability Statistics	
Cronbach's Alpha	Number of Items
0.890	60

Source: Research data 2014

Validity is the degree to which result obtained from the analysis of the data actually represents the phenomenon under study Mugenda and Mugenda (2003). According to montetee etal (1990) validity refers to the accuracy of a measuring instrument in measuring the variable that it is intended to measure. According to Orodho (2004), validity can be defined as the extent to which a measuring instrument provides adequate coverage of the topic under study or in simple terms, the degree of relevance the instruments are towards the research. The use of in-depth questionnaire will enable the researcher to probe more based on the responses of the respondents. The data gathered from the pilot study will then be subjected to Cronbach’s alpha a coefficient of reliability that gives an unbiased estimate of

data. Cronbach's alpha is a coefficient of reliability that gives an unbiased estimate of data, (Zinbarg, 2005). Both reliability and validity should be high to be desirable (Golafshani, 2003).

Data Analysis

Data collected was edited, coded, and tabulated for accuracy, reliability and ease of analysis and presentation using the SPSS version 20 software program. The analysis of qualitative data will be through a thematic and content analysis approach. This will involve generating percentages, graphs and frequency tables. Inferential statistical tools especially Pearson's correlations, was used to investigate the effect of intergroup conflict on the performance of Public Universities in Kenya.

3. RESULTS AND DISCUSSIONS

Simple regression analysis beta (β), this is equivalent to the Karl Pearson correlation coefficient (r) was used to determine the effect of intergroup conflicts on the performance of Public Universities. The hypothesis was tested at 0.05 % significance level, with 95% confidence, which is acceptable in social sciences.

The study set out the following research hypothesis; intergroup conflicts have no effect on the performance of Public universities in Kenya.

Karl Pearson's product moment correlation coefficient was used to check whether there is a any effect. The results were as shown in the table below.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.805 ^a	0.648	0.646	0.50017

Predictors: (Constant), Intergroup conflict

ANOVA^a

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	86.421	1	86.421	345.455	.000 ^b
	Residual	47.031	188	.250		
	Total	133.453	189			

a. Dependent Variable: Organization performance

b. Predictors: (Constant), Intergroup conflict

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	.588	.193		3.041	.003
	IC	.887	.048	.805	18.586	.000

a. Dependent Variable: Organization performance

Source: Research data 2014

The regression results between the mean of intergroup conflict and the mean of organization performance (P) had a beta term =0.805 at p=0.01. In the hypothesis criteria, we were to reject H₀ if $\beta > 0$. However, from this results, the value of beta =0.805 > 0 . The study therefore rejects the null hypothesis and concluded that intergroup conflicts had a positive statistically significant effect on organizational performance.

4. CONCLUSIONS AND RECOMMENDATIONS

The results show that there is a positive significant relationship between intergroup conflicts and organization performance ($r=0.805$, $p < 0.01$). The results show that 64.8% of organization performance can be explained by intergroup conflicts ($r^2 = 0.648$).

Based on the study findings, the following recommendations were made; the study recommends that a Public Universities should aggressively engage in assigning departments specific duties to be accomplished since through intergroup conflicts, it is expected that the performance will improve.

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ANALYSIS OF YOUTH ENTERPRISE DEVELOPMENT FUND REPAYMENT RATES AND DISPARITIES OF REPAYMENT BETWEEN NYANZA AND CENTRAL PROVINCES IN KENYA

Solomon M. Mburung'a

Abstract

As in most countries, unemployment rates in Kenya are highest among young people. Not only does it mean that they are economically unable to fend for themselves, it also leads to other risk factors such as depression, hopelessness and low self esteem. In response, the Kenyan Government initiated the Youth Enterprise Development Fund (YEDF). The objective of the fund was to provide loans for the youth to start income generating activities. However, according to the Youth Enterprise Fund Status Report (2011) out of Ksh 442,872,291.90 disbursed to the youth in as at November, 2011, the repayment was only Ksh.149,751,560.40 translating to 33.8 percent repayment rate. His study therefore, sought to investigate whether there is any relationship between repayment rates and number of groups, and the amount given. The limitation of the study was that, this study relied only on secondary data provided by Youth Enterprise Fund management and other secondary data. The methodology of the study was reviewed of related literature and quantitative data analyzed using correlation and sampling theory was used to test the hypotheses. From the findings of the study, it was concluded that, there is no significant relationship between the amount of money lent to the youths per constituency and the repayment rates of the loans. The correlation coefficient of 0.350569 at 95% level of significant depicted a positive but moderately weak relationship between the two hence insignificant. However, an increase in amount of money lent to youths seems to lead to higher repayment rates. In addition, there was no significant relationship between the number of youths accessing the YES loans in the constituencies and the repayment rates. A correlation coefficient of 0.30205 showed a positive but moderately weak relationship between number of youths and repayment rates. Lastly there was no statistical significant difference between Nyanza Province and Central Province repayment rates.

Key words: Youth Enterprise Development Fund, Repayment rates, Amount of Loan and Regional Disparities in Kenya.

1. INTRODUCTION

The United Nation defines youth as those people aged between 15 and 24 years while the Government of Kenya defines youth as those aged between 15 and 30 years (UN, 2004, and Ministry of Gender, Sports, Culture and Social Services, 2004). According to Central Bureau of Statistics *et al* (2004), seventy five percent of Kenya's population is under 30 years of age.

According to World Bank (2005) labour force participation rates for young people is very low. A study of 15 countries in Sub-Saharan Africa found that only Malawi, Uganda, Nigeria and Ethiopia had lower participation rates for young people (Liabrandt, et al, 2004). Out of all unemployed people in Kenya, 60 percent are under the age of 30 years.

According to World Bank (2005), while many young people in Kenya may choose to go into entrepreneurship as an option, most are poorly prepared and have limited access to financial capital. Lack of gainful employment has led the youth to engage in crime, violence and substance abuse. According to United Nations (2004), over 50% of all convicted criminals in Kenya are young males aged between 16 and 25 years. In addition, most crimes committed by young people in Kenya are financially motivated.

Unemployment is a risk factor for youth. As in most countries, unemployment rates in Kenya are highest among young people. Not only does it mean that they are economically unable to fend for themselves, it also leads to other risk factors such as depression, hopelessness and low self esteem. The problem of youth unemployment has long been recognized in Kenya. The 1972 International Labour Organization (ILO) report on employment in Kenya, acknowledged that the informal sector had limited capacity to generate enough jobs to absorb the existing labour force. Central Bureau of Statistics (2003) reveals that, the vast majority of unemployed people, (92 percent), have no vocational or professional skill training. In effect unemployment is not just due to lack of jobs, but it is also due to the workforce lacking the skills needed to support a growing economy. According to Farstad (2002), most of the entrepreneurs are recruited among those with weak educational background.

Despite lack of skills to manage enterprises successfully, young people who chose to go into self employment have to face the problem of access to capital (World Bank, 2005). Most financial institutions were unwilling to provide loans to the youth because of their lack of collateral. While a number of NGOs and youth organizations make loans available to young people interested in starting their own businesses, the qualification for those loans are stringent. NGOs require that the youth already be in business, have some savings and join a group savings and credit scheme among other requirements (World Bank, 2005).

In addition, youth organizations are often reluctant to give loans to the youth because they find it difficult to keep track of the loan recipients (World Bank, 2005). In response to the above challenges faced by the youth and the rising unemployment rate, the Kenyan Government initiated the Youth Enterprise Development Fund (YEDF) in 2006 as one of the strategies of addressing youth unemployment. The objective of the fund was to provide loans for the youth to start income generating activities.

However, according to YEDF (2011), out of Ksh442,872,291.90 disbursed to the youth under the

Constituency Youth Enterprise Scheme (C-Yes) as at November, 2011, the repayment was only Ksh.149,751,560.40 translating to 33.8 percent repayment rate. This indicates that the businesses or projects initiated by the youth were not servicing their loans well. Fafi constituency had the lowest repayment of 0 per cent while Nithi and Keiyo South constituencies had the highest repayment rate of over 80 per cent (See Appendix 1).

In Central Province, out of the Ksh60,204,423 disbursed to the 29 constituencies under the Constituency Enterprise Scheme (C-Yes) to 1706 groups, the youth groups repaid only Ksh. 23,583,221 accounting for 38.68 percent, which is above the national repayment rate. This reveals that youth groups' repayments were very low. In Nyanza Province, out of Ksh. 66,213,862.40 disbursed to 1998 youth groups, the groups paid Ksh. 18,849,579.70, translating to a repayment rate of 27.72 per cent. There exist a disparity in repayments of these loans between constituencies this paper tries to find out whether there is any correlation between number of groups and repayment rates, between the amount received and the repayment rate, and whether there is any significant difference between Central Province's repayment rate and the Nyanza Province's repayment rate.

This should provide sufficient literature on what has been done with regard to the problems being formulated, identifying milestones made so far and deficiencies in past approaches (Aduol, 2009). Throughout the paper, sufficient references should be cited with preference being the latest publications in the area (Kamau, *et al*, 2004; Rasnamurthi and Raj, 2010). Citations follow the American Psychological Association (APA) style.

Equations should be numbered if used as follows:

$$s = \int_{t_0}^{t_1} v dt \tag{1}$$

With the terms being properly defined e.g. s = distance, v = velocity and t = time

Once the background has been dispensed with, the authors should provide objectives to be accomplished in the paper (from the undertaken research).

Problem Statement

Unemployment is a risk factor for youth. As in most countries, unemployment rates in Kenya are highest among young people. Not only does it mean that they are economically unable to fend for themselves, it also leads to other risk factors such as depression, hopelessness and low self esteem. The problem of youth unemployment has long been recognized in Kenya. The 1972 International Labour Organization (ILO) report on employment in Kenya, acknowledged that the informal sector had limited capacity to generate enough jobs to absorb the existing labour force. Central Bureau of

Statistics (2003) reveals that, the vast majority of unemployed people, (92 percent), have no vocational or professional skill training. In effect unemployment is not just due to lack of jobs, but it is also due to the workforce lacking the skills needed to support a growing economy. According to Farstad (2002), most of the entrepreneurs are recruited among those with weak educational background. In addition, youth organizations are often reluctant to give loans to the youth because they find it difficult to keep track of the loan recipients (World Bank, 2005). In response to the above challenges faced by the youth and the rising unemployment rate, the Kenyan Government initiated the youth Enterprise Development Fund (YEDF) in 2006 as one of the strategies of addressing youth unemployment. The objective of the fund was to provide loans for the youth to start income generating activities.

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There exist a disparity in repayments of these loans between constituencies, and this paper tries to find out whether there is any correlation between number of groups and repayment rates, between the amount received and the repayment rate, and whether there is any significant difference between Nyanza Province repayment rate and the Central Province repayment rate.

The objectives include finding out whether there is any relationship between: number of groups in receipt of the loan and repayment rates; the amount received and repayment rates; and whether there is any significant difference between repayments of Central Province and the Nyanza Province repayment rate. The hypotheses to be tested are:-

Ho –there is no significant relationship between number of youth groups in the constituency benefiting from C-YES and the repayment rates of the loans

H1-there is significant relationship between number of youth groups in the constituency and the repayment rates of the loan

Ho- there is no significant relationship between the amount of money disbursed and the repayment rates of the loans

H1-there is significant relationship between the amount of money disbursed and the repayment rates of the loans

H0- there is no significant difference between Central Province repayment rate and Nyanza Province repayment rate.

H1- there is significant difference between Central Province repayment rate and Nyanza Province repayment rate.

The limitation of the study is that, this paper used only secondary data provided by Youth Enterprise Fund management and other secondary data.

2. LITERATURE REVIEW

Youth Enterprise Development Fund

The Youth Enterprise Development Fund (YEDF) was conceived by the Government of Kenya in June 2006 as one of the strategies of addressing youth unemployment. The fund was officially launched on 1st February 2007 and it was transformed into a state corporation in 11th May 2007.

The objective of the fund was to provide loans for on-lending to youth enterprises attract and facilitate investment in micro, small and medium enterprises, oriented commercial infrastructure that will be beneficial to youth enterprises, support youth oriented micro, small and medium enterprises to develop linkages with large enterprises. It also facilitates marketing of products and services of youth enterprises both in the domestic and international markets and facilitates employment of youth in the international labour market (YEDF, 2011).

Mode of Disbursement

According to YEDF (2011) funds are disbursed in 3 ways: The Constituency Youth Enterprises Scheme (C- yes) maximum amount Ksh. 50,000. Such a loan is approved through community committees at the constituency level. Secondly, Easy Youth Enterprise Scheme. Under this mode, the scheme finances project of individuals who belong to groups that have completed repayment of the C- YES loan. Individuals start with loans of Ksh. 25,000 and graduate upwards to Ksh 1000,000 after which they can access the loans through financial intermediaries. The third mode is through financial intermediaries. This is managed by 32 financial intermediaries that are in partnership with the youth fund. The fund gives term loans to these intermediaries at 1% interest who in turn lend to the youth at 8% interest. They use the 7% difference to cover administration arise from leading to a clientele perceived as risky and can lend to a maximum of Ksh.1,000,000.

Disparities in Kenya

Inequalities in well-being often take a regional dimension. In Kenya, regional or geographic differences in well-being may mean ethnic differences in wellbeing as ethnic groups often reside in given geographical regions. There are stark differences in development opportunities and outcomes across Kenya's rural-urban divide and other regions too. Like at the national level, the distribution of incomes is skewed in favour of the higher wealth groups across Kenya's eight provinces. In Nairobi, for example, the top

10% of the households command about 45% of the total income while the bottom 10% command less than 2%. Nairobi, Nyanza and Rift Valley provinces seem to have the widest income inequalities (SID, 2004). According to Integrated Labour Survey (1998/99), percentage income distribution of Central Province bottom 10% is 1.1 % while top 10% is 39%. In Nyanza Province, bottom 10% is 0.6% while top 10% is 43%. This indicates there is some disparity in employment rates as well as unemployment rate as Nyanza is seen to be better though the difference is not so pronounced.

There are disparities in education indicators across the provinces. In Central province gross enrolment rates in primary school in 2000 was 106% compared to 94% in Nyanza Province. The corresponding figures for secondary education for the two regions are about 38% and 24%, respectively. The differences are not so pronounced, Central Province seems to be doing better in terms of enrolment to both primary and secondary schools. Hence in terms of employment and education, the two provinces seem to be at par though the repayment rates of youth fund loans are very different. This paper assesses whether the difference is statistically significant or not.

Amount of Loan

Balogun and Alimi (1988) found that the default rates in loans to small farmers in Lagos region in

1985 and 1986 were in the range of 55 and 90 per cent respectively. Anderson (1982) spoke of default rates as varying from 10 per cent to 60 per cent or more in most developing countries. The observed low delinquency rates by the SMEs operators could be to preserve their reputations as good borrowers and to avoid the threat of direct sanctions.

Oladeebo and Oladeebo (2008) in their study "Determinants of loan repayment among small-holder farmers in Ogbomoso agricultural zone of Oyo state, Nigeria" they found out that, a positive coefficient of amount granted of loan granted to farmers, may enable farmers to adopt agricultural innovations which can translate to increase in the level of income and hence high level of loan repayment ceteris paribus. Increase in gross income may lead to increase in loan repayment. An increase in hectare of farm land may lead to higher income resulting from higher level of production and hence loan repayment capacity. This study assesses if there is any correlation between amounts given disbursed in the constituencies and the repayment rates.

Theory of the Study Theory of Repayments

Microfinance organizations often use high frequency repayments. The theory was advanced by Prof. Mohammed Yunus in 1990s during formation of Grameen Bank. Borrowers are typically required to repay their loans in regular installments, beginning soon after the loan is given out. This aspect of the repayment schedule is usually explained as inducing

'fiscal discipline' among borrowers. Jain and Mansuri (2003) argued that an alternative rationale for this loan repayment structure lies in the difficulty of monitoring borrowers' actions. The potential for moral hazard leads MFIs to use innovative mechanisms, such as regularly scheduled repayments, which indirectly co-opt the better-informed informal lenders. Conversely, this installment repayment structure allows informal lenders to survive. Further, they show that this linkage can not only expand the volume of informal lending, but may also raise the interest rate in the informal sector. Fischer and Ghatak (2009) proposed an alternative theory based on present-biased, quasi-hyperbolic preferences in order to capture the belief of many microfinance practitioners that clients benefit from the fiscal discipline required by a frequent repayment schedule. Their work is motivated by a pervasive sense among practitioners that frequent repayment is critical to achieving high repayment rates. This belief is captured well in the following observation by Muhammad Yunus: "It is hard to take a huge wad of bills out of one's pocket and pay the lender. There is enormous temptation from one's family to use that money to meet immediate consumption needs... Borrowers find this incremental process easier than having to accumulate money to pay a lump sum because their lives are always under strain, always difficult".(Yunus ,2003).

Intuitively, when borrowers are present-biased, the immediate gain to defaulting on any large

repayment is subject to significant temptation. When these payments are spread out, the instantaneous repayment burden at any time is smaller and thus less subject to temptation. Frequent repayment also means that at the time of the first payment, the rewards (typically access to future credit) are further away from the repayment decision and thus more heavily discounted. On the other hand, so, too, is some of the repayment burden. On balance, frequent repayment relaxes the incentive compatibility constraint for present biased borrowers. But these benefits do not come without costs (Yunus, 2003).

Frequent repayment imposes an opportunity cost of meeting attendance on borrowers and direct costs on the lender. It might also distort the investment incentives of borrowers toward projects that generate consistent, if meager, returns. The optimal frequency balances these costs against the positive incentive effects. Basu (2008), for example, looks directly at the effect of time-inconsistent preferences on the demand for commitment savings products and their welfare implications.

The quasi-hyperbolic utility functions underlying these models can come from a number of different

sources, including insecure savings, demands of future consumption from other family members or a behavioral bias towards current consumption. The theory, following standard practice, embeds them all in the parameter for present bias and

represents a further step in understanding the role these collected factors may play in repayment behavior.

3. METHODS/METHODOLOGY

The study reviewed related literature and quantitative data analyzed using quantitative technique namely correlation and sampling theory was used to test the hypotheses.

4. STUDY FINDINGS

Relationship between Loan Amount and Repayment Rate

The amount disbursed to the youth in all constituencies in Kenya was Kshs. 442,872,291.90, Kshs.

441,872,291.90. Total amount repaid was Ksh. 149,751,560.40 translating to a repayment rate of 33.81%. From the data provided the countries repayment rate has a standard deviation of 15.593 (Appendix1).

The Pearson Product Moment Correlation (r) between the amount received in every constituency and the corresponding repayment rate was 0.350569 (at $\alpha = 0.05$) The correlation coefficient 0.350569 implies there exist a positive but moderately weak correlation between the amount of fund disbursed in the constituency and the repayment rate. Hence we can conclude that though there exist a positive relationship between loan amount and repayment rate, an increase in loan amount will not adversely lead to more default of loans given to youth groups under C-YES. Therefore we accept the null hypothesis, that is, there is no significant relationship between amount, loan and repayment rates. This finding corresponds with the finding of Oladeebo and Oladeebo (2008) which concluded that a positive coefficient of amount of loan granted may lead to higher repayment rates of loans given to farmers.

Relationship between Number of Youth Groups and Repayment

According to YEDF (2011), the total number of youth groups that benefited from the youth Development Enterprise Fund was 13,087 from all the constituencies in Kenya while the country's repayment rate was 33.8%. From the data provided by YEDF report, Pearson Product Moment Correlation was used to compute the correlation coefficient (r) between the youth number of youth groups and the repayment rate per constituency at a significant level 95%.

The correlation coefficient is 0.30205. This correlation coefficient (r) of 0.30205 implies there exist a positive but moderately weak correlation between the number of youths benefiting from youth fund and the repayment rates. Meaning an increase in the number of youths benefiting from youth fund leads to an increase in the repayment rate of C-YES loans.

It could also mean that, the constituencies with more groups benefiting, the youths there are well trained or their business is doing well or they are better organized hence other factors could be affecting the repayment.

Therefore, we can accept the null hypothesis and reject the alternative hypothesis i.e. there is no significant relationship between the number of youth groups in the constituency benefiting from C-YES and the repayment rate of the loans.

Difference between Central Province and Nyanza Province

Central Province

Sample size (number of constituencies) = 29

Mean repayment rate (X1) = 38.68% or 0.3868

Standard deviation of constituency repayments = 11.3266

Nyanza Province

Sample size (number of constituencies) = 32

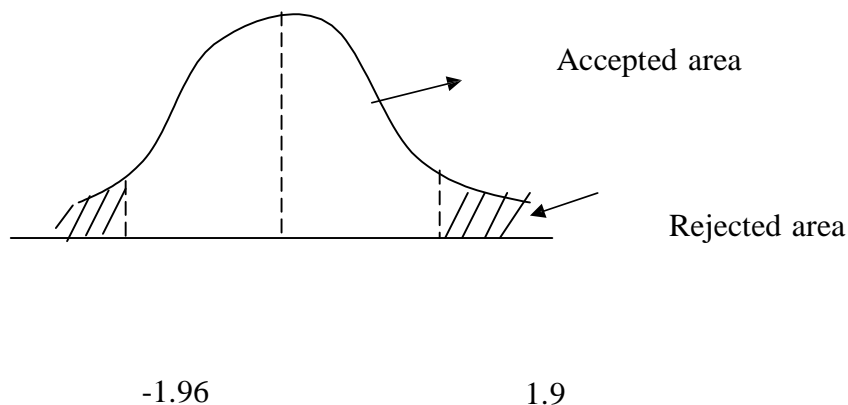
Mean repayment rate (X2) = 27.716509% or 0.277165

Standard deviation of constituency repayments = 14.0794

H₀ there is no difference between Central Province youth loan repayments and Nyanza youth loan repayments rates.

H₁ there is difference between Central Province and Nyanza Province youth loan repayment rates

At 95% level of significant the Z score = 1.96



Computed

$$Z = \frac{X_1 - X_2}{\dots}$$

Error (S.E

$$\frac{p_1}{n_1} + \frac{p_2 q_2}{n_2}$$

S tan

$$\left(\frac{p_1}{n_1} + \frac{p_2 q_2}{n_2} \right)^{1/2}$$

dard

x_1

y_2

$$p_1 = 0.3868$$

$$a_1 = 1 - 0.3868 = 0.6132$$

$$n_1 = 29$$

$$p_2 = 0.2772$$

$$a_2 = 1 - 0.2772 = 0.7228$$

$$n_2 = 32$$

$$S.E = \sqrt{\frac{0.3868 \times 0.6132}{29} + \frac{0.2772 \times 0.7228}{32}}$$

$$= \frac{0.008178}{\sqrt{0.01444}}$$

0

066261261

$$= \frac{0.12016655}{0.12017}$$

$$= 0.9120413$$

$$Z = \frac{X_1 - X_2}{S.E. X} = \frac{0.3868 - 0.277165}{0.12017}$$

X_1

0

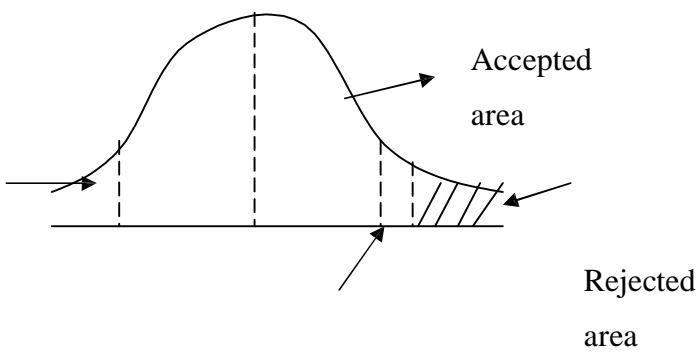
.12017

$S.E. X$

$- X$

1 2

$$= 0.9120413$$



0.912413

-1.96

Since the calculated value lies in the accepted area at 95% level of significance, we accept the null hypothesis. Therefore it can be concluded that, there seems to be no difference between Central Province Youth loan repayments and Nyanza Province Youth loan repayments rates. This finding relates to the corresponding difference in income distribution and education for the two regions which are not so pronounced.

5. CONCLUSION

From the findings of the study, it can be concluded that, there is no significant relationship between the amount given to the youths per constituency and the repayment rates of the loans. The correlation coefficient of 0.350569 at 95% level of significant depicted a positive but moderately weak relationship between the two hence insignificant. However, an increase in amount seems to lead to higher repayment rates. In addition, there was no significant relationship between the number of youths accessing the (-YES loans in the constituencies and the repayment rates. A correlation coefficient of 0.30205 showed a positive but moderately weak relationship between number of youths and repayment rates. Therefore an increase in number of youths could increase repayment to a small extent. Lastly there was no statistical significant difference between Nyanza Province and Central Province repayment rates.

Recommendations

The national repayment rate of C_YES loans is very low i.e. at 33.82%. this calls for training of the youths on importance of repayment of loans and management of their loans. In addition there exist serious inter constituencies disparities on the loan amount youth are borrowing, number of youth groups accessing the loans and in repayment of the loan. For example Fafi Constituency had a repayment rate of zero while Nithi had 80% repayment rate. Such regional disparities should be ironed out through sensitization and by the YEDF management.

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QUALITY OF KENYAN UNIVERSITY GRADUATES AND THEIR WORK PREPAREDNESS

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Abstract

The demand for university education has greatly increased as more Kenyans seek quality learning to boost their chances in the job market, yet little attention has been given to the higher education subsector. Increased student enrollment without proportionate improvement of the available physical resources, learning environment, service quality, attraction of highly qualified teaching staff, inadequate development of a curriculum that is relevant to current job market needs and matching students skills to their employment needs are some of the problems facing the universities. These challenges are raising doubts on the quality of graduates produced by the Kenyan universities and by extension the level of their preparedness in their employment market. This research explored these two issues of graduates quality and their job preparedness, and also compared the graduates in terms of their employability skills to close these gaps and add more knowledge on this area. The study used descriptive and explanatory designs to gather information for the study. The first objective was to investigate the quality of Kenyan university graduates; second was to explore their work preparedness and third was to compare graduates in terms of employability skills. Literature reviewed was on quality of education globally, in Africa, regionally and locally while the conceptual framework guided the study. The target population was 420 graduate employees and 46 managers of the COYA 2013 companies who were given questionnaires to fill. A survey of 5 public and 5 private universities was also conducted to interrogate the university side of the research to get an all inclusive perspective of this study. Characteristics of the study variables were analyzed using SPSS and the relationship between variables was tested using Pearson's correlation analysis. The study findings indicated that 72 percent of the graduate employees have no practical skills, 13.6 percent were working in jobs they were not trained on, 4.5 percent were not hands-on and 4.5 percent did not possess theoretical skills. In addition, 51 percent of the graduate employees were not well prepared for the present employment both practically and theoretically. The study recommends that universities should work with the industry in developing a curriculum that satisfies the university, graduates, and labour market needs. The research filled the gap and added knowledge on quality of graduates and their work preparedness. The study recommended that a similar research can be carried out in other countries to add more knowledge on the area. In addition a research can be carried out to investigate the possibility of obtaining a flexible degree with skills that are applied across different sectors.

Key words: University graduates, Quality, work preparedness, employability skills

1. INTRODUCTION

Statement of the Problem

According to UNICEF (2000) and Wilson (2009) quality education is achieved through quality lecturers, adequate curriculum, training facilities, state of students in use of learner centered teaching, holistic learning environment, knowledge content, teacher knowledge and skills. Wanjala (2013) documents that in Kenya, both public and private institutions of higher learning have a questionable quality, efficiency, relevance and academic fraud in common.

Meeting these requirements is difficult since Kenya has limited resources yet, the fast expansion of Kenyan universities has only focused on raising student numbers rather than improving the quality of education and research. Increased student enrollment without a proportionate improvement in available physical resources, learning environment, service quality, attraction of highly qualified teaching staff, developing curriculum that is relevant to current job market needs and matching students skills to their employment needs are some of the problems facing these universities. These challenges are raising doubts on the quality of graduates produced by the Kenyan universities and the level of work preparedness in their employment market. This research will explore these twin issues to close the gap and give recommendations.

1.1 Objectives of the study

- a. To investigate what determines quality of a university graduate
- b. To determine how graduates quality compare among various universities in Kenya
- c. To find out the link between graduates employability skills and work preparedness

2. LITERATURE REVIEW

The literature reviewed was on higher education globally, in Africa, regionally and Kenya as discussed below.

2.1 Context of Higher Education Sector in Kenya.

The Kenyan Higher Education has evolved under the influence of political, economic, socio-cultural, legal and technological issues. These aspects have shaped the history of higher education in Kenya. In East Africa, Makerere College in Uganda was established in 1922 as a small technical institute to serve the three countries of Kenya, Tanzania and Uganda. In 1956 Kenya established the Royal Technical College in Nairobi which later became a University College of Nairobi in 1963. This was followed by Dar es Salaam and the three offered degrees from University of London until 1970 when the three universities got the right to operate Makerere, Nairobi and Dar es Salaam as autonomous institutions (Kalayu, 2013). After attaining independence in 1963, Kenya put more emphasis in education to achieve social economic development. The University Education has since then expanded to provide qualified personnel that are required for growth of Kenya's economy. Since then, there has been a rapid increase of higher education institutions and students enrolment (Sifuna, 1998).

2.1.2 Quality of graduates

Quality of graduates refers to the quality of the educated to meet the requirement of academic degree and the use of the knowledge to make contribution to research and the society. All universities are facing the issue of ensuring quality of graduates' education. Higher education institutions have to ensure and guarantee training of advanced talents to meet the needs of the country as well as developing science and technology. To meet the requirements of today's dynamic job demand, universities should strengthen and improve quality of graduates they produce. The achievement of quality of education comes from quality of graduates who have been educated. The quality of graduates produced must accord with moral demands from society and fulfill the requirements of human resources from enterprises. The equality of graduates educated should satisfy self development, promote social science, competence at work, theory learnt and demonstrate required knowledge skills (Suzhang *et al.*, 2010). The Kenyan graduates' quality is ranked through employability skills, present job competence, job involvement, job confidence, practical application of theoretical and practical skills learnt at their universities.

2.1.3 Quality assurance in Higher education

According to Storey *et al.* (2000), quality assurance (QA) is a method of management that includes all systematic actions needed to provide an adequate and planned confidence that a service, product or result to satisfy quality requirements and fit for use. Additionally, it should achieve the required standard and it aims at preventing mistakes or defects either in manufacturing or service.

Quality assurance is important as it guarantees certain standards of higher education are processed and evaluated as universities have an obligation to make quality explicit and effective. It is seen that, in the developed countries, quality assurance in higher education was steadily gaining in importance due to the governments and industries advocacy of well educated workforce that was essential for increasing productivity and maintaining a competitive advantage in global knowledge economy (Harvey & Night, 1996; 1998; 2005; Woodhouse, 1999).

Additionally, universities across the world administrative units, students, service and academic areas are under pressure internally and externally to increase quality, efficiency and effectiveness. Higher education institutions should be committed to excellence, however, the pace of improvement and change in these institutions is slow (Spelling 2006a, 2006b).

Thus, quality assurance in higher education is a necessary ingredient to national development. In HEI, quality assurance is everyone's responsibility in applying best practices and benchmarking by using tools such as: process flow charts, Pareto analysis, Fishbone and scatter diagrams, Check sheets, Control charts, and brain storming (Mishra, 2007).

Globally, UNESCO (2011) recommends factors that should be considered as units of assessment in quality assurance of higher education. These are students, academic programmes, internal quality control, academic staff, research, infrastructure, management and the organization. NAAC of India, Regional Accreditation of USA, and Indonesia's National Accreditation Board for Higher education (BAN-PT) also use these variables to assess quality of higher education. The International Network for quality Assurance Agencies in Higher Education (INQAAHE), International Association of University Presidents (IAUP), the Council for Higher Education Accreditation in United States (CHEA), OECD, and UNESCO are the world organizations that emphasizes quality of higher education and production of quality graduates. Hanlie and Parker (2009) agree that there is a real need to address issues between expectations of the employers and quality of output from higher education globally.

They also document that graduates should be able to apply the knowledge they learnt on their job market. This study recommends the use of innovations in higher education to bridge this gap.

Additionally, in Africa, there is creation of regional coordination mechanisms for assessing quality assurance in higher education in most of the countries to include all stakeholders such as African Development Bank (ADB), African Union (AU), Regional Economic Community (REC), CAMES, AAU, ADEA, and all African universities. There is a need to set strategies for maintaining quality of higher education in African universities, share experiences, and information on quality assurance by 2013. It is noted with importance the crucial need for African countries and universities to work together to improve their educational programmes to achieve and establish coherent systems of equivalence and accreditation (UNESCO, 2012).

Furthermore, in East Africa and internationally, IUCEA maintains high and comparable academic standards in higher education in the region. IUCEA emphasizes promotion of quality assurance (QA), quality management, and maintains international standards to the regions universities. They support and fund academic activities to promote quality assurance in East Africa as well as liaising with African and other world academic bodies. According to IUCEA, all stakeholders should be involved in quality assurance including policy makers, employers, students and parents to produce quality output who are the graduates. They agree that each university in East African region has to operate its core academic functions and activities with some forms of quality assurance systems.

More importantly, IUCEA confirms that curriculum is an instrument of quality assurance and quality improvement in East Africa. Therefore, university Vice Chancellors, Deputy Vice chancellors and Deans in the region meet regularly to discuss more on improving and maintain quality assurance in their universities. To emphasize this, IUCEA has 76 member countries in Africa who collaborate with development partners like DAAD, Germany Rectors Conference (HRK) and Dialogue on Innovation Higher Education Strategies (DIES) to promote quality assurance in this region (Chacha, 2010). In addition, the regional on peace in education report in Eastern and Central Africa (2008) document that there should be value –based education with students placed at the centre to contribute to improvement on quality of teaching, learning environment, academic outcomes and students behaviour to achieve student centered learning and quality education in the region. However, most of the teaching in the

region is teacher based rather than students based which raises questions on service delivery on teaching in higher education.

In Kenya, the university Bill (2012) established CUE to replace Commission for Higher Education (CHE) to oversee university standards. The CUE in Kenya is charged with the responsibility of establishing universities, setting standards, governance, accreditation and supervision (Wanjala, 2013). To safeguard the Kenyan university standards, CUE monitors foreign universities offering degrees in Kenya for accreditation from their own countries to maintain quality standards in Kenya. CHE was established in 1985 to accredit and inspect public and private universities and maintain quality assurance. CHE collaborated with Kenyan universities to develop a framework for sustaining and measuring quality assurance in Kenya. Individual universities in Kenya have their quality Assurance department and career development programs to assess each of their departments on the quality of the education programmes that they offer (Lenga, 2010). Quality assurance globally aims at achieving quality in universities and their output which the graduates produced.

The above reviewed literature and supporting arguments lead to formulation of the following null hypothesis:

2.1.4 Quality assurance in Higher Education in Kenya

British Standard Institution (BSI), posits that quality is totality of features and characteristics of a product or service that bear on its ability to satisfy implied or stated needs (BSI, 1991). According to Materu (2007 pp.31) “Quality assurance within institutions of higher learning should takes place throughout the teaching and learning process. It includes screening of candidates for admission, staff recruitment and promotion procedures, curriculum reviews, teaching and learning facilities, quality of research, policy development and management mechanisms, student evaluation of staff, external examiners for end-of-semester or end-of-year examinations, tracer studies, academic reviews and audits.”

However, what Materu (2007) document is supposed to be done but in Kenya the process of implementation is weak due to failure to keep up with teaching timelines, increased workload for lecturers and few lecturers are available to supervise research.

Arguably, according to Bashaka *et al.* (2009) quality in higher education cannot be avoided. They posit that the entry of private higher education provides and declining government funding has caused decline in quality of graduates. The Kenyan quality assurance in higher education is undertaken by professional bodies, higher education institutions (HEIs), directorate of quality assurance and standards and commission of university education.

2.1.5 Universities in Kenya

Kenyan new universities are established through university rules 1989, section 7 (1) (a-f), (C.U.E, 2012) which stipulates the guidelines and details of commencing requirements such as: Proposed name, historical background, vision, mission, justification, physical resources, academic character, location, philosophy, objectives, governance, academic programs, human and financial resources. A letter of interim authority leads to awarding of charter after set requirements are achieved. According to CUE there are a total of sixty seven private and public universities in Kenya which have spread campuses across the country. CUE has set standards and guidelines for physical facilities, university libraries, setting up private universities, curriculum preparations, conduct and discipline of students, teaching qualifications, collaboration between institutions and standards for validation of diploma programmes (Standa, 2008). Public and private universities follow CUE guidelines for quality in all areas to produce quality graduates in Kenya. However, public universities are managed by the government while most of the private universities are church sponsored with a different leadership style.

Consequently, in the light of the discussion above, the study postulated the following hypothesis:

Commission for University Education and Quality Assurance

As discussed the handbook for CUE, quality in higher education is regarded as attaining high level standards or exceptionally high standards, conforming to standards and fitness for the purpose of the institution. CUE (2013) document that Quality Assurance involves putting all systems in place to guarantee quality in education by monitoring and controlling the set standards. It also involves process control to ensure compliance with the pre-set standards. The external body (CUE) assesses quality in higher education monitoring programmes, processes, practices and service delivery in the institutions. Quality audit of educational institutions in Kenya is referred to as “re-inspection”. The principle of CUE is to operate on the best practices and flexibility to achieve the pre-determined procedures and standards.

For this reason therefore, Educational institutions maintain the individual Internal Quality Assurance (IQA) then engages the External Quality Assurance (EQA) external bodies like CUE to assess and maintain quality assurance in the institutions. In Kenya, Higher institutions have quality assurance and control departments that monitor and check whether all activities were carried out as intended. Universities meeting these standards are awarded a charter meaning that the institutions continue to maintain academic excellence set by CUE.

As explained earlier, CUE ensures maintenance standards, relevance, quality in training and research, continuous improvement, management of quality education and safeguard academic integrity of university education in Kenya (Lenga, 2009).

2.1.7 The National Strategy for University Education 2007-2015

In 2006 the government of Kenya (GoK) through the Ministry of Education created a taskforce for development of the national strategy for university education to formulate goals, strategies, specific objectives, targets and output in the university sub sector. The taskforce developed strategies to address eight areas namely: equity and access, relevance and quality, science, financing, students and staff

welfare, technology and innovation, ICT in education, partnership and Linkages and governance and management in university education.

2.1.8 How quality was measured in this study

Quality in university education is viewed as multidimensional concept that considers: Teaching and academic programmes, research and scholarships, staffing, students, building, facilities, equipment, services to the community and academic environment (Sakthivel, 2007).

However, globally, many countries are debating whether higher education systems are fit for the students training and education that meets countries' development the needs of the society. Today, quality in higher education is the key to producing quality output, the graduates. In this study quality in higher education was measured by assessing competence of academic staff, service delivery, curricula, physical resources, institutional reliability, learning environment and quality of graduates produced. However, some other variables can be used to measure quality in higher education but have been recommended for further studies.

3.0 METHODOLOGY

3.1 Research Design

In this research the descriptive and explanatory design was selected because descriptive data was collected through a detailed questionnaire for graduates and the managers/supervisors of COYA companies. The explanatory design was used to study and explained relationships between university graduates and their workplace preparedness. Qualitative approach helped to involve interaction between the researcher and the respondents to discuss their environment (Burns, 2000). Both quantitative and qualitative techniques were used in analyzing the collected data. Data was collected by means of a structured questionnaire comprising of two sections namely A and B. Questionnaires were use because they are less expensive and easier to administer. Section A contained questions that were answered by university graduates regarding quality of education and service delivery in the universities they attended. An interview was conducted on the selected respondents. Section B consisted of questions which required the employer /manager to evaluate the graduates on their job competence, employability skills, job involvement, confidence of their present job, and opinion of their supervisors on the graduates practical and theoretical skill application at their work place. All items in the questionnaire used Likert scale rating that were presented as statement on a scale of 1 = strongly disagree to 5 = strongly agree. In addition to the main scale addressing individual items, employers provided the overall rating comparing public and private university graduates in their present work performance. The university attended was also indicated by the graduates to provide ranking information. Both sample sizes of graduates and the employer were selected from the 53 COYA companies in Kenya selected by size the sample frame of using the formula by fisher *et al.* (2009).

3.2 Target population

The target population in this study was the Kenyan Company of the year award (COYA) and the graduates working in these companies. Supervisors or managers of graduates working in these companies were used for this study because they were the ones who could measure graduates present job competence, job confidence, job involvement, employability skills and also give their opinion on practical and theoretical preparation of the graduate employee. Graduates who had worked in these companies for a period of 1- 5 years were selected as target population of the research. These graduate employees were selected because they knew their universities competence of staff, service delivery, curriculum, physical resources, institutional reliability, learning environment and the quality of the university. Additionally, they were the right people to judge the training and skills they received from the universities and how it compared with the needs of the present employment requirements. 5 public and 5 private universities were also used to get the university side of research.

3.3 Why COYA companies were selected for this research.

COYA promotes excellence and integrity in management practices, to increase competitiveness and management performance in global world. COYA companies represent various economic sectors in Kenya such as: Finance, regulatory, service, education, communication, ICT, manufacturing, insurance and transport, agriculture, and hotel sectors. COYA is benchmarked against international best practices in marketing, financial management, corporate citizenship to embrace business performance and excellence. COYA has the aim of improving company competitiveness and improving the quality of companies and their products in Kenya (Muthoka, 2013). COYA companies were selected on best practices; they are ranked on productivity and quality of service and being the top companies most university graduates were expected to be working in there.

To get an all inclusive perspective of this study, a survey was done to interrogate the university side. These universities Nairobi, Kenyatta, JKUAT, Egerton and Moi represent the public while Strathmore, Daystar, Mount Kenya (MKU), Kemu and KCA represent the private universities. The results of this study will be all inclusive and can also be generalized to represent a local and global perspective since these companies are benchmarked against international best business practices and the universities used for the survey have participated in the world ranking. This gives the study results a global perspective.

3.4 Sampling Procedure

Sampling is the process of obtaining units of analysis of population frame from which a sample is drawn. In this survey, the researcher used the simple random sampling technique to arrive at a representative sample of both the companies and graduates. A sample population was drawn from the sampling frame of the 53 companies of COYA 2013. There are two types of sampling methods namely probability and non probability sampling. Probability sampling was considered appropriate for this research as it allows calculation of precision of estimates and specification of sample error from the sample (Mugenda, 2013; Saunders *et al.*, 2003). The study employed simple random sampling which allowed equal representation of the sample chosen for the target population.

Random sampling ensured inclusion of units in the sample which would otherwise be omitted by other sampling methods. If a population from which a sample is to be drawn does not constitute a homogenous group, random sampling technique is generally applied in order to obtain a representative sample. In random sampling each unit of the population has an equal chance of being selected (Kothari, 2004). There was no bias as every graduate and employer will have an equal chance of being selected for the interview and similarly, there was no discrimination on gender. In any sample design sample size determination is crucial. According to Israel (2009), it is important to take into consideration boundaries of mistakes and errors in crucial areas in estimating population for sample size. He recommends three approaches of determining sample size. The first is to use a published table, second is to apply formulas and third is to adopt similar findings of other researches that have been done previously. In this study, 46 COYA 2013 companies were randomly selected from a total of 53 companies constituting 86.8 per cent. The managers/supervisors of graduates and graduates in these companies were given questionnaires to fill.

Mugenda and Mugenda recommend 30 percent (1/3) as a representative for a sample. In addition another sample of 425 University graduates were selected and used for this study of which 44 (95.6%) companies and 413 (97.1%) graduates returned the questionnaires.

3.5 Data collection instruments and procedure

Questionnaires

There were two types of structured questionnaires divided into questionnaire (A) and B. Questionnaire A was administered to the graduates working in the selected COYA 2013 companies and questionnaire (B) was issued to the employer, manager or supervisor in these institutions to assess the job market preparedness of the university graduates. The questionnaires had open and closed ended questions. The questionnaire was attached to a cover letter introducing the researcher to the respondents. The required data was collected as identified in the objectives, hypothesis, literature review, theoretical review and conceptual framework.

3.6 Study Population and Sample selection

A Sample of 46 companies were randomly selected using a simple random sampling (SRS) and from each selected company graduates from Kenyan universities working in these companies were interviewed. Forty six of the 53 COYA companies were selected translating to 86.7 percent of the total managers or supervisors. A total of 413 graduates were used for this study. A survey was done to interrogate the university side of the research by using 5 public and 5 private universities. The assessment of quality of Kenyan universities was used using the indicators of: academic staff competence, academic staff qualifications, curriculum relevance and adequacy, physical resources, learning environment, service delivery, intuition reliability and quality of its graduates'. Employer assessment of graduates used present job competence, job confidence, job involvement and employability skills. In addition the employer assessed practical and theoretical work preparedness for the present job employment.

3.7 Sample Size Justification

To get a representative sample size for the survey, descriptive sample size calculation was employed as shown in equation 3.1 and 3.2 respectively.

$$n_0 = \frac{Z^2 \cdot p \cdot q}{e^2} \quad \text{Eqn 3.1}$$

For the employers, the sample size needed to be corrected since it was a finite population, N is known.

This becomes;

$$n = \frac{n_0 N}{n_0 + (N - 1)} \quad \text{Eqn 3.2}$$

Where;

N = Total Population size;

n = Sample Size

$Z^2_{/2}$ = X-axis value corresponding to 95% Confidence Interval

= portion of work preparedness set at 50%, since no other study was done to establish the levels. Using the above formulae, the total companies to be sampled were 46 (after adjustment) and 385 graduates. Since 385 was the minimum any figure above was appropriate therefore a sample of 420 graduates was used. Krejcie and Morgan (1970) recommend a sample of 384 where the population size is more than 100,000.

3.8 Data collection and Management

The research permission was obtained from the Director of school of Graduates Studies and research, Dedan Kimathi University of Technology and from the managers of the COYA 2013 companies. In addition, three research assistants were selected and trained one week before piloting the study. The minimum qualifications of these assistants were a holder of a degree as they understood and communicated comfortably in English. The procedure of collecting data was first seeking permission from the companies, booking the appointments and self-delivering the questionnaires. The questionnaires were collected at the agreed date and time from the manager/supervisors and the graduates.

The data was collected using the coded questionnaires. The collected data was forwarded into a central place for data editing and valid checking. After the cleaning, the researcher within consultation with the statistician designed a data entry screen in Micro Soft Access. This was a preferred as it could allow for the data entry controls and skip pattern. The data was double entered and later merged for quality check. The clean data set was exported to Statistical Package for Social Scientist (SPSS) version 21.0 for analysis and inference building.

4. DATA ANALYSIS AND PRESENTATION.

According to Saunders *et al.* (2003) data analysis is a body of methods and approaches that are used for describing facts for developing explanations in a given representation of a population. It guides hypotheses testing and different pattern of events. The Statistical Package for Social Sciences (SPSS) is the most widely used programs for statistical analysis in social science and it is appropriate for this research. It will be used to generate descriptive statistics and predict numerical outcomes was be used to analyze qualitative and quantitative data of this study.

To test the relationship between variables Pearson's correlation coefficient was used. Testing the operational framework model was done using the path analysis and the Structured Model Equation (SME) using Amos 18.0.

The factor analysis helped to explain the variability among observables and serve to eliminate the items which do not load on the expected factor for the sample. Thus, items which remained in case of any deletion were further selected to build each of the constructs to be used for further analysis. A new factor analysis was further performed for the items that remained after deletion. This process was undertaken for all the variables within the employer and the graduates. This facilitated the factor reduction to arrive and a parsimonious model representation.

The second step, involved undertaking an independent sample t-test for the equality of means for both the public and private universities. This was performed on present job competence, job confidence, job involvement, employability skills, for the employer analysis. For the graduates the competence of staff, service delivery, curriculum, physical recourses, institutional reliability, learning environment and quality of graduates analysis. A recursive method was used to eliminate the path with the lowest t-statistic at each iterating level, until all coefficients were significant at the 95% level of significance ($p < 0.05$). The results of this study were presented in tables, pie charts and bar charts. Regression coefficients were interpreted and the coefficient of determination reported. A p-value of 0.05 and less was considered statistically significant while values above 0.05 were not significant.

The results of data analysis and discussion of the findings in relationship to existing literature was presented using tables and charts. The relationship between the dependent variable and the independent variables was established using multi-regression analysis.

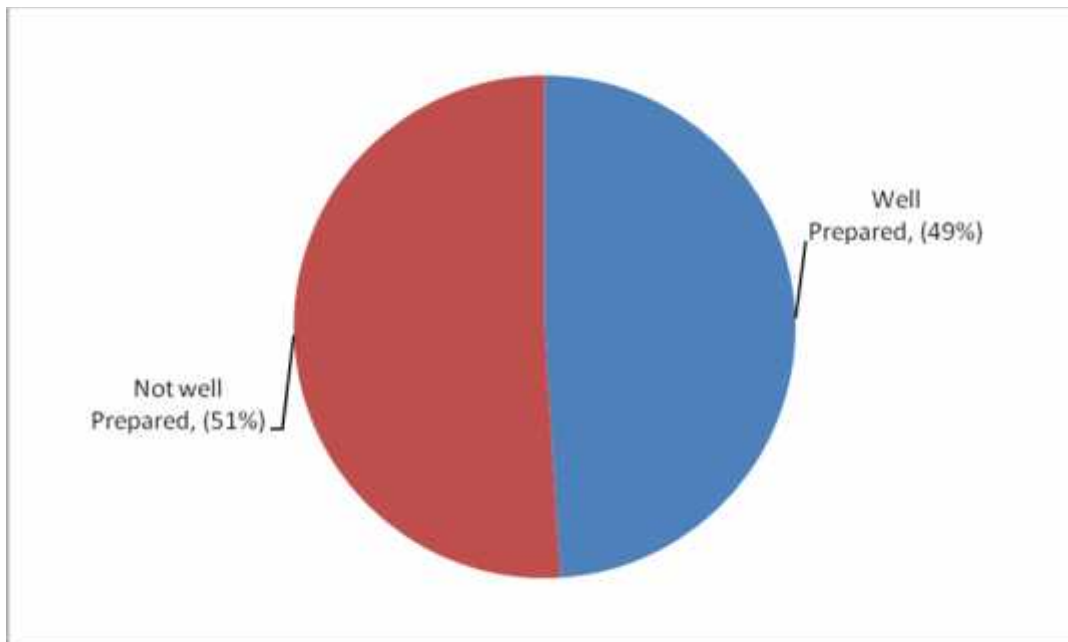
4.1 Findings

Objective one investigated what determines quality of a university graduate. Majority of the employers indicated that job competence and job involvement were main (mean score 4.5) determinants of a university graduates in the Kenyan sectors. Job competence was mainly required in finance, service, regulatory and education sectors. The findings also reviewed that transport industry required less employability skills, job involvement, job confidence and present job competence shown by a mean score of below 3 agree. Additionally, study findings show that all factors were significantly different by sector. The findings implied that the employers regarded as quality those employees who worked

independently, exerted themselves to cope with work and could handle large amount of information. To explore the relationship between the quality of a university and quality of its graduates, the hypothesis was tested and the findings showed that there was no significant difference between them. A Pearson Correlation indicated a p-value (0.0650) of more than 0.05. The null hypothesis was accepted.

Objective two showed that there is no significant difference between graduates quality from public and private universities indicated by a p-value (0.142) which is more than 0.05. The hypothesis H_0 failed to be rejected but there was no evidence to accept alternative hypothesis. Further the research findings show that private universities were consistent in quality than public universities as indicated by the box plot figure 4.26 where both the 'narrowing' and 'consistency' factors were displayed. From these findings it can be implied that some public universities are in producing quality graduates. However a mean score of 1-5 shows inconsistency of the public universities while private universities have a mean score of 3-5 showing consistency in graduates quality.

Figure below provides the overall opinion of the employer on work preparedness of the graduates.



Work preparedness of the graduates.

4.2 Work preparedness of Graduate as rated by employers

The results indicate that majority of the graduates (51 percent) were not well prepared for their current employment both practically and theoretically. The managers/supervisors felt that more practical preparation and on job training was necessary. Only 49 percent of the graduates were well prepared in their employment. The findings of this study are consistent with the literature reviewed on employability skills Opinion of the employer on job preparedness of graduates.

This study further sought to determine the opinion of the employer on whether the university graduates were well prepared for the present employment practically and theoretically. The results indicate that 72.7 percent had no practical skills for present employment, 13.6 percent were doing jobs they were not trained for, 4.5 percent were only prepared theoretically, 4.5 percent were not hands on and another 4.5 percent were not prepared well theoretically for the current job market. This is supported by figure 4.10 on page 117 where and overall 51.0 percent of the employers agree that graduates are not well prepared theoretically and practically by their universities for the current labour market. The link between graduates employability skills and work preparedness indicated that an increase in employability skills increases work preparedness as the two of them are positively correlated. The hypothesis tested showed that there was a positive link (p value 0.000) between present job competence, job confidence, job involvement and employability skills. It can be argued that an increase in employability skills also increase job confidence, job involvement, and job competence. A coefficient of 0.596, 0.572, and 0.605 respectively shows a strong relationship.

4.3 Contribution of the study to knowledge

The results of this study have added significant information to the body of knowledge, specifically on the quality of Kenyan university graduates and their work preparedness. This research filled the gap that existed on graduates quality and their work preparedness. Quality of graduates and their work preparedness has been subject to a lot of debate globally because of its implications in countries' development. Furthermore, research of this kind had not been done in Kenya. Hence, this study gave a new insight into the importance of quality of Kenyan university graduates and their work preparedness.

5.1 Recommendations on the research findings

This study provides recommendations for universities, the labour market, Government of Kenya and further studies. The universities and the employers in the labour market needs to work together to develop a curriculum that will meet the needs of the graduates in the job employment market. To increase the work preparedness of the graduates the universities have to increase the employability skills including job confidence, job competence and job involvement.

This research ascertained that majority of the graduates employees (72%) have no practical skills and 51% were not well prepared for the present employment and 13.6% are working in jobs they are not trained for. These results indicate that universities are not meeting the labour market employment needs and therefore these recommendations should be adopted by the university developers to remedy the situation. However, there seems to be a critical disconnect when employers complain that Kenya is still experiencing shortage of relevant skills at technological, technical and graduates. Therefore, there should be a projection of critical skills from the industry as all countries need a balanced manpower demand and supply for all levels of skills.

The study recommend that practical skills can be increased through yearly internships in the industry, establishing practical incubation centers in all universities, involving industry players in career days, setting up career centers and employing lecturers with practical experience from the industry. It is also

critical for Kenya's higher education to tailor make skills for their graduates to fit into the job market since the findings indicate that universities are not meeting the demands of the employer.

Therefore university developers, policy makers and the industry should embrace these and encourage university manager, lecturers, students and graduates to adopt them.

However, there are practical implications for execution of the recommendations such as Government bureaucracies and lack of funds may hinder implementation of the suggested recommendations. Labour market needs are dynamic making it difficult to solve the disconnect between the labour market needs and university graduates skills as Changing the curriculum regularly to adapt to market requirements may not be acceptable to Commission for University Education (CUE).

5.2 Areas for further studies

This study was done from the Kenyan perspective and further research may be carried out from East African perspective. The study focused on manager/supervisors of the university graduate employees and further study can be conducted using the universities. In addition, this study used present job competence, job confidence, job involvement, employability skills and the opinion from the employers in assessing their graduates for present job preparedness and therefore other variables can be studied. It would also be prudent to carry out this research in colleges, secondary and primary school subsectors of Kenyan education. A number of other variables were identified but not tested such as:

- a) Relationship of accessibility of university on quality of graduates
- b) How understanding students needs influences quality of graduates.
- c) How completeness of supplementary knowledge and skill affect quality of university graduates.
- d) What is the flexibility of the degree skills and the extent it can be applied in other fields?

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