DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

PROCEEDINGS OF THE 3RD DeKUT INTERNATIONAL CONFERENCE ON SCIENCE, TECHNOLOGY, INNOVATION & ENTREPRENEURSHIP

THEME:

'Harnessing Science, Technology, Innovation and Entrepreneurship for Sustainable Development'

PROCEEDINGS OF THE 3RD DeKUT INTERNATIONAL CONFERENCE ON SCIENCE, TECHNOLOGY, INNOVATION & ENTREPRENEURSHIP

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To be the premier technological University excelling in quality Education, Research and Technology transfer for national development.

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DeKUT Core Values

Innovation, Scholarship, Diversity, Integrity. Teamwork

DeKUT Motto

Better Life through Technology.

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PREFACE

The 3rd DeKUT International Conference on Science, Technology Innovation and Entrepreneurship (STI&E) was held on 1st – 3rd November, 2017 at Dedan Kimathi University of Technology (DeKUT) Main Campus in Nyeri. The theme of the conference was '*Harnessing Science, Technology, Innovation and Entrepreneurship for Sustainable Development'.* Conference sub themes were;

1. Engineering Technologies and Innovations for Industrialization.
2. Business Management and Entrepreneurship for Sustainable Development.
3. Basic and Applied Sciences for Advancement of Research and Innovations.
4. Innovative Agricultural Sciences and Technologies for Sustainable Food Production and Food Security.
5. Water, Energy, GIS and Remote Sensing, Environment, and Climate Change.
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10. Security Trends and Innovations.
11. Trends in Technical Education and Training.
12. African Development, Harnessing Traditional Knowledge
13. Data Science for Sustainable Development

The conference provided researchers from local and international institutions, a forum to discuss and share ideas on latest innovations and research outputs that address local and global challenges and those that improve the quality of life for the people and inform the decision-making process in matters of development by government and businesses. International delegates came from countries such as Germany, Japan, Ethiopia and Mozambique and Rwanda. The conference was officially opened by the then Governor of Nyeri County, His Excellency, late Dr. Wahome Gakuru. The late Dr. Gakuru was a great friend and partner of Dedan Kimathi University of Technology for many years. Over the years he had offered immense support, knowledge and intellect that focused on growth and development of the University.

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

The conference organizing committee would like to thank all the key note speakers, authors and sponsors for their great effort to make this outstanding conference come true. We look forward to seeing you again during the 4th DeKUT International Conference on STI&E to be held on 7th – 9th November, 2018.

Prof. Charles N. Mundia
Chairman, Conference Organizing Committee

ECOSYSTEM INTEGRITY OF RIVER KUJA BASED ON HABITAT AND FISH BIOTIC INDICES

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Abstract

Riverine aquatic ecosystem has been continuously compromised by the human activities resulting in a threat to its integrity. For conservation and management purposes it's important to have standardized, cost effective measures to ascertain the integrity of the ecosystem. This study was conducted to assess ecosystem integrity of River Kuja based on habitat and fish biotic indices. Sampling was done at six stations along the river between November 2016 and July 2017. Habitat characteristics were used to estimate the metrics for Habitat Quality Index. The metrics were summed up to find the Habitat Quality Index. Fish were caught using electrofishing equipment and a seine net measuring 24m × 2m of mesh size 10mm stretch measure. The specimens were identified to species level and categorized as exotic or indigenous and tolerant and intolerant species. They were also classified into trophic levels. A total of 2224 fish were caught belonging to 11 families and 27 species. *Barbus altianalis* was the most dominant (57.3%) while *Amphilius jacksonii, Gnathonesmus longibarbis* and *Barbus paludinosus* were the least with 0.045% each. Omnivores constituted of 45%, carnivores – 32% and detrivores – 23%. Fish-based Index of Biotic Integrity, Habitat Quality Index and total fish catch were highest at Kanga with 50, 24 and 290 respectively. Fish-based Index of Biotic Integrity and total fish catch were least with 26 and 6 respectively at Wath Ong'er. Habitat Quality Index was lowest with 13 at Nyokal. Fish-based Index of Biotic Integrity positively correlated with Habitat Quality Index, species richness and fish population size. Habitat Quality Index positively correlated with Fish-based Index of Biotic Integrity, species richness and fish population size. Fish-based Index of Biotic Integrity can therefore be used to predict Habitat Quality Index and fish population size and species richness.

Keywords: Habitat Quality Index (HQI), Fish-based Index of Biotic Integrity (FIBI), Pearson correlation, metrics

INTRODUCTION

Biotic and abiotic factors interact within the environment to attain a self-sustaining system referred to as the ecosystem. The ecological integrity is at equilibrium when the structure, composition and functions of the ecosystem are not interfered. It is either altered by natural ecological processes or human factors. The natural ecological processes do not greatly influence the ecosystem due to the fact that an ecosystem has a self renewal attribute that ensures it can revive itself from natural perturbations. Unperturbed ecosystem promotes biodiversity and sustainability. Human activities pose a great threat to the aquatic ecosystem. For instance they have led to increased nitrogen fixing surpassing nitrogen fixation by all natural terrestrial sources. It has also increased Carbon (IV) Oxide by nearly 30% (Vitousek

et al., 1997). Activities along the watershed have led to reduced canopy cover, increased water temperature, erosion and siltation (Mbaka, 2010).

The riverine ecosystems are important because they provide habitat for aquatic living organisms like fish, recharges ground water, purifies water and recycles the nutrient among other functions. A river has got sections that effectively suit the provision of its good and services. Upstream is dominated with trees hence shredders and primary producers. This will translate to high primary consumers on the stream. In midstream the river is rocky and trees play an important role as a supplier to the organic material. At this site the rate of photosynthesis is normally higher than respiration. At the lower stream the rate of photosynthesis is low due to increased turbidity. At this point the respiration outpaces the photosynthesis. These translated to the different macroinvertabrates that will dictate the kind of fish to reside in the area due to change of trophic levels. Existence of woody debris in stream is known to provide habitat and shelter for aquatic organisms. Plants on the river banks help in controlling floods and stabilize the banks. The condition of the rivers are greatly affected by the geology and activities found at the catchment. A healthy catchment supports a healthy river.

The status of aquatic ecosystem integrity can be evaluated through chemical, physical or biological approaches. The physical and chemical approaches have been proven to be very expensive and time consuming. This prompted a new approach of using the aquatic biota in estimating the integrity of the aquatic ecosystem (Raburu and Masese, 2010). The use of living organisms in evaluating the integrity of ecosystem is what is referred to as biomonitoring. Different organisms have been used in biomonitoring (Li *et al.*, 2010). Originally researchers used macroinvertebrates, macrophyte and bryophyte in assessing the ecosystem integrity. This has been applied greatly in Europe (Brabec & Szoszkiewicz, 2006; Staniszewski *et al*., 2006; Szoszkiewicz *et al*., 2006). Lately the use of fish diversity, assemblage and distribution has gained momentum (Karr, 1981). This is because fish are more visible, easy to identify, have the ability to integrate the effect of watershed degradation, have wide trophic levels and are valued by enforcement agencies, politicians and general public. These make them suitable in assessing the biological integrity of an aquatic ecosystem.

Fish studies integrate their biological metric dynamic like area of preference, pollution tolerance, presence or absence of a fish species and trophic level to assess ecological integrity. Karr (1981) was the first to suggest the combining of fish metrics to come up with an index of biotic integrity (IBI) currently referred to as FIBI. Different researchers have embraced this method with modification of a few metrics in order to suit their areas of research. Raburu and Masese (2010) came up with a FIBI that have been used in Lake Victoria basin in rivers Nzoia, Nyando and Sondu-Miriu.

River Kuja is one of the major rivers flowing into Lake Victoria. Anthropogenic activities in the catchment which could interfere with the integrity of the river include agriculture and industrial development projects. Some of these include growing of crops like tea, sugarcane and maize. There is also mining and brick making activities in the area. Studies on River Kuja are limited with gaps in information on the biota and water quality. This study therefore assessed the aquatic integrity of the river and provides information on the key fish species in the river and habitat quality characteristics.

METHODS

Study Area

River Kuja is located between longitude 34°36’58’’E and 34° 59’56’’E and latitude 00°34’40’’S and 00°57’37’’S. The basin lies within an altitude ranging from 1100 to 2050 m above sea level. It experiences a high rainfall of 1977 mm per annum.

The river drains a region which is primarily agricultural. The main agricultural activities include growing of tea, coffee, sugarcane and other subsistence crop like maize, beans, millet, vegetables and cassava. Other anthropogenic activities in the river basin include agro processing industry projects, gold mining and brick making.

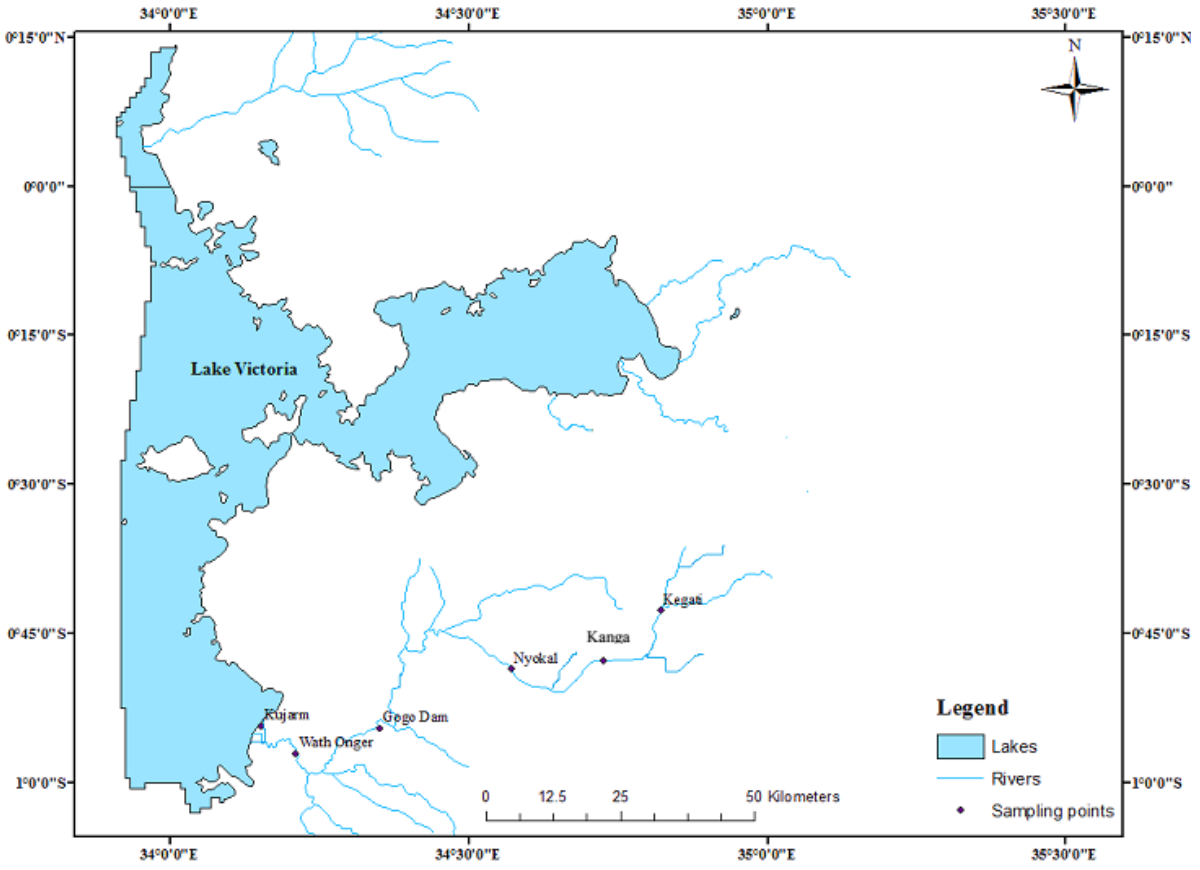

Figure 1. Map of Lake Victoria (Kenya) basin showing sampling points along River Kuj

Sampling design

Six stations (Table 1) were sampled as from November 2016 to July 2017. The sampling position was marked using GPSmap 78s.

Table 1: Some physical characteristics of sampling sites

Site	Altitude	GPS
Kegati	1760	34.821817˚E, 0.711408˚S
Kanga	1589	34.587100˚E, 0.833480˚S
Nyokal	1338	34.571938˚E, 0.809173˚S
Gogo	1234	34.349540˚E, 0.908027˚S
Wath Ong'er	1140	34.210316˚E, 0.951535˚S
River mouth	1170	34.151337˚E, 0.904197˚S

Habitat Quality Index

HQI was estimated as per the Rodger's scoring criteria (Rodgers, 2016) comprising nine metrics. Stream depth was measured using a wooden pole and a meter rule. The stream and channel width were measured using a string and a tape measure. The width of the natural vegetation cover was also measured using a tape measure. The number of riffles and channel sinuosity were physically counted. The river bed substrate type, bank erosion profile, aesthetic of the reach and instream cover were visually examined and recorded. HQI was calculated by summing up all scores for each metric. Total scoring was translated as shown in Table 2.

Table 2: Classification of HQI score

Score range	Classification
26-31	Exceptional
20-25	High
14-19	Intermediate
8-13	Limited
<7	Minimal

Physico-chemical parameters

Dissolved oxygen (mg/l), conductivity (μScm^{-1}), turbidity, Total Dissolved Solids (mgL-1), temperature (˚C) and pH were measured *in situ* using YSI hydro lab model 650 MDS. Replicate water samples of 300ml for nutrient analysis were collected in bottles then stored in ice in a cooler box. This was later taken to the laboratory within 48 hours for analysis of total phosphorous (µg/L) and total nitrogen (µg/L) using the method described in APHA (2004).

Fish-based Index of Biotic Integrity

Fishing along the river was done using an electrofisher and electronic GX 240 Honda 8.0 generator producing a current of 400V and 16A. However at the river mouth a beach seine of mesh size 10mm was used. The fish caught were preserved in cooler boxes containing ice and taken to the laboratory. In the laboratory they were sorted, identified to species level and weighed using an electronic balance to the nearest 0.1g. The following metrics were recorded for estimation of FIBI: species composition, trophic status, abundance and condition factor of fish.

The species composition comprised the sub-metrics: number of native, rheophilic and intolerant species, percentage proportion of tolerant, benthic and cyprinid individuals. The species were classified as indigenous or exotic using Witter and van Densen (1995),

Ochumba & Manyala, (1992), Mboya *et al.*, (2005). The trophic status comprises of three sub-metrics: percentage composition of carnivore, omnivore and the detrivore individuals. Information on stomach content analysis was obtained from literature available (Balirwa, 1979; Outa *et al*, 2014) to assist in classifying the fish species into trophic levels. The abundance metric was estimated by counting the number of fish caught in a 50m of the river stretch. The condition factor of fish assesses the well being of a fish. It was estimated using the equation:

MIWB = 0.51nN + 0.5 lnB + HN + HB *where*

N - Number of individuals caught per unit distance sampled,
B - Biomass individuals caught per unit distance excluding that of tolerant and exotic species,
HN and HB - Shannon Wieners diversity index based on numbers and biomass respectively.

Formulae for Shannon Wiener's diversity index:

(HN)

$$H = -\sum_{i=1}^{S} p_i \ln(p_i)$$

pi is the relative abundance of each species calculated as a proportion of individuals of a given species to the total number of individual in the community.

(HB)

$$H = -\sum_{ii=1}^{S} p_{ii} \ln(p_{ii})$$

pii is the relative biomass of each species calculated as a proportion of individuals of a given species to the total biomass of individual in the community excluding the tolerant and exotic species. FIBI was then estimated by summing up all the scores in each metric. The values obtained were then used to classify the sampling site (Table 3).

Table 3: Clarification of FIBI scores

Score range	**Classification**
51–60	Excellent
41–50	Good
31–40	Fair
21–30	Poor
< 20	Very poor

Minimally disturbed site was selected to be the reference point (Stoddard *et al.*, 2006). The value for FIBI was computed in relation to the reference site.

The estimated FIBI, HQI and physico-chemical parameters were correlated using an IBM SPSS statistics version 20 to identify their relationships.

RESULTS AND DISCUSSION

The highest mean HQI was recorded at Kanga (24± 0.58) and lowest at Nyokal (13± 0.58) with no trend being observed along the river.

Riparian natural vegetation showed an increasing trend downstream. This was because human activities like tree falling, agricultural activities and settlement were more prevalent upstream. The low bank stability values at the river mouth and Nyokal could be attributed to degradation by large livestock population and gold mining activities respectively.

Mean temperature was highest at Wath Ong'er (26.65±0.76˚C) and the lowest at Kegati (18.03±0.76˚C) . The high temperature recorded at Wath Ong'er could be attributed to the time of sampling. The station was always sampled first early in the morning while the temperatures were low while Kegati was always sampled later when the sun had risen. Temporally the highest temperature was recorded in the month of February 2017 while the lowest in the month of July 2017. The variation could be due to the climate of the area where February is one of the driest months. The mean pH tend to increase downstream with highest at river mouth (8.40±0.14) and lowest at Kegati (7.27±0.14). The highest pH of 9 was recorded at Wath Ong'er in the month of February 2017. During this period effluents from Oria Sugar factory had been discharged to the river. And this could have caused an increased pH. Lowest DO (0.3 mg/l) was recorded at Gogo due to the same effect of the effluents. The highest DO (7.25 mg/l) was recorded at Nyokal in the month of May 2017. TP and TN values were highest in the month of July 2017 with 1032 µg/L and 2447.82 µg/L at Wath Ong'er and Nyokal respectively. Rains were experienced during July and from the catchment must have found their way into the river.

A total of 2224 fish were caught during the study belonging to 11 families and 27 fish species. Family Cyprinidae had the highest number (9) of species while Mastacembelidae had a single species each (Table 4). *Barbus altianalis* dominated the catch with 57.3% while *Barbus paludinosus, Gnathonemus longibarbis* and *Amphilus jacksonii* were the least abundant with 0.045% each.. The highest catch was from Kanga (290) in the month of March 2017 and the lowest was at Wath Ong'er (6) in the month of July 2017. Kanga station was the least disturbed station hence probably preferred as habitation and breeding zone for fish. The station was marked with high instream cover of above 50% and bottom substrate (> 50% gravels). The reverse was true for Wath Ong'er. The low catches in the month of July 2017 could have been due to high amount of water levels hence reduced efficiency of electrofisher.

Table 4: Checklist of the fish species recorded during the study

Family	Species
Cyprinidae	*Barbus paludinosus* *Barbus numayeri* *Barbus apleurogramma* *Barbus cercops* *Barbus profundus* *Barbus jacksoni* *Barbus kerstenii* *Barbus nyanzae* *Labeo victorianus*
Cichlidae	*Oreochromis niloticus* *Oreochromis leucostictus* Haplochromines
Claridae	*Clarias theodorae*

	Clarias gariepinus
Mochokidae	*Synodontis victoriae* *Chiloglanis somereni*
Amphillidae	*Leptoglanus* *Amphilus jacksonii*
Mormyridae	*Mormyrus kannume* *Gnathonemus longibarbis*
Poecillidae	*Gambusia affinis* *Protopterus aethiopicus*
Mastacembelidae	*Afromastacembelus frenatus*
Alestidae	*Brycinus sadleri*
Schilbeidae	*Schilbe mystus*
Latidae	*Lates niloticus*

The highest mean of FIBI (50±1.38) was recorded at Kanga while the lowest (28±1.38) was resorded at Wath Ong'er . Kanga had the highest number of fish species (13). Wath Ong'er and river mouth recorded the lowest percentage of Cyprinidae. The low value of various sub-metrics recorded at Wath Ong'er could be attributed to the anthropogenic activities in the area.

Fish species richness was significantly correlated with fish abundance (P=0.001), FIBI (0.001) and HQI (p=0.026). Fish abundance was also significantly correlated with FIBI (P=0.001) and HQI (P=0.003). FIBI had a significant positive correlation with HQI (P=0.045) and was insignificantly negative correlated with the nutrients TN and TP. HQI was negatively correlated with all the physic-chemical parameters except DO where there was a positive correlation. The correlations exist because the quality of a habitat influences the occurrence, assemblage and existence of fish in a locality. Fish prefers the environment which is favorable and conducive, free from pollution. Once habitat is disturbed then fish migrate or die. FIBI and HQI showed a slight positive correlation because the FIBI does not rely entirely on habitat characteristics. Temperature negatively correlated with fish abundance, DO positively correlated with abundance and negatively with TN (Table 5). Increased TN promotes eutrophication leading to an increased dissolved oxygen demand. This lowers the dissolved oxygen in water column and hence fish assemblage. Reduced dissolved oxygen is also affected by increased temperature in water column re. Once temperature increases oxygen to be diffused in water reduces. Since fish depends on DO for survival they are likely to migrate from a lowly DO zone. The first order stream was not chosen for correlation because it was dominated by only one species (*B. neumayeri*).

Table 5: The Pearson correlation analysis between the HQI, FIBI and physico-chemical parameters

Correlations

		Richness	Abundance	FIBI	HQI	pH	Temp	DO
Richness	Pearson Correlation	1	.604**	.760**	.384*	.100	.021	.14
	Sig. (1-tailed)		.001	.000	.026	.314	.459	.24
Abundance	Pearson Correlation	.604**	1	.581**	.521**	-.006	-.373*	.36
	Sig. (1-tailed)	.001		.001	.003	.488	.030	.03
FIBI	Pearson Correlation	.760**	.581**	1	.340*	.069	.079	.14
	Sig. (1-tailed)	.000	.001		.045	.368	.350	.24
HQI	Pearson Correlation	.384*	.521**	.340*	1	-.272	-.280	.10
	Sig. (1-tailed)	.026	.003	.045		.090	.083	.29
pH	Pearson Correlation	.100	-.006	.069	-.272	1	.245	.18
	Sig. (1-tailed)	.314	.488	.368	.090		.114	.18
Temp	Pearson Correlation	.021	-.373*	.079	-.280	.245	1	-.27
	Sig. (1-tailed)	.459	.030	.350	.083	.114		.08
DO	Pearson Correlation	.142	.361*	.140	.109	.184	-.277	1
	Sig. (1-tailed)	.245	.035	.248	.298	.184	.085	
TP	Pearson Correlation	-.092	-.114	-.209	-.180	.047	.304	.10
	Sig. (1-tailed)	.328	.290	.153	.189	.411	.066	.30
TN	Pearson Correlation	-.196	.122	-.165	-.111	-.183	-.134	-.38
	Sig. (1-tailed)	.169	.276	.210	.295	.186	.257	.02

**. Correlation is significant at the 0.01 level (1-tailed).

*. Correlation is significant at the 0.05 level (1-tailed).

c. Listwise N=26

CONCLUSION

Fish catches, HQI and FIBI varies along River Kuja. The metrics are impacted on by anthropogenic activities. If the quality of a habitat and water remains unimpaired probably a high HQI will be recorded and hence high Fish-based Index of Biotic Integrity, species richness and fish abundance. Significant activities along the river include deforestation, agriculture and mining. This study therefore provided information on the status of the river Kuja in terms of its integrity and fish found in the river.

Recommendation

There is need for more investigation with longer period data set in River Kuja for better understanding of the ecosystem.

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GROWTH, MORTALITY AND EXPLOITATION RATE OF BARBUS ALTIANALIS OF RIVER KUJA

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Abstract

There is a history of the decline in *Barbus altianalis* abundance and distribution in the Lake Victoria basin. This fish, formerly widely distributed in the Lake and the rivers draining into it, is nowadays mainly confined to the rivers. To assess the condition of the populations; growth, mortality and exploitation rate of *B. altianalis* in the Kuja River were analyzed using the Fisat software. Fish samples were collected from October 2016 to July 2017 using an electrofishing equipment. Length, weight of individual fish and total counts were measured at four different sampling points along the river. Length-frequency data collected from the fish were used to estimate the growth parameters K, L_∞ and Z/K using the Powel Wetheral method. Total mortality rate was estimated by multiplying the growth constant K by the parameter Z/K and the natural mortality M was calculated using Pauly's method. The asymptotic length, (L_∞) and the ratio of the total mortality rate (Z) to the growth constant (K), were estimated to be 54.05 cm and 1.717 respectively. The curvature parameter K was 1.47^{-y}, Z was 2.52 and the growth performance index ($\emptyset'\emptyset'$ = Log 10 K + 2 log 10 L_∞) = 3.63. Total, natural and fishing mortalities and exploitation rate were estimated 2.52, 1.71, 0.81^{-y} and 0.32 respectively. The results indicate presence of fair amounts of *B. altianalis* in the Kuja River though over 79.8% constitute fish that are sexually immature, this therefore requires that sustainable management measures are put in place to conserve the *B. altianalis* populations.

Keywords: growth parameters, mortality, exploitation rate, sexual maturity, recruitment pattern

INTRODUCTION

Barbus altianalis (Boulenger 1900) is a ray finned fished from the Cyprinidae family. *It inhabits Lake Victoria and its drainage basin, Lake Edward, Lake George, Lake Kyoga, Lake Kivu and Kagera River (Ntakimazi, 2006). It's an important fish for food and sports fishing. Its* common name in luo is fwani (Obiero, et al, 2012). In Kenya, B. altianalis is restricted to the Lake Victoria and its drainage basin. It is a potamodromous fish that migrates upstream to spawn (Ntakimazi, 2006) and currently its population has drastically declined in the Lake catches (Ondhoro et al., 2016). It inhabits inshore waters of lakes and rivers, including fast-flowing waters and feeds on algae, insect, plant material, mollusk (Ombogo, 2012). It's a stomach less riverine fish with a maximum recorded total length of 90cm (Ondhoro et al., 2016).

It is listed in the International Union for Conservation of Nature (IUCN) red list of threatened species since as a native species of Lake Victoria, the populations have drastically declined (Ntakimazi, 2006). The fish faces threats due to anthropogenic activities such as

unsustainable farming methods, domestic and industrial pollution (Chemoiwa et al., 2013) which have led to eutrophication and loss of fish migratory routes (*Geelhand et al*. 2016).

River systems are known to have rich and diverse fish communities (Obiero *et a*l., 2012) which form an important resource for fisheries and aesthetic values. Unfortunately, fish in rivers are less studied compared to those in lakes and reservoirs (Welcomme & Merona). Chemoiwa *et al*., (2013) observed that cyprinids, particularly Barbus species are the most successful in colonizing the affluent rivers of Lake Victoria and are little studied (Ombogo, 2012).

Observation by Ojwang, *et al*.,, 2007 indicate presence of confined populations of the altianalis at the river mouths. Further studies by Chemoiwa *et al.*,, 2017 indicate that*B. altianalis* is not purely a potamodromous fish but also has permanent river-dwelling populations.

Overfishing mostly targeted at cyprinid fishes (*Barbus,* and *Labeo species)* in the riverine habitats of Lake Victoria, has reduced populations that were once abundant (Chemoiwa et al., 2017). The introduction of more efficient gillnets and unregulated fisheries have negatively impacted on the riverine spawning fish stocks (Taabu, 2004; Njiru, 2010). Intensive fishing using monofilament nylon gillnets has over time removed large sized fish from riverine stocks, only allowing smaller sized fish to access most of the upstream riverine habitats. (Obiero *et al*., 2012).

The purpose of this study was to assess the stocks of *B. altianalis* in the River Kuja, to obtain information on population structure, growth, mortality, exploitation rates and sexual maturity which are essential inputs in models used for fisheries management and conservation.

METHOD

Study area

River Kuja extends from a longitude of 34^{o}7’60’’E to a latitude of 00^{o}55’60’’S. It has an altitude of 1133 meters above sea level. It has a length of 149 km with an area of 6900 km^{2} and with an average discharge of 58 m^{3}/s. It’s Inhabited by fairly rich diverse species including *B.altianalis, B.neumayeri, B.cercops, B.kerstenii, B. nyanzae, B.jacksonii, B.apleurogramma, C.gariepinus, Chiloglanis sp, Leptoglanis sp, C.theodorae, L.victorianus, Haplochromis sp, A.frenatus.* It drains through an Agricultural area, that supports crops like

coffee, tea, maize sugarcane and it's used for the Lower Kuja Irrigation project.

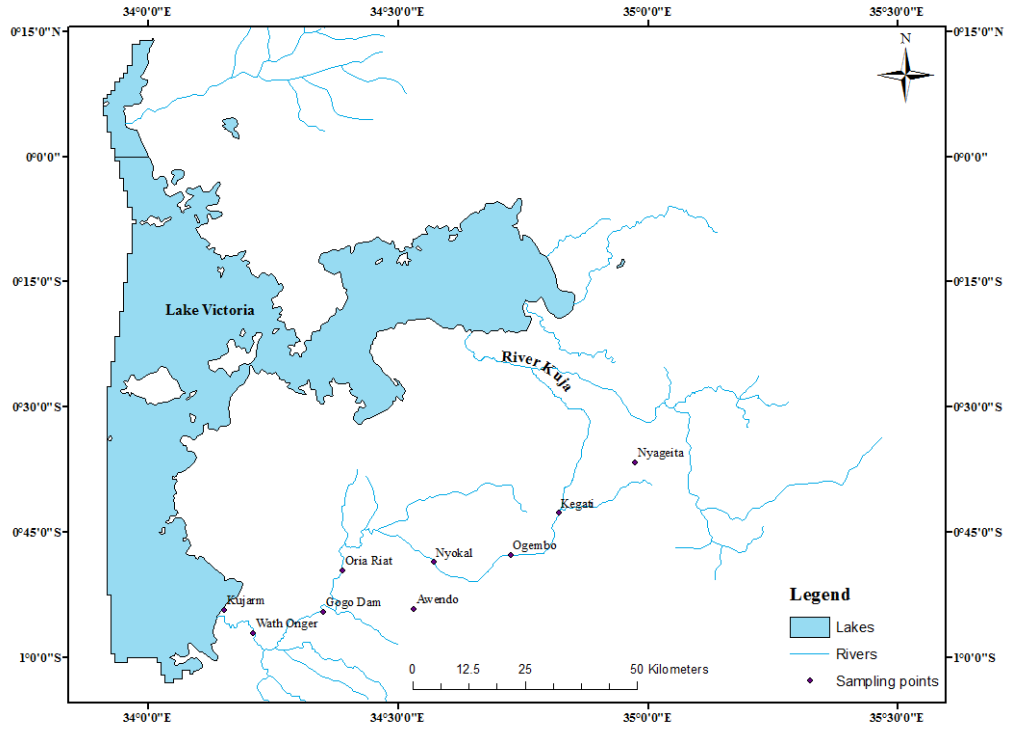

Figure 1: River Kuja map showing study areas

Collection of sample

Length-frequency data on *B. altianalis* fished using an electrofishing equipment were collected once a month from four different sampling sites (Figure 1) for a period of ten months (Oct 2016 to July 2017), for use in assessing the population structure, growth, mortality, exploitation rate and sexual maturity. All fish were measured to the nearest centimeter total length (TL) and focal length (FL), weighed to the nearest gram and separated into males and females to obtain sex ratio. The fish were dissected for sexual maturity examination. The gonads were categorized according to the developmental stages for the species as described by Rutaisire and Booth (2005).

Analysis

The Powel method Wetherall et al. (1987) was used a plot L_i against L_i - L'_i from which $L\infty$ and Z/K are estimated thus:

$$L\infty = \frac{a}{-b} L\infty = \frac{a}{-b}$$

$$\frac{Z}{K} = \frac{1+b}{-b}$$

Model by Sparre et al. (1989) was used to estimate total mortality Z:

$$Z = K\,(L\infty - L)/\,(L - L')$$

WhereL∞ and K are parameters of the von Bertalanffy Growth Function (VBGF).

L= Mean length
L∞ = Asymptotic length/ mean length of the old fish
K = Growth coefficient/ curvature parameter/ how fast the fish approaches their asymptotic length

The growth constant K was estimated using Ebert's (1973) method:

$$K = \ln {L_\infty}^D - {L_2}^D / {L_\infty}^D - {L_1}^D .1/(t_1 - t_2)^D K = \ln {L_\infty}^D - {L_2}^D / {L_\infty}^D - {L_1}^D .1/(t_1 - t_2)^D$$

(Vakily et al., 1986).

Where L_1 and L_2 are the mean lengths at times t_1 and t_2 when length-frequency samples were taken and D, the surface parameter.
Natural mortality (M) will be estimated using the empirical relationship of Pauly (1980):

$$Log_{10}M = -0.0066 - 0.279 Log_{10}L\infty + 0.6543 Log_{10}K + 0.4634\, Log_{10}T$$

Where, M is the natural mortality, L∞ the asymptotic length, K the growth co-efficient of the VBGF and T the mean annual habitat water temperature °C.

Once Z and M were obtained, fishing mortality (F) was estimated using the relationship:

$$F = Z - M$$

Where, Z is the total mortality and M, natural mortality.

The exploitation level (E) was estimated using the Gulland (1971) formulae;

$$E = F/Z$$

The growth performance index was computed according to Moreau et al. (1986):
$$\emptyset' = Log10K + 2Log10L\emptyset' = Log10K + 2Log10L_\infty$$

The relationship between the length (L) and weight (W) of the fish will be expressed by the equation (Eagderi & Radkhah, 2015):

$$W = aL^b$$

Where, W - weight (g), L - total length (cm), a – coefficient related to body form, b – exponential expressing relationship between length and weight.

Linear transformation will be made using natural logarithm at the observed lengths and weights proposed by Ricker (1975).

$$\text{Log } W = \text{Log } a + b \text{ Log } L$$

RESULTS AND DISCUSSION

Length frequency

The data presented in Figure.2 was used for the estimation of the growth parameters and the total mortality rate. The smallest fish fully represented in the catch are 5 cm (range of 3 – 53 cm). Most of the fish in the distribution are immature and have not attained recruitment age.

Figure 2: Frequency histogram for Barbus altianalis from River Kuja.

Length weight relationship

Relationship between body weight and total length of *B. altianalis* was described by the equation: $BW = -2.3815TL^{3.24}$ ($r^2 = 0.92$)

Figure 3: Length weight relationship of B.altianalis of River Kuja

Growth, mortalityand exploitation rate

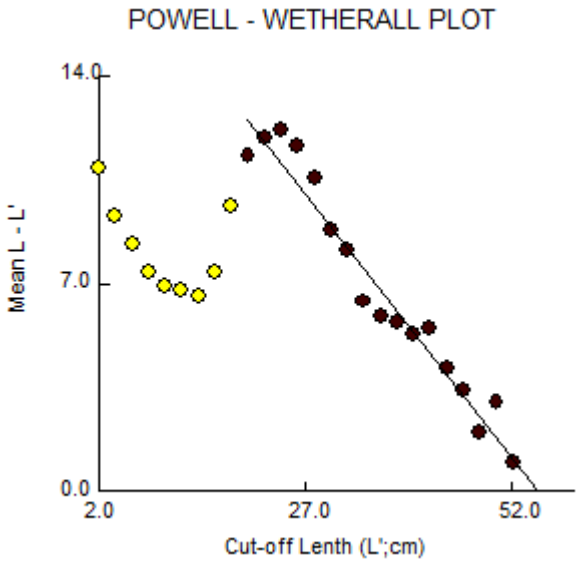

Figure 4: Estimation of L_∞ and Z/K using the modified Wetherall method for Barbus altianalis in River Kuja.

The estimation of L_∞ and Z/K using the Wetherall modified version (Pauly, 1986) is depicted in figure4 with the estimated values of L_∞ as 54.05 and Z/K as 1.717.The growth constant K estimated using Ebert's (1973) method was K = 1.47 y^{-1} .

Total mortality Z was calculated from the values of Z/K and K and was estimated to be 2.52 .The growth performance index = 3.63. Total, natural and fishing mortalities and exploitation rate were estimated 2.52, 1.71, 0.81 y^{-1} and 0.32 respectively.

Recruitment pattern

The recruitment pattern shows two cohorts revealing that the fish recruits twice a year in the 3rd and 7th month respectively.

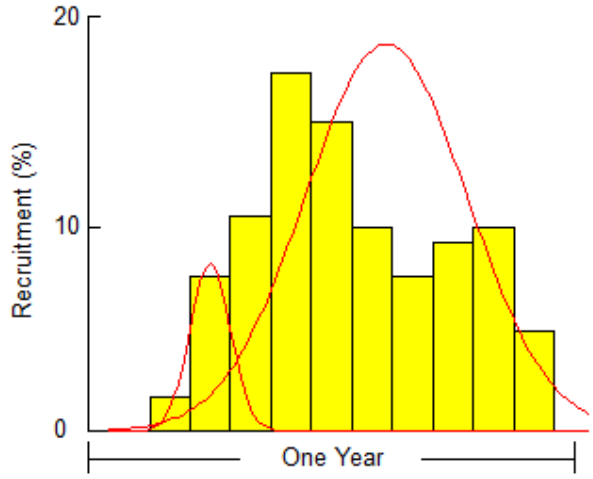

Figure 5: Recruitment pattern of B. altianalis of River Kuja

Mean Length distribution

The length ranged between 7 and 14 cm.

Figure 6: Mean length of Barbus altianalis distributed in the months

Sex

Minimum mature size was 16.5 cm, Sex ratio of Female: Male was 285:383. 21.95 % mature and 78.05 % immature. Out of the 21.95% that were mature, 79.78% were male.

DISCUSSION

Knowledge of various population parameters like as asymptotic length (L_∞), growth coefficient (K), mortality (natural and fishing) rate and exploitation level (E) are necessary for planning and management of fisheries resources (Amin, Arshad, Bujang & Siraj, 2009).

The observed total length is smaller than what has been recorded to be the maximum length of the fish (90 cm) (Ondhoro *et al*., 2016). Length-weight relationship is an important aspect in the assessment of fish biology of fish. (Akintola *et al.*, 2010). The growth constant (b

value) of 3 illustrates a positive allometric growth of the fish and the state of well-being of a specific population (Yongo *et al*., 2016). The b value (3.24) estimated demonstrates normal growth dimension. The coefficient of determination ($r^2 = 0.92$) shows an isometric growth for *B. altianalis* species and strong correlation between length and weight.

The asymptotic length, (L_∞) and the ratio of the total mortality rate (Z) to the growth constant (K), were estimated to be 54.05 cm and 1.717 respectively. The curvature parameter K which is how fast the fish approaches the asymptotic length was 1.47^{-y}. The growth parameter shows that *B. altianalis* of R. Kuja grows moderately. No work has been done for comparison.

The total mortality Z was 2.52 and the growth performance index was 3.63. The total mortality rate Z=2.52 is highdue to fishing, blocking of migratory patterns, pollution, turbidity caused by siltation through agriculture. The high growth performance index exhibited by *B. altianalis* in River Kuja could be attributed to overfishing which reduces the size of fish and in turn increases growth rate. The average size of the fish is therefore attained much faster, leading to an increase in the growth constant.

Total, natural and fishing mortalities were estimated to be 2.52, 1.71, 0.81^{-y} respectively. The natural mortality is greater than the fishing mortality which could be due to pollution and other anthropogenic activities (Obiero et al., 2012). The fishing mortality is lower due to the small sizes available that cannot be exploited due to immaturity. Overfishing (Njiru, Mkumbo & Knaap, 2010) has reduced both the fishing mortality and exploitation rates. The exploitation rate was estimated to be 0.32.

The *B. altianalis* fish is recruited twice a year being the 3rd and 7th month. This basically shows that the fish is able to grow to a reproductive size and join the fishery; hence the immature sizes available. The minimum mature size was 16.5 cm witha sex ratio of Female: Male (1:1.34). There was no significant difference ($p>0.05$) in the sex ratio as depicted by the chi square test. From the total catch, 21.95 % of the fish were mature and 78.05 % immature and this is due to the anthropogenic impacts that affected mostlyaffected the mature part of the fishery. Out of the 21.95% that were mature, 79.78% were male and this could be attributed to the fact the fish is potamodromous and seasonal.

The mean length observed ranged between 7cm and 14cm during the ten months. A clear indication of small immature fish harvested. Overfishing and loss of migratory routes caused the decline in population of larger fishes (Chemoiwa, 2013).

The results indicate presence of fair amounts of *B. altianalis* in the Kuja River though 79.8% constitute fish that are sexually immature, this therefore requires that sustainable management measures are put in place to conserve the *B. altianalis* populations.

CONCLUSION

The results indicate presence of fair amounts of *B. altianalis* in the Kuja River though 79.8% constitute fish that are sexually immature, this therefore requires that sustainable management measures are put in place to conserve the *B. altianalis* populations. The management will ensure the growth of the immature sizes then lead to an increase of both the fishing mortality and exploitation rate.

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INFLUENCE OF MANAGERIAL SKILLS ON SUSTAINABLE DEVELOPMENT OF RURAL SACCOS IN MERU COUNTY

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Abstract

Co-operative societies in Kenya have transformed lives and livelihoods through provision of effective solutions to socio-economic challenges. Since independence, majority of co-operative societies have evolved in terms of membership, capital outlays, assets, and infrastructure. On the other hand, a number of co-operatives have retarded in development, while others have closed down. This is pegged on the kind of management skills rendered by leadership. Their management capabilities have constrained the achievement of cooperative full potential. Today co-operatives in Kenya are unable to sustain their developments. The solution to this problem lies with the management leadership. There is a need to employ proper managerial skills to sustain development and long term survival. The objectives of the study were to examine the influences of effective communication, strategic thinking, relationship management and teamwork on sustainable development of rural Saccos in Meru County. The study applied a descriptive design which focused on 200 directors in all the 21 rural Saccos in Meru County. The study applied a proportionate stratified random sampling method to select a sample of 50 directors. Data was collected through questionnaire which comprised of both close and open ended questions. The study concludes that effective communication and information need enhancement to increase sustainable development in rural SACCOs in Meru County. Strategic thinking was inadequate and need to be the pillar of every organization. The relationship management was paramount despite low feedback. The SACCO management needs to increase the collaborative relationship management to sustain development of their rural SACCOs. On teamwork the researchers concludes that due to less teamwork articulation among staffs it should be improved for the benefit of all stakeholders for sustainable development. Lastly the study concludes that SASRA needs to be prudent in management leadership responsibilities of the rural SACCOs.

Keywords: sustainability, development, co-operatives, strategic, teamwork

INTRODUCTION

This study concentrated on the Influence of managerial skills on sustainable development of rural SACCOs in Meru County. The objectives of the study were to examine the influences of effective communication, strategic thinking, relationship management and teamwork on sustainable development of rural Saccos in Meru County. Their management capabilities have constrained the achievement of cooperative full potential. Today co-operatives in Kenya are unable to sustain their developments. The solution to this problem lies with management leadership. There is need to employ proper managerial skills to sustain development and long term survival.

SACCOs are one of the most successful tools for development with the ability to positively affect its participant's economic and social status. The roles they play depend on their management skills which in turn give varying degrees of success or failure in view of sustainable development rural SACCOs. A study by Mutesasira (2009) indicated that a lot of people struggle with poverty in the world. In addition, Cuevas and Fischer, (2006) argue that Co-operatives have a wider role to play in eradicating poverty .The major problem is worsening credit control in SACCOS organizations that affects their financial performance. This problem arises when the credit offices do not take strict measures before and after dissemination of credit. Globally, a study by Campion, (2010) has attempted to obtain efficiency measures in relation to management capabilities. Locally studies show that SACCOS are not making significant impact in growth and development despite some level management knowledge, skills and experience. Raikes, (2009) indicated that the rural SACCOs have problems in management and this hiders them to achieve their desired objectives. It is against this background that the researchers sought to assess the Influence of managerial skills on sustainable development of rural SACCOs in Meru County.

SACCOs are member-owned and they contribute resources which are pulled together and with this contribution, the SACCO uses them to offer small loans to the members (Rosemary and Atieno, 2011). This therefore makes them user-owned and in return offers all financial services to the members.

SACCOs operate across all sectors of the economy and it has been estimated that cooperative societies in Kenya, provide livelihood to 63% of Kenyans both directly and indirectly. The financial sector had mobilized estimated domestic savings amounting to Kshs. 150 billion by 2006 and the sector continues to grow at 20% per annum while at the same time, cooperative institutions contribute to the direct employment of over 250,000 people and indirectly through establishment of linkages between firms, farms, markets and through provision of collective and individual investments (Chambo, 2012).

World Bank documented that 24% of world's population lives on less than a dollar a day mainly in developing countries, Kenya included. New technologies promise to reduce transaction costs and increase access of funds. The World Bank group is helping regulators balance consumer protection with innovation, and work with phone companies and banks to create viable business models.

Communication at all levels is necessary for people to work toward goals of sustainable development (McPherson, 2007). The best way for individuals and organizations to engage the public sustainably is through extensive research on issues and formulation of effective communication for public awareness and action concerning those issues. Communication is an amplifying voice, facilitating meaningful participation and fostering social change (Andrews and Baird, 2009).Without communication structures and processes which enable the two-way exchange of information between state and citizens, it is difficult to imagine how states can be responsive to public needs and expectations (Harris, & Nelson, 2008). Crucially, two-way communication allows citizens to monitor the states' activities, to enter into dialogue with the state on issues that matter to them, and to influence political outcomes. To date, a handful of widely-cited empirical studies have found that open communication environments - particularly free media and access to information are correlated with improved government responsiveness and accountability, lower levels of corruption, and economic development (D'Aprix, 2010).

There are effective methods to help people to reach a consensus and find common grounds for action, based on their own needs and capabilities (Harvard Business Review, 2009). Maintaining people's participation always requires much of communication work within the community in order to make a bridge of understanding. Communication and media help

people to visualize and cross that bridge more swiftly as the strategic use of media and political communication tools is primal to influence behavior and brings about meaningful social change. Communication encourages the development of independent and pluralistic media, especially in conflict and post-conflict areas and in post-disaster situations (Harris, & Nelson, 2008).

Strategic thinking is about analyzing a problem and its solutions from a broad perspective and understanding the potential impacts of every action on other people in an ecosystem. Thinking is strategic when an individual has the mindset of a professional problem solver who uses a holistic approach and available information to define micro problems in light of the macro picture, identify solution options, and select the best solution to deal with day-to-day issues (Dorling, 2010). Searching for an optimum solution to a problem requires the application of creative thinking which is the ability to generate fresh alternatives, visualize new possibilities, formulate new approaches to getting things done, and being opened to new information that does not support existing assumptions about the way people should do things. (Liedtka, 2011). Creative techniques include challenging existing assumptions, welcoming provocation, envisioning an ideal world, gathering others' perspectives, and creating the right environment for creative thinking. Strategic thinking is a continuous process. People who think strategically constantly reassess their environment (Chike-Okoli, 2014). This constant environmental scanning and rescanning occurs at the corporate level by looking at the organization's strategy, customers, competition, and corporate trends. It might equally be at the lower level of an organization by analyzing the group's internal challenges and positioning. They gather and analyze extensive information to estimate the changes regarding past mistakes and current weaknesses that must be made today in response to the changing environment and generate desired results (Kneeland, 2012).

Teamwork in the workplace offers the company a chance to learn how to work together. The importance of teamwork at work is vital to the success of the company and to the development of each employee (Robbins, and Judge, 2009). Understanding those important elements will assist in developing company policies geared toward encouraging team growth in the workplace. A team that works well together understands the strengths and weaknesses of each team member. One of the benefits of strong teamwork in the workplace is that team leaders and members become proficient at dividing up tasks so they are done by the most qualified people. Without strong teamwork, it can be difficult for managers and executives to determine which staff member to allocate certain job (Vandenberghe, 2008)..

According to Zheng & Ricardo (2009), work groups and teams develop systems that allow them to complete tasks efficiently and quickly. When a task is handed by a well-trained and efficient team, the team's work pace assures that the task will be completed quickly and accurately and generate better revenue. When a team works well together, it allows staff members to feel comfortable in offering suggestions. Team members become accustomed to processing brainstorming information and the company benefits from the variety of suggestions that come from effective teams. A team that works well together understands the strengths and weaknesses of each team member. One of the benefits of strong teamwork in the workplace is that team leaders and members become proficient at dividing up tasks to the qualified people. Without strong teamwork, it can be difficult for managers and executives to determine which staff members can best accomplish job tasks (Robbins, and Judge, 2009).

METHODS

Research Design

This study adopted a descriptive survey research design. Descriptive survey is the process in which data is collected in order to test hypothesis or to answer questions concerning the current status of the subject under study. The intention of survey research is to gather data at a particular point in time and use it to describe the nature of existing conditions (Benedict 2009). The descriptive survey is therefore to be adopted mainly because the effect of the independent variables is exerting pressure on dependent variable.

Target Population

According to Comer (2010) target population for a survey is the entire set of units for which the survey data are to be used to make inferences. Thus the target population defines those units for which the findings of the survey are meant to generalize. The study population comprised of 200 directors in all the 21 rural Saccos in Meru County.

Sample size and technique

The study used simple random sampling method to select a sample size of 50 directors drawn from a target population of 200 directors. This is because it is considered the simplest, most convenient and bias free selection method. It enables every member to have an equal and independent chance of being selected as respondents.

The study adopted 25% sample size of the targeted population.

Table 1: Target Population and Sample size

Categories	Population	Sample 25% of Population
Directors	200	50

Research instruments

Jwan, (2010) noted that questionnaires enable the researcher to explain the purpose of the study and give meaning of terms that may be unclear. The design included multiple choice questions, fill in questionnaires and questions requiring ranking of answers. The questionnaire was drawn to elicit information or data on Influence of managerial skills on sustainable development of rural SACCOs in Meru County. Secondary sources were also used to gather information on annual SACCOs' reports.

Pilot testing of the instruments

This study conducted a pilot study of the questionnaires before using the questionnaire. The instruments were pre-tested to determine the accuracy, clarity, validity and reliability.

Validity of research instrument

Data validity refers to the degree to which results obtained from analysis of data actually represents phenomenon under study (Mugenda and Mugenda, 2003). The study made use of university supervisor as the team of experts to enhance content validity. The researcher consulted with the supervisor and made adjustments in the content of the study that were raised and advised by the supervisors.

Reliability of research instruments

Reliability of data is the consistency of measures in a study. It is the degree to which research instruments yield consistent results of data after trials (Uma & Bougie, 2009). A pre-test comprising of ten directors was selected randomly from the accessible population and used to carry out the test-pretest of the questionnaire.

Data Analysis techniques

The collected data was thoroughly examined, checked for completeness and comprehensibility. The data was then summarized, coded, tabulated for easy analysis, interpretation and drawing of conclusions. Descriptive statistics using graphical aids such as frequency tables, pie charts, bar graphs and frequency was used. Finally, conclusions will be drawn and appropriate measures recommended for further actions.

Ethical Considerations

This research is the researcher's original work arising out of interest in the cooperative movement specifically the SACCO sector. An exception is the information obtained from other writers which is properly referenced. The researcher conducted data collection in the most transparent and responsible manner to obtain the most valid and reliable data from the target groups. Respondents were treated with respect and the data collected was held in utmost confidentiality. The SACCO management will also have access to the results of this study.

RESULTS AND DISCUSSION

Examine the influences of, strategic thinking, relationship management and teamwork on sustainable development of rural Saccos in Meru County.

Effective communication in my organization

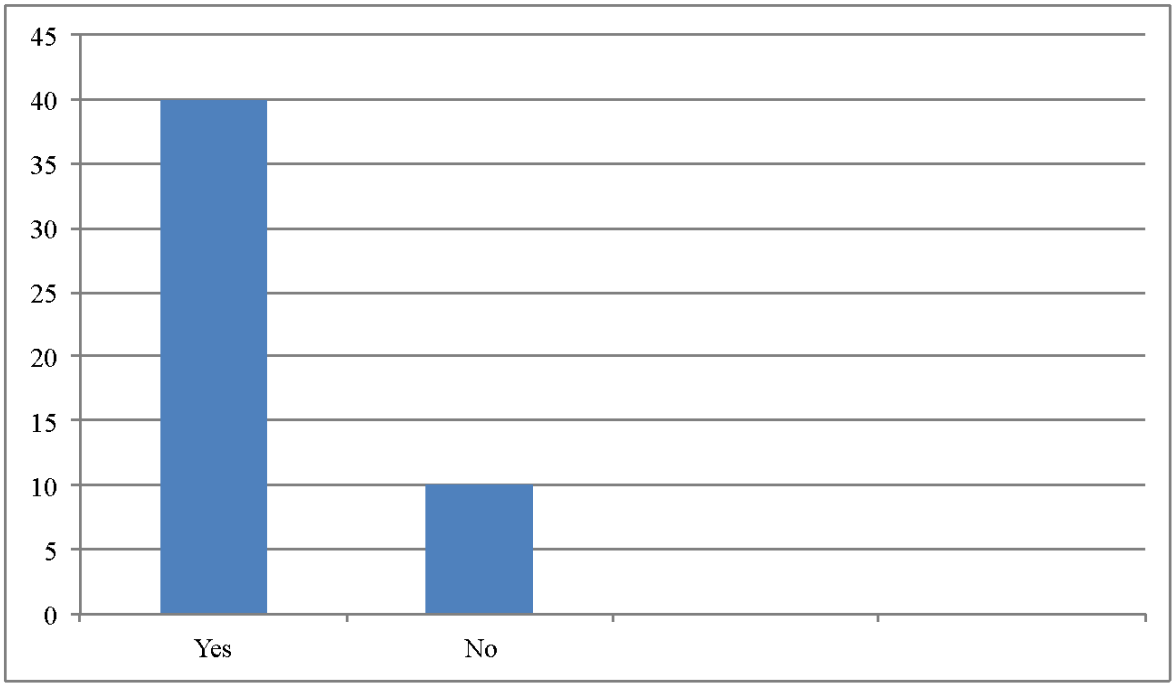

Figure 1: Effective communication in my organization

Figure 1 above shows that there are effective communications in rural SACCOs. 40 of the respondent indicated that there is effective communication while 10 were for different

opinions. This shows that 80% of the SACCOs have effective communication while 20% do not have effective communication.

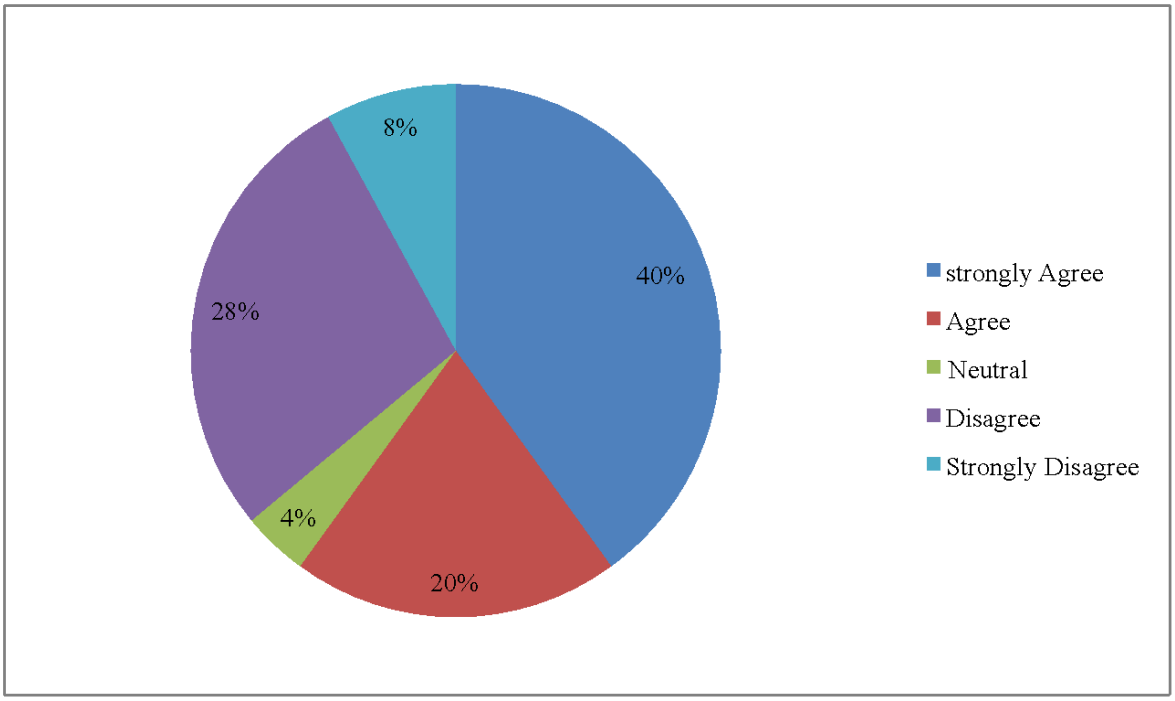

Figure 2: Effective communications from top to bottom and vise versa

From Figure 2 above it clear that Majority of respondents strongly agree that there is effective communication to and fro top to bottom. 20% agree, 4% are neutral, 28% disagree and 8% strongly disagree. Majority SACCOs therefore have effective flow of communication from top to bottom and vise versa. That disagree and strongly disagree indicates that there are no effective communication in their organization.

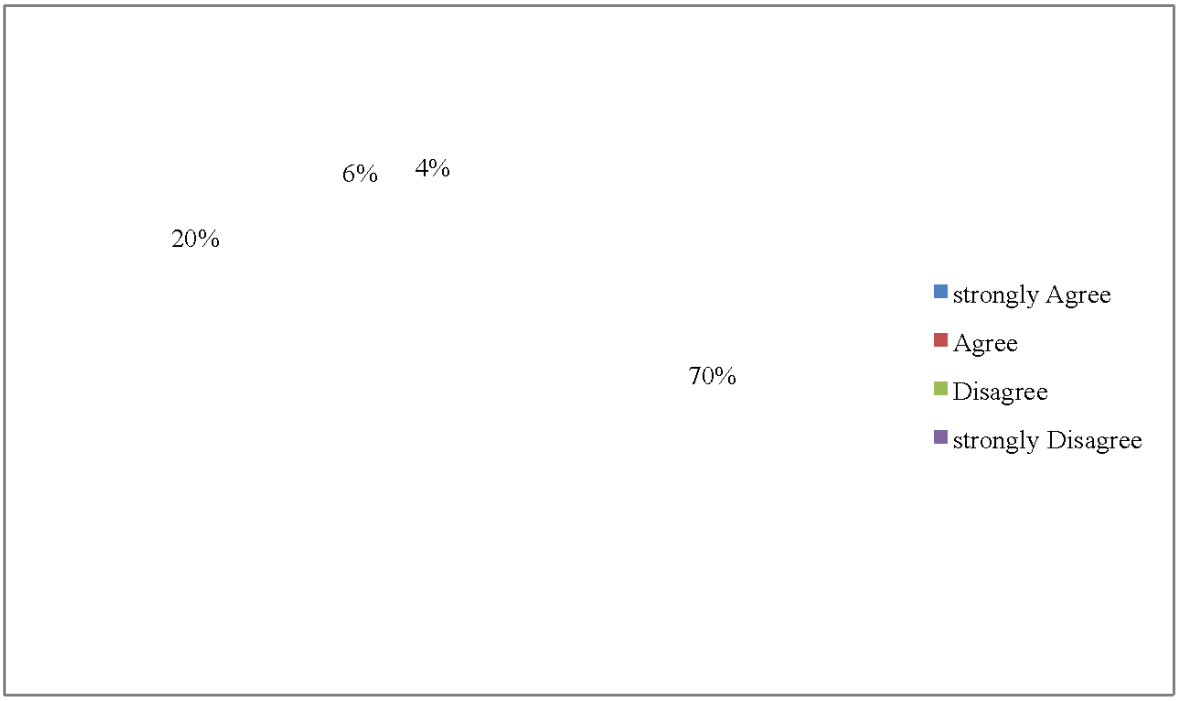

Figure 3: Effective communication influence sustainable development of rural SACCOs

Majority of respondents strongly agree that effective communication influence sustainable development of rural SACCOs. 70% strongly agree, 20% agree, 6% disagree and 4% strongly disagree. This results shows that there is a strong correlation between effective communication and sustainable development. In this case the majority of respondent were for the strongly agree and agree that effective communication influence sustainable development of rural SACCOs.

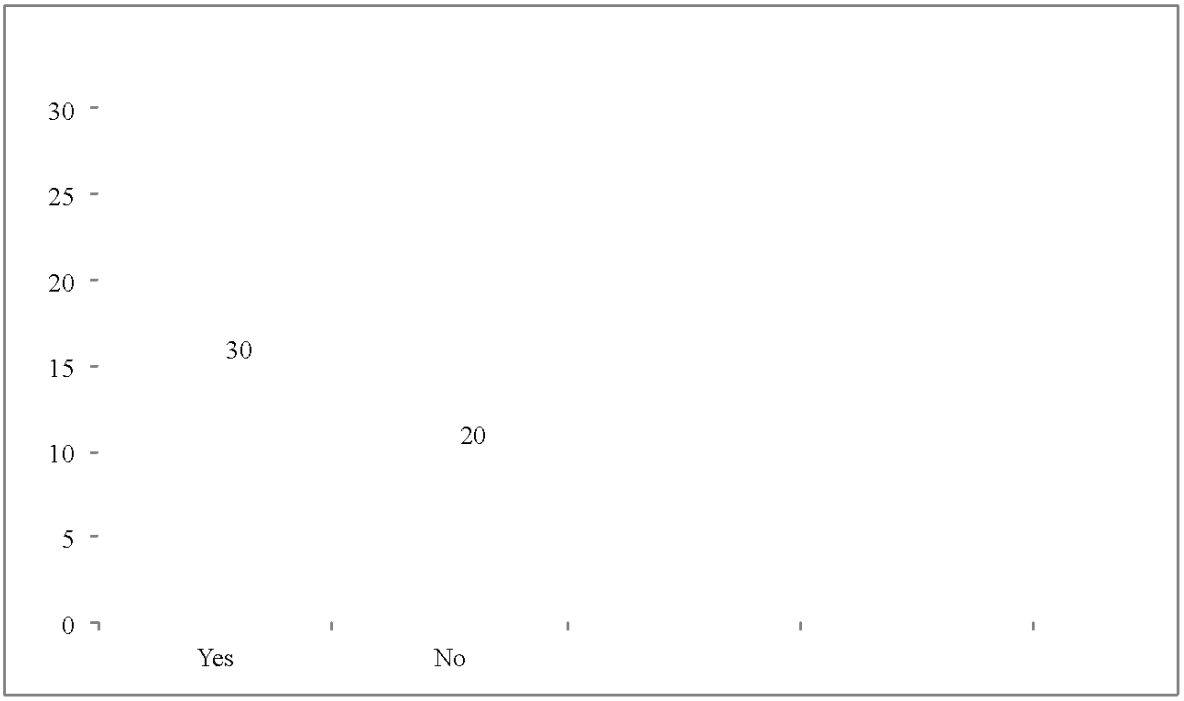

Figure 4: There are strategic plan in our organization

The Figure 4 shows that 60% of SACCOs have strategic plan and 40% do not have one. The strategic plan guides the organization and hence majority of SACCOs had strategic thinking.

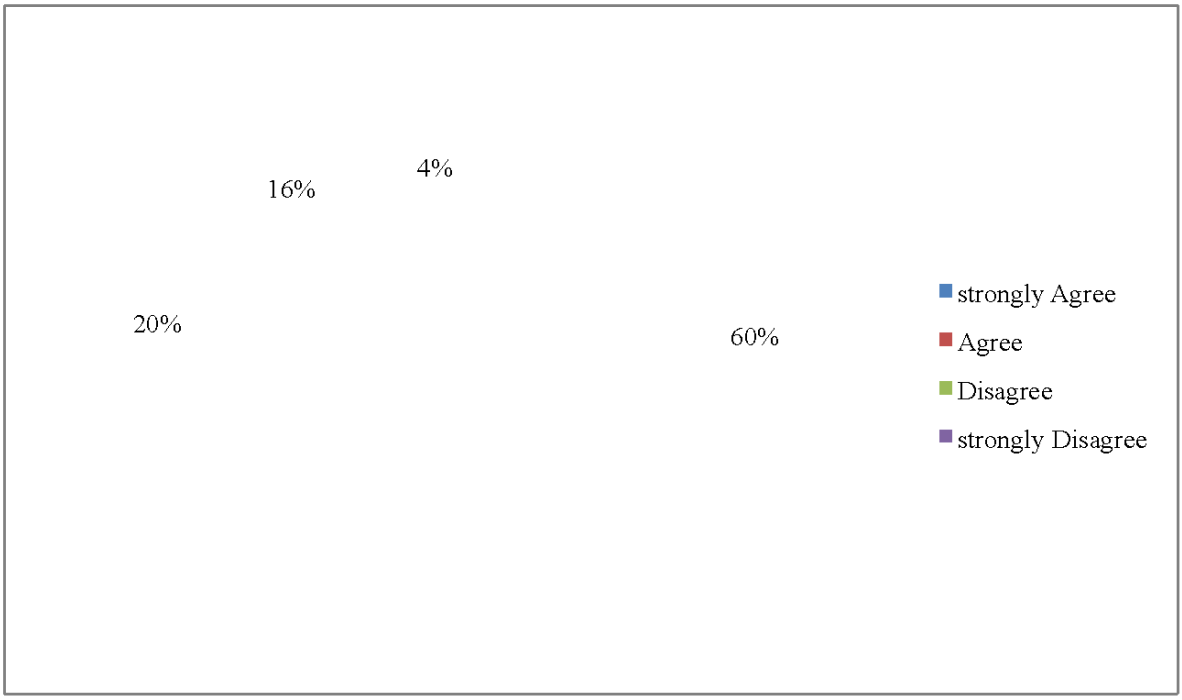

Figure 5: Our leaders are strategic thinkers

Figure 5 above indicates that the leaders of SACCOs are strategic thinkers.60% agrees, 20% agrees, 16% disagree and 4% strongly disagree. This shows that Sacco leaders and managers are strategic thinkers.

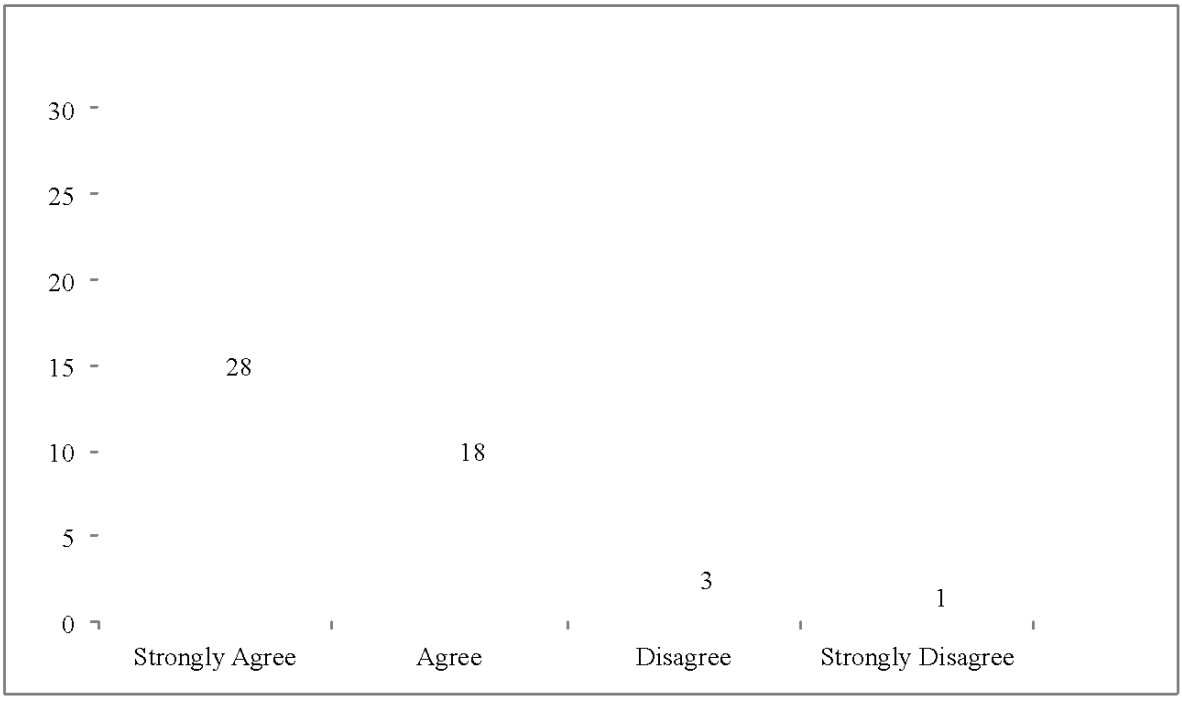

Figure 6: Our leaders are strategic thinkers

Figure 6 above shows that our leaders and Managers are strategic thinkers, 28 of the respondents indicated strongly agree, 18 agree, 3 disagree and 1 strongly disagree.

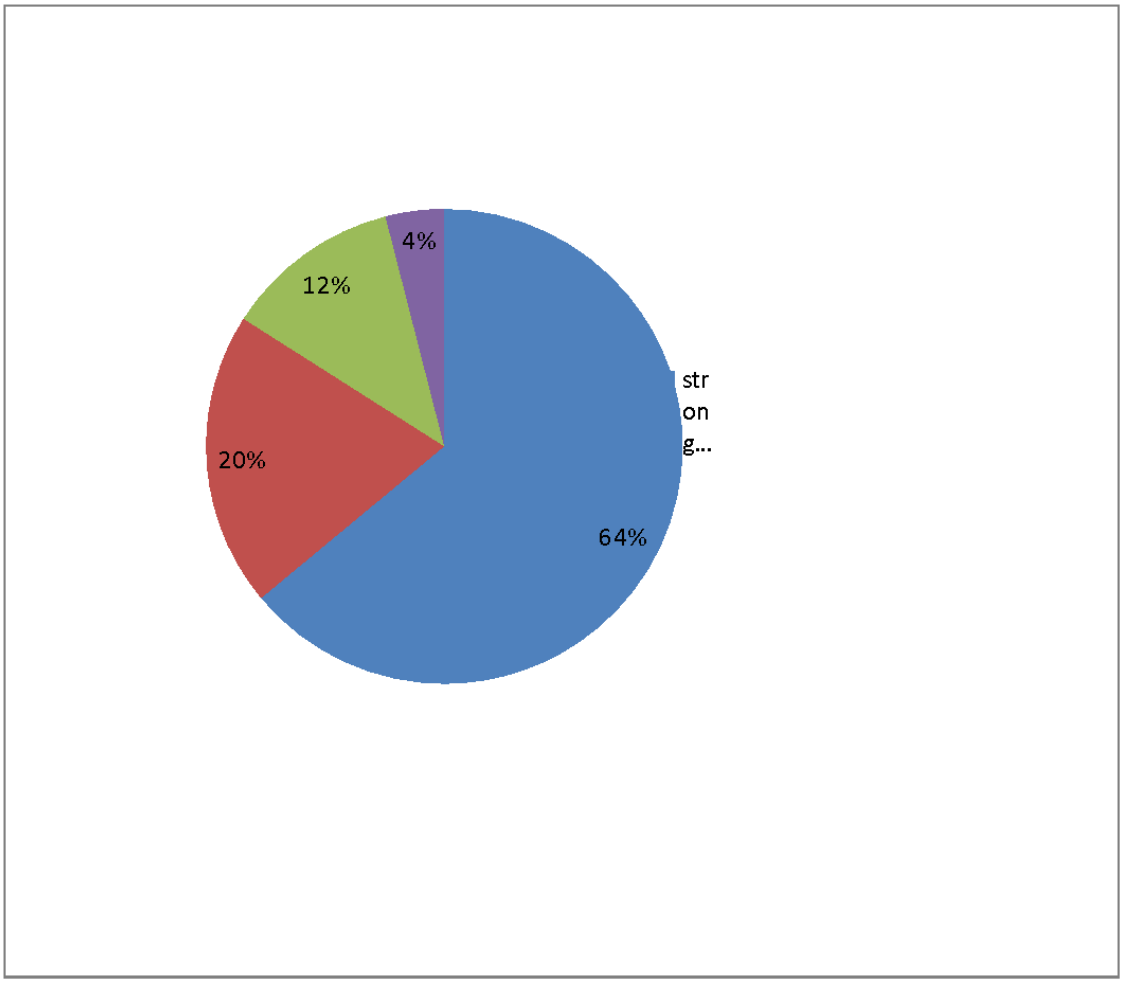

Figure 7: There is conducive relationship between all stakeholders in our organization

Figure 7 above shows the relationship between the stakeholders in SACCOs. 64% of the respondents strongly agree that there is a condusive relationship of all stakeholders, 20% agree, 12% disagree and 4% strongly disagree. This shows that there is condusive relationship between all stakeholders in most of the rural SACCOs.

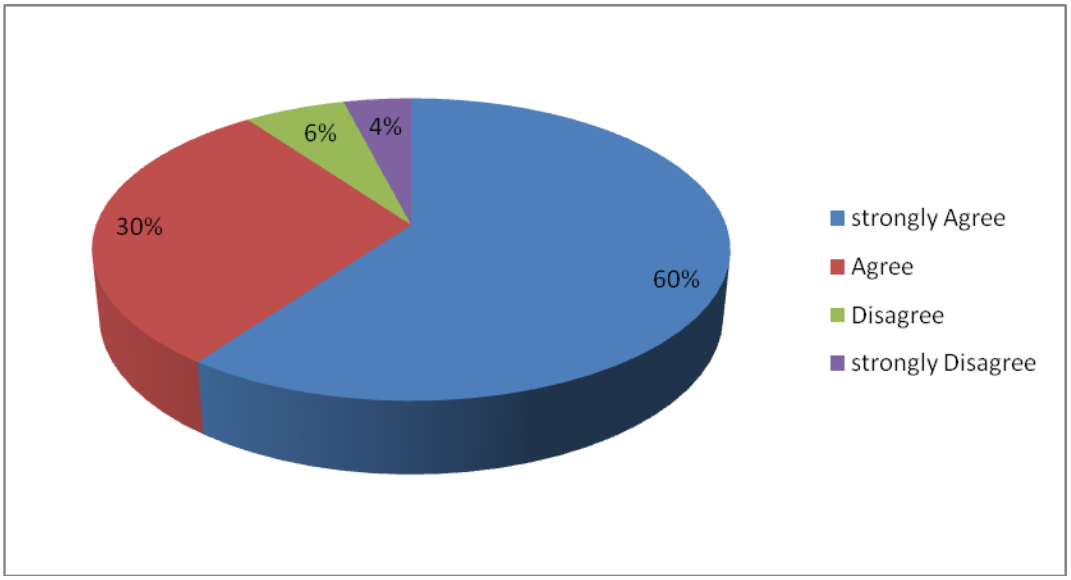

Figure 8: Relationship management influence sustainable development of rural Saccos

The above figure 8 shows the results of how Relationship management influences sustainable development of rural SACCOs. 60% strongly agree, 30% agree, 6% disagree and 4% strongly disagree. This indicates that the relationship management influences the development of rural SACCOs.

Staffs and management work as a team

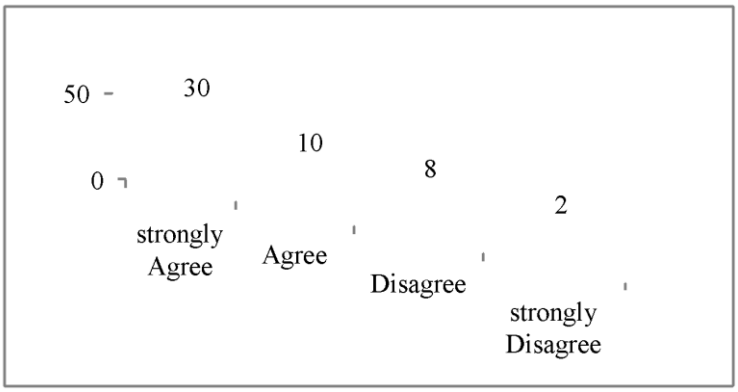

Figure 9: **Staffs and management work as a team**

In most rural SACCOs the staffs and management work as a team as shown by figure 9 above. Most of the respondents indicated that they strongly agree that Staffs and management work as a team, 10 agree, 8 disagree and 2 strongly disagree. This shows that there is teamwork in rural SACCOs in Meru County.

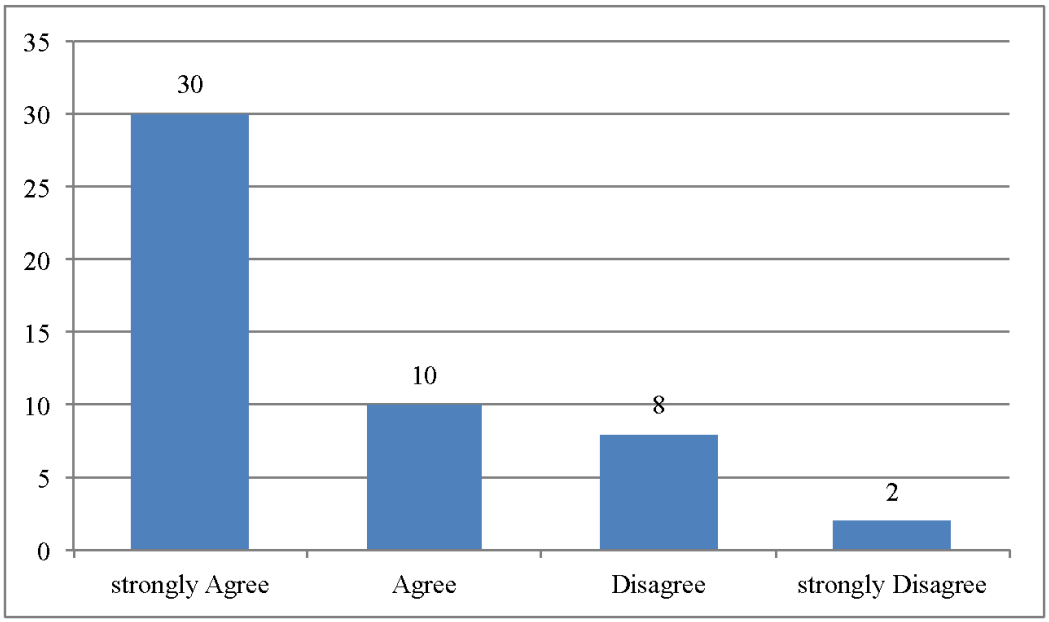

Figure 10 Relationship management influence sustainable development of rural SACCOs

Figure 10 shows the results on the relationship managements influence sustainable development of rural SACCOs. Majority of the respondent indicated that relationship management influences sustainable development in rural SACCOs. 30 of the respondents' strongly agree, 10 agree, 8 disagree and 2 strongly disagree. This shows that if the relationship between the stakeholders is managed properly, then the development in rural SACCOs is maintained to a great height.

CONCLUSION

The study concludes that effective communication and information need enhancement to increase sustainable development in rural SACCOs in Meru County. Strategic thinking was inadequate and need to be the pillar of every organization. The relationship management was paramount despite low feedback. The SACCO management needs to increase collaborative relationship management for sustainable development of rural SACCOs. On teamwork the researchers concludes that due to less teamwork articulation among staffs it should be improved to benefit all stakeholders for sustainable development. Lastly the study concludes that SASRA needs to be prudent in management leadership responsibilities of the rural SACCOs

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THE NEXUS BETWEEN MICROFINANCE, SOCIAL CAPITAL AND INVESTMENT FOR SUSTAINABLE DEVELOPMENT

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Abstract

Financial inclusion is a key tool used by world economies in employment creation and poverty reduction through household investment. This has seen the development of technology and review of regulations in order to accommodate bigger populace into financial system for sustainable development. Technologies like mobile banking and agency banking are some of the technologies that have revolutionized the financial market. The access to financial services in Kenya is through Microfinance Institutions, commercial banks, bank agents or through mobile phones. Microfinance Institutions (MFI) are friendlier to young entrepreneurs who don't have collateral to secure their loans. This study sought to find out whether there was any relationship between Microfinance, Social Capital, and household investment. The study population was Kenyan youth aged between 18 to 35 years. The study used a descriptive survey research design where the sample size was 463 respondents. A questionnaire was used to collect the data. A t-test indicated that those who are members of Microfinance had a higher level of Social Capital and the difference was statistically significant with a p-value = 0.00 at 95% confidence level. Binary Logistic regression demonstrated that Social Capital was positively related to investment and statistically significant in predicting whether a person will invest (Wald = 51.776, df=1, p=.000). Being a member of Microfinance, Binary Logistic regression indicated that it was positively related to investment and statistically significant in predicting whether a person will invest or not (Wald = 34.553, df=1, p=.000). The results of the study clearly demonstrated that Microfinance Institutions are playing a critical role in employment creation for sustainable development. The study recommends mechanisms to be put in place by governments that will enhance access to finances through Microfinance institutions especially for the young entrepreneurs who may lack collateral. The model used by Microfinance should be adopted by other financial institutions.

Keywords: financial inclusion, household investment, microfinance, social capital

INTRODUCTION

Financial inclusion has been found to be a critical tool in reducing poverty and achieving inclusive growth through household investments amongst the poor. The critical role makes financial inclusion a strategic agenda by a majority of the countries globally (Demirguc-Kunt *et al.,,* 2015). Many studies have confirmed the relationship between financial inclusion and poverty reduction. It has been indicated that providing the poor with affordable financial services can help them move out of poverty (Brune *et al.,,* 2013; Petreska& Mojsoska-Blazevski, 2013; UNDP, 2013; World Bank, 2008).

One way of enhancing financial inclusion is the use of Microfinance and this has seen financial inclusion increase among the poor (Togba, 2009). Microfinance has been generally defined as providing financial services to the low-income population, socially cohesive groups and other consumers who have been traditionally excluded from the banking services (Ledgerwood, 1999). In a broad perspective, the objective of microfinance is to increase financial inclusion to the poor who may remain permanently excluded from the mainstream

banks. The proponents of microfinance hold the view that access to finance through microfinance will help people move out of poverty (Togba, 2009)

Though microfinance in Kenya has its roots from the 1980s, it got more established after the Operationalisation of Microfinance Act in May 2008 (RoK, 2013). Currently, Kenya has eight deposit-taking MFI operating under a regulatory framework assessed by the Economist Intelligence Unit (EIU) and Kenya was the best in East Africa. MFI in Kenya is performing well where it is second best in Africa and among top 10 in the world. FinAcess (2016) noted that the increase in access to financial services where people were moving from the traditional brick and mortar would have a positive impact in an increase in access. On MFIs, there was an unprecedented increase in microfinance and their network. MFI were also reviewing their operational procedures and technology platforms in order to increase access to financial services. The increase in MFI is the fact that they are found to be more friendly to the poor (Ellis, Lemma and Rud, 2010),.

The government's efforts towards financial inclusion including MFIs have continued to bear fruits with increased financial inclusion (World Bank, 2014; FinAccess, 2013; Demirguc-Kunt *et al*., 2015; Villasenor, West & Lewis, 2015). Lately, FinAccess (2016) indicated that Kenya has maintained high levels of financial inclusion at 75.3%. Though financial inclusion has been confirmed to help in employment creation and poverty reduction through household investment, this is not the case in Kenya. The poverty levels are still high among the youth. (Balwanz, 2012; KNBS, 2016; Muyia, 2014; World Bank, 2016). However, those who were members of microfinance seemed to have higher levels of social capital (Togba, 2009). Maclean, (2010) noted that people with higher levels of social capital doing better economically through household investment. Other scholars who noted a positive relationship between social capital and economic well-being of individuals (Togba, 2009) observed this. It was important thus to find out whether there is any relationship between microfinance, social capital, and investment.

Statement of the problem

The main goal of microfinance is to alleviate poverty as it enhances financial inclusion (Demirguc-Kunt *et al*., 2015; Togba, 2009). However, so and so noted that this is not being achieved as expected. (Togba, 2009) noted that microfinance uses social capital as collateral to advance loans to the poor. The use of social capital has been proved to be a very effective form of collateral and illustrates the importance of trust and relationships in economic development (van Bastelaer and Leathers, 2006). Microfinance activities increase social contacts that can support income-generating activities (Kabeer, 2001; Mayoux, 2000). In the end, there is a reduction in poverty. Despite the high levels of financial inclusion in Kenya, the positive effect expected from this has not been achieved as unemployment and poverty levels are still high (World Bank, 2015; Klapper *et a*l.,, 2016). However, preliminary studies indicated that those who are members of microfinance could be doing fairly well than those who are not.

Objective of the study

Evaluate the nexus between micro finance, social capital, and investment among financially

included youth.

Review of literature

The impact of social capital started being conceptualized in the 1980s. Bard (1985) from the perspective of economic empowerment defined social capital as that aggregate potential resources which can be related to having a reliable and strong network of relationships with mutual benefits. Baker (1990) on the other hand looked at social capital as a resource that persons derive from specific social structures and use it to pursue their personal benefits. Putnam (1993) indicated social capital as a concept and relationship to the participation of people in the social spheres. Portes and Landholt, (2000) and Woolcock, (1998) noted that social capital has continued to be a prominent source of capital. Social capital is also looked at how individuals create a network, which they can use to access resources (Bebbington, 2007; Bourdieu, 1985; Rankin, 2002). Mayoux, (2001) and Molyneux, (2002) looked at social capital as a property of communities or even nations. Despite the multiplicity of views about social capital, there is a consensus that social capital helps persons secure benefits by virtue of membership in social networks, groups or other social structures.

Microfinance started in the 1970s in Bangladesh as a series of lending experiments through Yunus and Grameen Banks and other Bangladesh banks like BRAC (Yunus 2007). Currently, Grameen boasts of approximately 8.4 million women and this is in other 84 countries while BRAC has over 100 million borrowers globally. Microfinance has grown globally with over one billion borrowers where they have borrowed over US dollars 70 million (Haldar & Stiglitz, 2012). The main objective of microfinance was to help the poor access credit. It was viewed that traditional banks were exploiting the poor that thus they could not access credit. The poor were left in productive investment and thus they remained poor. The original idea of microfinance was to provide the poor with credit without any collateral the aim of empowerment (Haldar & Stiglitz, 2012; Yunus 2007).

Sinclair, (2012) noted that the increased importance of microfinance as a development and poverty reduction tool has enabled industries towards financial self-sufficiency. Microfinance is more popular among the poor due to social capital involved in microfinance framework. The concept of Social capital has been used at several levels in microfinance literature (Olomola, 2002). The social capital as understood from microfinance perspective is the power that arises from one's network (Maclean, 2010). Microfinance and social capital became prominent in the 1990s. This was after World Bank used them to show more of the human side of development in a market-led development. This approach emphasized more on economic growth (Van Bastelaer and Leathers, 2006).

Social capital plays an important role in information asymmetric alleviation. This is from the fact that borrowers can use their social capital to overcome the problems associated with asymmetric information in credit markets (Gomez and Santor, 2001). Through microfinance, there is group screening during loan application and this ensures only credible borrowers passes the test. This enhances information sharing among the members and this improves social capital (Aryeetey, 2005). This is clear evidence that, microfinance enhances the level of social capital.

With the advent of microfinance and with increased social capital, more poor people are able to access finances. Actually, exclusion from social networks and institutions has been a defining feature of being poor in developing countries. Without access to networks, credit, information, insurance, social capital is low and it is hard to work one's way out of poverty (Fafchamps & Minten, 2001; Fafchamps & Lund 2003). With social capital, people are able to create mutual insurance mechanism in the communities where if a person has a problem, the community members come to his assistance. Those communities that are endowed with

strong social networks are in a stronger position to fight poverty as compared to communities where the social network is weak. With social networks, people are able to guarantee one another and they are able to access credit.

Social capital has been found to play part in improving the quality of life among the poor (Hamdan, Yusof & Marzukhi, 2014). People with low levels of social capital are not able to embrace financial inclusion. Youth have been found to be affected by this as most of them are at development stage in life and mostly, they have not developed networks with a high stock of value (Paaskesen & Angelow, 2015; Schaefer-McDaniel, 2004). This lack of strong network has an implication on the social capital of the youth.

A number of studies have indicated a positive relationship between social capital and economic well-being of the citizens. Hamdan *et al*., (2014) in his study noted high levels of social capital among the household's urban neighborhoods in Malaysia. The study found that social capital four dimensions were being influenced by neighborhoods if developed, the diversity composition of its people, locations, and the surrounding developments. This social capital helped in improving the quality of life. In Africa Balogun and Yusuf, (2011) carried a study in Nigeria on the effects of social capital on the welfare of rural households in the Southwestern Nigeria. The study confirmed social capital to have effects on financial investment. The study concluded that social capital played a key role in household welfare and poverty alleviation.

Here in Kenya, Kangogo, Lagat, and Ithinji (2013) carried out a study to ascertain the influence of social capital dimensions on households' participation and repayment performance in micro-credit groups in the study area. It was based on a sample of 174 households selected using a multistage sampling technique who were members of microfinance. The results on group financial performance using the Tobit model revealed that experience in-group borrowing, the number of visits by loan officers, peer pressure, meeting attendance index and heterogeneity index, which enhances social capital, positively and significantly influenced the performance. This clearly indicated the influence of membership to microfinance and effect on financial decision-making.

Another study in Kenya was by Mwangi and Ouma (2012). They carried a study to evaluate what role social capital could play in access to credit. The study revealed a positive relationship between social capital and access to credit. Thus, social capital enhances financial inclusion through increased access to informal loans. The higher the number of groups one pledges loyalty to, the higher the probability of accessing a loan.

Studies have clearly indicated that social capital has a positive relationship with economic well-being. It has also been confirmed that microfinance enhances social capital. However, it has never been fully documented on the interrelationship between social capital, microfinance and investment and thus the focus of this study.

METHODS

This study was guided by positivism philosophy, and descriptive survey research design was adopted as the research design. The probabilistic sampling design was used for this study to get the respondents. The main data of the study was primary data that was collected between December 2016 and February 2017 usinga structured questionnaire. Cronbach's alpha coefficient was used to confirm reliability where coefficient was, 0.803 and it was considered appropriate.

RESULTS AND DISCUSSIONS

Response rate and respondents characteristics

To undertake the study, four hundred and sixty-three (463) questionnaires were distributed. Four hundred and twenty (420) questionnaires were accurately filled and used for analys is representing 90.7% response rate. Of the sampled youth, only 13.1 percent indicated to be formally employed. On income levels, 18.7 percent of the respondents were found not to be earning anything whereas majority 30.1 percent indicated that they were earning less than Kshs 5,000 (49 US Dollars).The study found that the level of financial inclusion among the youth was high at 92 percent, where 30 percent were members of microfinance. The study also noted that only 47.3% had undertaken investment, Further, a majority of the youth financed their investments from own savings at 26.9 percent of the total population, followed by loans at 16.7 percent. However, a majority of the youths were not earning or earning very little, only less than half had undertaken some form of investment. This is against the fact that majority had access to financial services.

Relation between social capital and members of microfinance

A t-test to find out the whether there was any statistical difference in levels of social capital, between those who were members of microfinance, and those who were not members was done. The results are as indicated in Table 1.

Table 1: Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Social Capital	Equal variances assumed	1.504	0.221	-6.486	406	0	-1.301	0.2006
	Equal variances not assumed			-6.326	226.77	0	-1.301	0.2056

It was noted that there was a statistically significant difference in levels of social capital between members of microfinance and non-members with t = -6.486, degree of freedom = 406, p-value 0.000. This clearly indicates that those who were members of micro finance had higher levels of social capital. The magnitude of the differences in the means was moderate (eta squared=.094).

Relationship between Membership to Microfinance and investment among the youth in Kenya

The study tested whether Membership to Microfinance had any significant effect on investment on financially included youth. A test of the full model against a constant only model was statistically significant, indicating that the predictors as a set reliably distinguished between those who invested and those who did not invest (chi square =37.000, p =.000 with df =1).

The Wald criterion demonstrated that Membership to Microfinance was positively related to investment and statistically significant as indicated in Table 2.

Table 2: Binary Logistic Regression of Microfinance Membership and Investment

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	MFIMembership	1.349	0.229	34.553	1	0	1.852	2.457	6.04
	Constant	-0.509	0.122	17.311	1	0	0.601		

a. Variable(s) entered on step 1: MFI Membership.

The model the study was Logit of (Invest) = -.0.509 + (1.349) * Membership to Microfinance. The positive B coefficients for predictor variable indicated that increasing predictor variables score is associated with increased odds of investing. The Odds ratio expressed as Exp(B) column indicates the overall effect on dependent variable of increasing the predictor variables. From the results, Microfinance membership was statistically significant in predicting whether the level of social capital with the overall effect which was 34.553, df=1, p=.000. Thus, increase in membership to microfinance among the youth increases the probability of increasing social capital by 85.2%.

Relationship between Social Capital and investment among the youth in Kenya

The study tested whether Social Capital had any significant effect on investment on financially included youth. Wald statistic was used to test the significance of the predictor variable against the dependent variable. The binary logistic regression analysis results are shown in Table 3.

Table 3: Binary Logistic Regression of Overall Social Capital and Investment

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Social Capital	.433	.060	51.776	1	.000	1.542
	Constant	-.559	.124	20.159	1	.000	.572

a. Variable(s) entered on step 1: Social Capital.

The positive B coefficient for predictor variables indicated that increasing predictor variable score is associated with increased odds of investing. The Odds ratio expressed as Exp(B) column indicates the overall effect on dependent variable of increasing the predictor variables. From the results, Social Capital was statistically significant in predicting whether a youth will invest or not if provided with finances with the overall effect which was 51.776, df=1, p=.000. Thus, increase in Social Capital among the youth increases the probability of investing by 54.2%.

The Relationship between Social Capital and Investment on Financially Included Youth

On the relationship between social capital and investment, the results of the study indicated that social capital was positively related to investment. An increase in the level of social capital increases the probability of investing. On the other hand, it has been clearly indicated that being a member of a microfinance institution has a positive impact on the level of social capital. This nexus creates a great importance of microfinance in the economies.

Microfinance has been found to have a positive impact on investment due to the social capital effect on it. Youth who are in groups had a higher probability of investing compared to their peers who were not in groups.

Nguyen (2007) noted group participation in microfinance increased economic decision-making capability. Those in groups are better placed to undertake economic activities compared to their peers who are not in groups. Several activities occur during the scheduled meetings, including loan payments, group cash contribution, issuing new loans, training in group operations and the importance of group solidarity, and monitoring of loan repayment by all members. Thus those youth who belong to group benefits from this kind of information and they perform better in financial decision making including investment (Kangogo *et al*., 2013).

During group meetings in microfinance setups, members share ideas in the group, evaluate options and come up with investment decisions as a group. The decision-making skill gained from the group improves on social capital and again it is used for individual decision-making. Tabi (2009) as cited by Kangogo *et al*., (2013) noted that efficient and equitable groups are those that allow participation of members in the decision-making processes, as well as the sharing of benefits and costs. The decision-making process has benefits to the members of the group and even on their individual capacity.

FSD, (2014) on their study on indigenous financial concepts and practices and their implications for financial inclusion indicated that people become 'real friends' when they provide support to each other. In the study, banks loans were noted to catapult to the center of the respondent's social network. The study also noted that joining of savings groups and merry-go-rounds were also perceived to be uplifting members' economic status and thus they were placed at the heart of respondents' social network. This was from the fact that, being in a group enhances social capital of the members. According to FSD (2014), members indicated that saving in a group context which is the microfinance model, was much more effective than on an individual basis because of the social control that is there in a group setting. The members believed that they were expected to look after each other and to boost the well-being of all members. This kind of setup ensures that the members encourage each other to save and they check each other's financial requirement. Thus, due to the social network, the members of a group on average tend to perform better economically compared to those who do not belong to any group.

Success in business was also associated with social capital as indicated by Mbugua *et al*., (2013). The scholars studied factors affecting the growth of micro and small enterprises on tailoring and dressmaking enterprises in Eldoret. The study noted a relationship between social capital and success in business. Those in business for less than two years and thus have fewer networks and registered no growth accounted for 54.4% while those with more than five years and similarly registered no growth accounted for 53.3%. Those with less than two years in self-employment and were yet to establish their own market niche and had no regular customers could be an early sign of despair or business failure. The category that had 3-5 years in self-employment and wide network registered the highest growth rate of 66.7%. This was clear evidence of social capital and economic growth.

Another indication of social capital and growth was noted by Kangogo *et al.,* (2013). Their study noted a positive relationship between experiences in group borrowing from a microfinance setup which was measured by the number of years one has been participating in the group. The relationship was found to be significant at 1 percent level with a positive coefficient. This implies that the more a person participates in a group, the probability of the person borrowing for investment increases. The person is then able to benefit from credit

facilities for economic benefits. The increase of social capital, in this case, increases the probability of investing.

An empirical investigation on the effects of social capital on welfare of rural households in the Southwestern, Nigeria also confirmed social capital to have effects on financial investment (Balogun& Yusuf, 2011). The result of regression indicated that location, marital status, household size, primary occupation, cash contribution index and heterogeneity index of households significantly influenced the welfare. The study concluded that there is need to enhance social capital ties as this has an impact on poverty alleviation.

Finally, Balogun *et al.,* (2011) found a positive relationship between social capital and economic welfare. The study was to find out effects of social capital on poverty among households in South West States, Nigeria. The scholars carried out a multistage sampling technique. Two states, Ekiti and Osun were randomly selected from the six states in Southwestern Nigeria. Data was collected by use of structured questionnaire and analyzed using descriptive statistics, Foster-Greer-Thorbecke (FGT) weighted poverty indices and Tobit regression. The study noted that social capital significantly influenced the amount of credit available from different sources. The study concluded that social capital had a positive impact on the well-being of the household. They recommended that policy makers interested in improving the living conditions of households should consider promoting social capital in order to achieve the Millennium development goals of reducing poverty by half.

CONCLUSION AND RECOMMENDATION

The study has concluded that being a member of a microfinance institution has a positive effect on the level of social capital. The study also concludes that there is a positive relationship between social capital and investment, those with high levels of social capital were found to have a higher probability of investing. For there to be entrepreneurship for sustainable development and financial inclusion to achieve its objective, the level of social capital has to be improved and microfinance approach can be one of the methods. For financial inclusion to achieve its objectives, this study recommends that the government and other stakeholders should try to improve social capital among the youth to achieve sustainable development. Stakeholders who advocate for financial inclusion should use microfinance, as it will achieve two objectives at the same time; enhance financial inclusion and improve social capital. Since financial inclusion and social capital are complimentary on poverty reduction, there will be more investment and sustainable development.

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IMPLEMENTING LEAN STRATEGIES FOR IMPROVING THE DELIVERY OF HEALTHCARE SERVICES IN KENYA PUBLIC HOSPITALS

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Abstract

Lean management implies the use of lean tools for optimizing the delivery of diagnostic and treatment healthcare services to patients, and extends to offering quality services to dependents and practitioners at healthcare facilities. Lean management and associated strategies are derived from the manufacturing sectors, with origins from the Toyota Company. However, over the years, the strategies have been increasingly adopted in the hospital environment from improving healthcare processes, and optimizing use of resources, for instance, medical devices, doctors, or nursing staff. Public hospitals in Kenya, however, are yet to actively adopt lean management practices for identifying and eliminating wasteful clinical processes, hence negatively influencing healthcare delivery. The paper reviews lean management practices discussed in the literature with a view of evaluating lean tools and methods, and the extent to which the tools and methods are applicable for public healthcare facilities in Kenya.

Keywords: Lean management, Healthcare, Strategies, Public hospitals

INTRODUCTION

Lean management and associated strategies originated from Toyota Company with an aim to provide what the customer wants, quickly, efficiently, and with little waste (Womack & Jones, 2003). A manufacturing industry therefore becomes a lean organization by focusing on the customer needs by utilizing the available resources to reduce cost of production and achievingzero waste. According to (Slack *et al*.,, 2013) there are seven wastes in the industry which include; overproduction, queues, transportation, inventory, motion, over processing and defective products and similar waste occur in hospital too (Fillingham, 2006). This however, has not been linked directly to the provision of quality healthcare services but as stated by (Womack *et al*.,, , 2005) lean principles can work in healthcare as they work in industries to improve operational efficiency.

Globally public healthcare has faced challenges in rise of demand of primary health services but facilities and specialists are not growing at the same rate (Jin & Lim, 2013) implying hospitals should rely on lean management principles to deliver quality services by efficiently and effectively utilizing the available resources. (Donabedian, 1966) Suggest that quality of healthcare services should be based on structures, process and outcome. According to (WHO, 2000) the developing countries focus on structures and technology in trying to achieve quality health care services and forget the processes and patient outcomes thus the healthcare system ends up with misplaced priorities (Sundari, 2016).The government of Kenya in its health sector strategic and investment plan lines out key focus point which include; physical infrastructure, medical equipment, information and communication Technologies and transport (KHF, 2016). This shows the gap and the little efforts done in Kenya to improve clinical process and outcomes. (Hughes, 2008) Calls for researchers to evaluate which

quality improvement tools and strategies that work best for whom, and in what context, hence the need for evaluate lean tools which work best in Kenyan public healthcare context.

Consequences of failing to adopt lean healthcare in developing countries

In clinics and hospitals across Africa, long waiting time which is a non-added value activity has been linked to poor medication compliance, skipped appointments, delayed implementation of clinical programs, and low healthcare worker morale (Sastry & Long, 2014).Patients continue to get adverse medical outcomes, added cost, untimely services and reduced efficiency resulting from the complications of handling patient delays (Hall, 2008) ; (IOM, 2008).

Lean healthcare in developing countries

Lean management principles have been applied in service industry particularly in healthcare to redesign clinical processes in order to improve flow and reduce waste (David, 2007). As stated by (Ahlsrom, 2004) service delivery is better translated to lean operations but hospitals in many developing countries use regulations, standards from accreditation bodies and audits reports for quality improvement in delivering the healthcare services (Mate & Rooney, 2014) . Lean management aims at providing quality services even though it is constrained to only the needs of the patients', but the time spent to diagnose and treat the patient's depend on the conditions in terms of the severity and criticality which may lead to more waiting contrarily to the patient wants .

Lean tools and techniques in healthcare

Lean healthcare hospitals apply different lean strategies which include; mapping process flows, analyzing the performances of the system and lean improvement strategies to improve clinical processes (Hughes, 2008).

Process flow mapping

According to Backer (2002) and Crawford (2016) identification of the non added value activities are done through process flow mapping. Therefore, to understand the processes of the flows and the quality flaws in the chain care, mapping the operational processes is a key lean approach. Flow mapping can either be done by Value Stream Mapping (VSM) or Process Mapping (PM).PM and VSM as applied in lean healthcare have a similar objective, to improve the quality of the healthcare service by visualizing the patient flow (Alkhani 2015); Rother & Shook, 2003). These methods have been applied in the healthcare system to visualize the clinical process flow (Cima, 2011; Khurma, 2009 ; King, Tovim, & Bassham, 2006 and Langstrand, 2016). Patient expect to have a smooth flow in hospital as shown Fig 2.1 below, but the patient flow may usually have operational inefficiencies that need to be evaluated.

Figure 1 Patient Flow

Process Mapping

According to Slack *et a*l., (2013) process mapping is a method of identifying all types of activities that take place during a process, flow of people and information in the system. A process map can be in form of a flow chart or a swim lane. Flow charts graphically

represents a system by arranging steps sequentially or a process using process symbols and connecting them with arrow (Moore, 2004) but swim lane charts distinguishes capabilities, roles, and responsibilities for each sub-process in operational process workflows (Gyuchan *et al*., 2009). The flow charts are easy to construct and identify opportunities for improvement but swim lane charts gives a clear intuitive visualization than flow chart. Swim lane charts hence a more advantageous to use in Kenya public hospital so that every individual involved in the pathway can have a better visualization of their role and how their decisions affect the flow.

Value Stream Mapping

VSM is a method of analyzing what adds value to the customer from the raw materials, the processes and the information flow (Jansson, 2017). Chandra (2013) proposes that for value stream map to be complete, all processes are standardized hence need to calculate takt time.Takt time in healthcare may imply the rate at which patients are treated .However, it is hard to measure the pace at which patients are attended to due to private nature of patient time and lack of measurement criteria (Longman, 2012; Peabody *et al*., 2014). Although, using value stream mapping will identify opportunities for both wastes and improvement it includes much data such as set up time, lead times and takt time of every process and to get all this data is a challenge in public hospitals as stated by (Glaser, 2014).

Comparison of Value Stream Mapping and Process Mapping

VSM allows quantitative analysis of the flow processes from the supply of medical stock , information flow to the patient outcomes hence more useful for identifying bottlenecks and their effects on patient treatment time.VSM does not give a clear visualization on the role of the medical staff in the pathway rather, it is focused more on material and information flow.PM, on the other hand, shows the role of medical staff in the patient pathway but does not show how the medical resources are utilized ,the quantity outcomes of the flow like how many patients have been treated per day and the magnitude of flow inefficiencies. It is more qualitative and does not show how long each process takes place and as part of lean management, patient do not want to spend cost on non- added value activities . Flow mapping is necessary to understand the current flow and PM may be a better method to apply in Kenyan healthcare since the focus is more on improving the process than VSM which is geared to improve the throughput rate.

Key Performance Indicators for Analyzing Patient Process Flows

In what follows, after flow mapping is the main analysis of each Key Performance Indicator (KPI) and is performed separately, as well as analysis of combinatory studies (using more than one KPI) (Cayirli & Veral, 2003). KPI'S can be defined according to the nature of operations, and applicable in sectors such as finance, emergency care among others (Miyake 2016)., Jouini *et al*(2014) noted that KPI'S that dictate hospital performance are total length of stay (LOS), waiting time, equity and timely treatment. The deficiency of using KPI to the measure hospital performance will depend on the structured KPI by researchers or management but other factors which contribute to performance measurement may be overlooked.

The key performance indicators depends on the nature of analysis performed on the hospital operations. The analysis may include a bottleneck analysis and quantifying patient flow times

Bottleneck Analysis

Hall *et al*., (2006), suggest that for proper patient management flow efforts should be focused on minimizing waiting time, lean synchronization of patients process and resources by eliminating bottlenecks that limit system performance. Bottlenecks in healthcare can be quantified using a time or discrete event simulation.

Quantifying Patient Flow Time

Cayirli & Veral (2003), observed that patient flow-time is the total time a patient spends in a hospital, and short throughput times directly relate to high patient satisfaction (Gentry, 2008). Therefore it is necessary to evaluate the patient flow time in relation to patient wants. This can be achieved using *cycle time* and *Single Minute Exchange of Dies* (*SMED).*Cycle time is the time when patient arrives in the hospital until he exits (Chandra, 2013). SMED eliminates activities that prevent the system from achieving set productivity by reducing the set up time (Mark, 2017). Both approaches have been used in healthcare as used to analyze hospital performance as show in Harders et.al (2006); (Gentry, 2008) and (Khurma, 2009) studies. However, SMED is limited only to clinical processes which require set up or change over time like operating rooms hence cycle time is a better tool to use compared to SMED. However, patient flows are complex and time alone cannot be used measure efficiency but it gives opportunities to improve areas where patient spent a lot of time.

Discrete Event Simulation

DES has become a popular and effective decision-making tool for the optimization and analysis of patient flow, to improve service delivery as stated by Sheldon *et a*l., (2011) . It has been applied to analyze bottlenecks for smooth flow as shown in (Takakuwa & Wijewickrama, 2008) and (Choi & Jamjoom, 2013) studies but has rarely been discussed with lean approaches in healthcare context (Radnor *et a*l., 2012).It is easy to model current and future performances hence a very intuitive tool to analyze hospital performance even in complex patient . Also there are some drawbacks to DES that all situations cannot be captured in the models (Armony, Israelit, & Mandelbaum, 2015 ; Hall *et a*l., 2006). The main deficiency to this tool however ,is that it does not give optimal solutions to the problem rather it only gives the user to test the what if scenario hence left to the management to choose what fits them.

Lean Strategies for Improving Process Flows

In healthcare organizations, bottleneck are eliminated using lean strategies such as root cause analysis and process reengineering concepts for improving process flows .

Root cause analysis based improvement strategies

Slack *et al*., (2013) suggests that cause and effect diagram is a method that can be used extensively in health care for improving processes. .It may be applied as a tool for brainstorming especially for identifying the root causes and act as a guide on how to redesign the processes with available medical resources. It is a fast method of quickly identifying source of the problem asking what, when, where, how and the why questions

Fig 2. Example of a Cause and Effect Diagram

(Source; Institute for Healthcare Improvement (2004)

The deficiency of this tool is that, it does not monitor the performance criteria and which cause has the highest effect on the outcome hence is better used with *pareto charts* which involves arranging information on the causes of problems and helps in setting priorities on areas of decision making. Cause and effect diagram is also limited to medical staff opinions. Pareto chart has a limitation that priority should be given to highest cause of the problem.

Improvement strategies based on process re-engineering approach

Slack *et a*l.,(2013) suggest that changing a process can significantly reduce the time that is needed and restriction is on concepts that add value. Process reengineering focuses in the following improvement areas ;cost reduction, short throughput time, improvement of healthcare quality and job motivation to the staff (Hoorn & Schirvejes, 2012)..But, as Vonderembse *et a*l., (2004) suggests, key things to look at when redesigning a process are credibility of a service, responsiveness, effect of communication and understanding patient preferences. Redesigned processes, should always be patient centered as stated by (CPA, 2014) and aimed at decreasing patient waiting time and effectively utilizing available medical resources (IOM, 2001).

Fig 3 Factors to be considered when redesigning health care processes

Source: Centre for Policy Ageing (2014)

Redesigning the clinical pathway is therefore based on patient perceptive, but this tends to ignore the medical staff and it may face resistance when implementing the redesigned care pathway.

CONCLUSION

This paper discusses the concept of lean management as a strategy that should be adopted in public healthcare systems in Kenya to enhance quality of healthcare services since according

to existing literature; focus has been on technology and structures. The Kenya public hospitals may apply PM to visualize patient flows but combine with quantitative techniques such as time and simulation to analyze bottlenecks. Thereafter use lean strategies to improve clinical process using process re-engineering and root cause analysis approaches.

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WEIGHTED VOTING IN COFFEE COOPERATIVES TO ENSURE MANAGEMENT COMMITMENT

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Abstract

A cooperative society is an autonomous association of persons united voluntarily to meet their common economic, social and cultural needs and aspirations through jointly owned and democratically run enterprises. Cooperatives are formed by members when the market place fails to provide the needed goods and services of acceptable quality at affordable prices. Many of cooperatives in Africa have faced decline in performance since 1980s as a result of the structural Adjustment programmes championed by the World Bank and the International Monetary Fund. In Kenya the programmes saw the government withdraw its influence and controls of the cooperatives. In Kenya the coffee cooperatives suffered a double tragedy; besides the ill-timed liberalization, the International Quota System that ensured stable coffee prices collapsed leading to very low prices. This led to decline in coffee production from 138000 tonnes in 1987 to 38000 tonnes in 2009. The entrepreneurs and innovators need to come up with a way of helping bring the cooperatives sector to its past glory. To help recover from the decline the cooperative management need an environment that is conducive - management of cooperatives is one area that needs improvement. Studies carried out in the cooperatives show a lot of management incompetence and general lack of suitability. This article highlights how weighted voting could be used to improve the management commitment to the cooperatives. It has two objectives; to assess the importance of management in cooperative societies and to evaluate the applicability of weighted voting to improve the quality of management of coffee cooperative societies. The study was conducted in Muthithi Coffee Farmers' cooperative society in Murang'a County, Kenya. It was concluded that weighted voting would improve the management commitment in the coffee cooperatives.

Keywords: Weighted voting, cooperative, dictator, dummy, Banzhaf index

INTRODUCTION

This section highlights literature done by earlier authors in the areas of cooperative management and weighted voting systems. It has been found that in Kenya weighted voting has not been studied much.

Cooperative Society

A cooperative society is an autonomous association of persons united voluntarily to meet their common economic, social and cultural needs and aspirations through jointly owned and democratically run enterprises, (Ortmann and King, 2007). A cooperative is a user–owned, user controlled and user benefitted organization, (Komo and Gamba, 2002). Cooperatives are guided by seven principles; open and voluntary membership, democratic member control, members' economic participation, autonomy and independence, provision of education, training and information, cooperation among cooperatives and concern for the community. In 1987 the United States Department of Agriculture, (USDA) adopted three principles of; User ownership, user control and user benefit. Cooperatives are formed by members when the market place fails to provide the needed goods and services of acceptable quality at affordable prices, (NCBA, 2005). About 1 billion people are engaged in cooperatives as

members and workers, (Njuguna, 2012). The development of cooperatives is shaped by various factors and influences, (Groves, 1989). These influences range from economic conditions (such as technology, government policy), farmers' organizations (such as quality of leadership, power to influence policy) and public policy. Agricultural cooperatives are important as they provide credit to members or facilitate the credit, they provide farm inputs and offer extension, (Njuguna, 2012).

Performance of Kenya Cooperative Societies

One way of classifying cooperatives is the agricultural and non-agricultural. In Kenya agricultural cooperatives play a major role in production, primary processing and marketing of commodities. Their primary objective is to promote economic interest and general welfare of the members, (Komo & Gamba, 2002). The cooperatives in Africa have faced decline in performance since 1980s as a result of the Structural Adjustment Programmes (SAPs) championed by the World Bank and the International Monetary Fund. In Kenya the programmes saw the government withdraw its influence and controls of the cooperatives – this wasn't well timed and led to decline in cooperative movement's performance. Besides the SAPs, Africa cooperatives have failed due to failure of holding management accountable to members, (Akwabi – Amenyaw, 1997). Cooperatives suffer due to the fact that ownership and control are separate, (Cook, 1995). Cooperative societies' coffee production has declined due to price fluctuations, mismanagement and reducing acreage, (Kimathi, 2015). Such organizations experience principal – agent problem where the interests of the principal (owner/shareholder/cooperator) compete with those of the agent (management), (Cook, 1995). Cooperatives also face disadvantage in that they don't have equity markets where the value of the company can be gauged which may also be sued to determine the performance of the manager, (Royer, 1995).

In Kenya the coffee cooperatives suffered a double tragedy; besides the ill-timed liberalization, the International Quota System that ensured stable prices collapsed leading to very low prices. This led to decline in coffee production from 138, 000 tonnes in 1987 to 38, and 000 tonnes in 2009. The decline between 1988 and 1998 was over 50% - During this period, the decline in the coffee cooperatives production was 61%. Some coffee cooperatives closed shop and others split. Coffee cooperatives are marred with mismanagement and corrupt practices that compromise service delivery, (Njuguna, 2012). The cooperatives are corrupt outfits exhibiting gross mismanagement, (Mude, 2006). The corruption is partly due to withdrawal of the government hand in the last two decades, (Gitu, 2012). Lack of good governance in the cooperatives contributes to the dismal performance, (Gitu, 2012). The liberalization of the coffee sector led to the nuisance of corruption, nepotism and tribalism that has led to the poor performance of the coffee cooperative sector in Kenya, (Karanja and Nyoro, 2005). It is not uncommon to find a management committee employing a manager who is not qualified but who belongs to family, (Nyangito, 2002).

The management of the coffee cooperatives needs to be given to the right people who, besides ability to run the outfits, also have interest in the development of the cooperatives. The cooperatives' challenges highlighted above could be mitigated, even if only partly, by having the right people in management. The reviewed studies carried out on cooperatives have not revealed any study that looked into how to ensure members productivity is considered in decision making. This paper proposes to ensure management commitment by giving the members of cooperatives who give more business to the cooperative more decision making power through weighted voting.

Weighted Voting Systems

In ordinary voting, democracy demands one man one vote practice – and this is democracy. A vote is important if it has the probability of changing the outcome of the election, (Gelman *et al*, 2002). In Kenya cooperative societies 'each member shall have one vote only in the affairs of the society irrespective of the number of shares he holds', (Kenya law - Cooperative societies act, 2004). The current practice favours equal representation where every person votes once, (Fishkin, 2012). In the diverse society that we live in it is natural that things are not equal. One person one vote doctrine is not democratic as people want it perceived, (Fishkin, 2012). Weighted voting is a situation where different votes are given different weights depending on the power that they possess. Weighted voting is a formal voting arrangement in which voters are not necessarily equal in terms of the number of votes they control. A known example is America presidential voting system; 'Each state shall appoint a number of electors equal to the whole number of the senators and representatives to which the state may be entitled to', (US constitution, article II, section 1). Other scenarios where weighted voting occurs are for example shareholder elections, the UN Security Council and the European Union Council of Ministers.

In weighted voting voters are referred to as players. 'Weight' is the number of votes that a player controls given a certain criteria. A 'quota' is the number of votes that are required to pass a motion.

These are denoted as;

$$(Q: P_1, P_2, P_3, P_{4,\ldots\ldots} P_n)$$

Where Q is the quota; P1, P_2, P_3, P_4 are the weights of voters 1, 2, 3 and 4 respectively and P_n is the weight of voter n

The quota must be big enough to avoid tallying of YES and NO vote; if they tally this leads to a situation called mathematical anarchy. If there are three voters each with four votes and the other one has 8 votes, if the first two vote together and the quota is 8 votes then mathematical anarchy occurs. In this case the quota should be set at least 9 votes. If the quota is set too high such that even if all the voters vote in affirmative the quota will not be reached then this leads to a mathematical gridlock. In weighted voting, a player may have a weight greater than the quota such that he can pass the vote alone; such is said to be a dictator. A dummy is a voter with no power or say and his vote is irrelevant. A voter who is not a dictator in a situation where the motion cannot pass without his vote is said to have veto power. A coalition is a group of players that join forces to work (vote) together. A critical player is the one who has to be present for the coalition to win. A grand coalition is a set of all players working together. A player is critical if it has to be present in a coalition for it to win.

Banzhaf power index

This is proportional to the number of coalitions for which a player is critical. It is an indicator of how important a player is in the voting, (Banzhaf III, 1965)

Objectives of the study

The objective of this study was to assess the importance of management in cooperative societies and evaluate the applicability of weighted voting to improve the quality of management of coffee cooperative societies.

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METHODS

This study was conducted in three months starting from January to March. It involved Muthithi Farmers Cooperative Society in Kigumo Sub-county, Murang'a County. Data was collected using three tools; a structured questionnaire, interviews and observation. Both primary and secondary data were used in the study. Secondary data was mainly the production statistics. The study then used descriptive statistics namely, mean, mode, median, standard deviation, percentages and frequency tables.

Population and sample

The population involved all the 4000 farmers of Muthithi Farmers Cooperative Society Limited. A sample of 88 farmers was selected using multistage sampling. Stratified sampling was used where three strata were identified as Gatune factory, Kamugi factory and Njora factory. Simple random sampling was then used to select farmers from each stratum.

Sampling

Since the population was low, then the fisher et al, (2003) formula was used.

The Fisher formula is as follows:

$$n = \frac{z^2 p(1-p)}{d^2}$$

Where;

n= sample size

z= the standard normal deviate value for the level of confidence - 95% level of confidence =1.96.

d= margin of error or level of precision at 0.1 for CI at 90%

p= proportion to be estimated, Israel (2009) recommends that if you don't know the value of p then you should assume p=0.5

Therefore, sample size is arrived at as follows:

$$n = \frac{(1.96^2)(0.5)(1-0.5)}{(0.1)^2}$$

$$n = 96$$

Since the population is less 10,000, the sample size is further adjusted as follows:

$n_0 = n/ (1+ ((n -1)/ N))$

$n_0=96/ (1+ ((96 -1)/1052))$

$n_0=88$

RESULTS AND DISCUSSION

The cooperative society has three factories with a total of 4000 active members. The farmers interviewed included 17 female respondents and 71 males. They were all over 18 years old as required by the law. The production data showed that the range of the coffee produced per household was quite wide. This is shown in the table below;

Table 1: **Statistical values of coffee production (kgs) in the sample**

STATISTIC	**VALUE**
	225.7435464
S.D.	
AVERAGE	114.8
MINIMUM	1
MAXIMUM	1458

The respondents were asked to state the major challenges starting with the most severe. An analysis of the challenges gave the following results. It is evident that management and prices are the most challenging; most respondents claimed that management was lacking in the cooperatives and the prices were low.

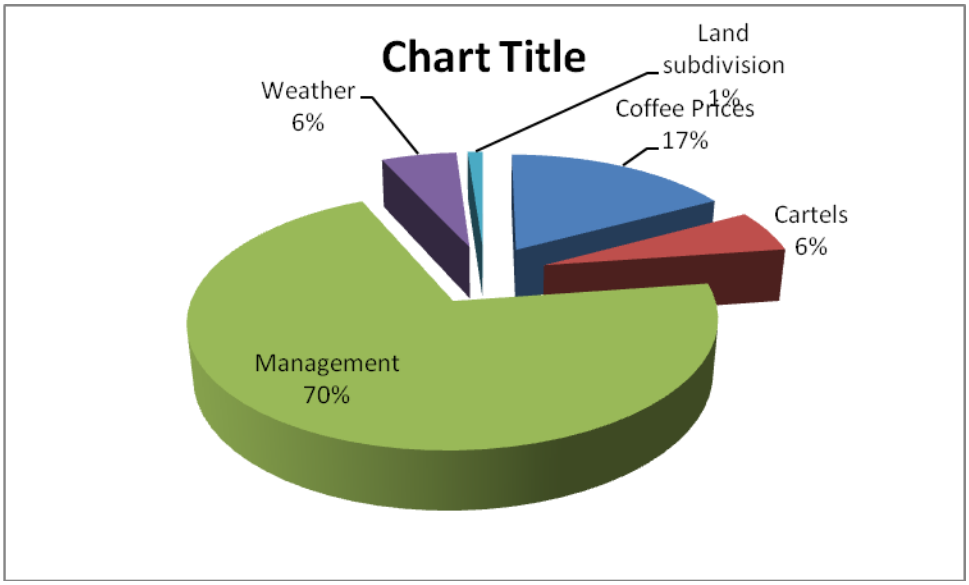

Figure 3.1 Main problems faced by coffee cooperative societies

All respondents were aware of the five important decisions that they were engaged in through presentations, discussions and voting. These were miller contract, marketing agent contract, external auditor contract, executive committee office bearers and the management committee bearers. All claimed that the voting is always done through balloting that is not secret (members are asked to raise their hands). The respondents were then asked to rate their agreement with coffee production based voting where those with high coffee production would have more say; the results were as follows.

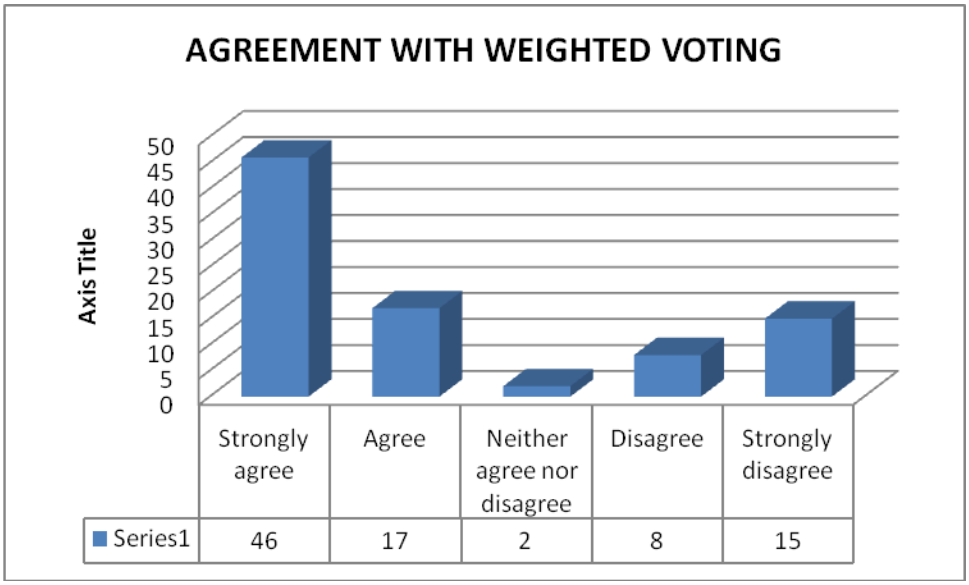

Figure 3.2 Respondents agreement with weighted voting

Table 2: Production per farmer

ANNUAL PRODUCTION (Kgs of cherry)	FREQUENCY (No of farmers)
1.0 - 50.0	54
51.0 - 100.0	13
101 - 500	18
501 - 1000	1
1000 - 1500	2

It is evident that majority (61%) of the respondents are low producers of coffee. They produce less than 50 kilograms of cherry per year. This is low given that it requires 7 kgs of cherry to make 1 kg of clean coffee that is offered for sale. Given the payout rate was Kshs 45 per kg of cherry in 2016/2017 season, it follows that the farmer in 0 – 50 kgs category would pocket only 1,125 per year.

Discussion on Voting Patterns

If the sampled farmers were to be engaged in a voting activity, where a simple majority wins, then the farmers producing less than 50 kgs would win regardless of what the higher producers would want *(see table 2).* A coalition formed by the low producers (most likely those who do not practice good agronomics) could sweep all motions. If the quota is raised from simple majority to 75% then 66 farmers would be required to pass a motion – Still the low producers could have their way since they would only require an additional 12 members from the producer of 51 – 100 kgs. The implication of this is that the hard working farmers who are likely to be highest producers would be dummies in the decision making activities in the society. Even if the quota were to be raised to 90%, still the high produces would be dummies. This would need to be mitigated through amendment of the articles of the cooperative to ensure that although the highest producers do not become dictators, they have their veto power. If the articles favour the high producers then some low producers would be made to be dummies.

Illustration

From table 2; the quota Q is simple majority (this would be 44 + 1 = 45). This is expressed as;

(Q; P_1, P_2, P_3, P_4, P_5) or

(45; 54, 13, 18, 1, 2)

It is evident that the low players P_1 and P_2 would have their way whether quota is simple majority or upper three quarters. The two are able to front their own leaders who are also likely to be low producers and vote for them against the wishes of the high producers.

Banzhaf power index

This is proportional to the number of coalitions for which a player is critical. This is calculated using a quota rule of 75%.

Table 3; Table of weighted votes

COALITIONS	CRITICAL PLAYER
P1 + P2	P1, P2
P1 + P3	P1 , P3
P1 + P2 + P 4	P1, P2
P1 + P2 + P3 + P4	P1, P2, P3
P1 + P2 + P4 + P5	P1, P2, P3
P1 + P2 + P3	P1, P2, P3
P1 + P2 + P3 + P5	P1, P2, P3
P1 +P2 + P5	P1, P2
P1 + P3 + P5	P1, P3

The Banzahf power index is

P1 = 9/22 = 41%

P2 = 7/22 = 32%

P3 = 6/22 = 27%

P4 = 0%

P5 = 0%

It is further evident that, despite the fact that P4 and P5 are the highest producers, their Banzhaf power index is zero meaning they are dummies. That is how below average motions are passed quickly by people with low or no interest of the cooperative.

Table 4; Table of weighted votes

ANNUAL PRODUCTION	MEDIAN (D)	FREQUENCY (F)	WEIGHT (FD)
1.0 - 50	25	54	1350

51 - 100	75	13	975
101 - 500	250	18	4500
501 - 100	750	1	750
1000 - 1500	1250	2	2500
TOTAL	**2350**	**88**	**10075**

In the table 4 above, the one man one vote has been amended by weighting it with the median of each class. This gives the high producers a higher weight than the low producer. In the resulting scenario the simple majority would be 10075/2 = 5038.The low producer would not be able to pass their leaders through the vote. They would require coalition with P_2 and another player to attain the required quota. They have about 26% of the required quota unlike before when they had exceeded the quota. If voting for critical leadership for example the supervisory committee member, then this would be raised to 75% making it a must for the low producer to involve $P_1 - p_4$.

Table 5; Calculation of Banzhaf power index of the weighted votes;

COALITIONS	**CRITICAL PLAYER**
P1 + P2 +P3 + P4	P1, P2, P3, P4
P1 + P2 + P3 + P5	P3, P5
P2 + P3 + P 4 + P5	P3, P5
P1 + P3 + P5	P1, P3, P5
P3 + P4 + P5	P3, P4, P5
P2+ P3 + P5	P2, P3, P5
P1 + P2 + P3 + P4 + P5	P3, P5

P1 = 2/19 = 10.5%

P2 = 2/19 = 10.5%

P3 = 7/19 = 36.8%

P4 = 2/19 = 10.5%

P5 = 6/19 = 31.6%

After weighting, the power is slightly more evenly distributed. The players with low production have lesser weight hence less influence in the voting. Every player has the chance to influence the vote.

CONCLUSION

'One man one vote system' is not appropriate for the coffee cooperatives as members who minimally participate in cooperative activities may unite and elect a leader with no much interest in the cooperative. The weighted voting will evidently lead to better decisions in voting. Specifically the leaders voted in will have the say of the cooperators who give the cooperative society a lot of business – this is as required by the principle of 'economic participation of members'. This system will be of great benefit to the coffee cooperatives that have been suffering from leadership issues.

Since the quality produced by different factories of the same cooperative society are different then additional weighting should be based on quality (Devonshire classes 1 – 10) where class 1 has more weight than class 10. A factory with 1 kg of class 1 coffee may have same power as a factory with 10 kgs of class 10 coffees or another with 5 kgs of class 5 coffees.

Further research should look into 'considering quality of the coffee in the process of weighting'. The production per tree should also be considered in weighting.

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ASSESSMENT OF THE EFFICIENCY OF FARM RECORD KEEPING IN KENYA: A CASE STUDY OF FARMERS IN CHERANGANI WARD, TRANS-NZOIA EAST SUB - COUNTY, KENYA

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Abstract

The use of farm records in the farm by farmers assists to continuously monitor farming enterprise and activities. Proper recordings are very essential for analysis and to carry out improvement of the enterprises and counter check losses and increase profits. The main objective of this study was to assess the efficiency and use of farm record keeping by farmers in Cherangani ward in Trans Nzoia East Sub-county, Kenya. The Specific objectives of the study were: To determine farm records keeping practices by the farmers, to assess level of effectiveness of the farm record keeping by farmers and to establish the utility of farm records to improve farming enterprises by the farmers in Trans Nzoia County, Kenya. The target population in the county was 15,000 farmers. The study used a systematic sampling technique to pick 50 farmers from each of the five locations in Cherangani ward of Tans Nzoia East sub-county that formed the 250 required sample size. The study used structured questionnaire to collect data which was analyzed using frequencies. Results established that 32% of the farmers had records but not efficiently used in the farms, while 68% farmers had no records, majority of the farmers (79%) were male, 54% were within the age bracket of 36-45 years, 61% practiced crop farming, 12% farmers kept or use physical records, 8% used the records for profitability analysis and 34% used the records for generating information useful in effective production. The study concluded that farmers in Trans Nzoia county did not keep effective nor used farm records efficiently which are a pre-requisite to modern commercialized farming in agricultural enterprise.

Keywords: Farm record keeping, farmers, farming

INTRODUCTION

Farming is not just a way of life but a business (DAEO, 2012) and should be operated under sound economic principles in order to be successful (Winkler, 2008). In many world agricultural nations, the farm business has to take account the unique combination of labor, land, capital and management particularly that of knowledge in order to meet the nation's goals and objectives (Wiig, 1997). It's important also to note that farming organizations or individual farmers have to be high performers in order to meet their objectives (Abel, 2000). In Kenya the Agricultural sector is the backbone of its' economy (DAO, 2013). It directly contributes 20% of the GDP and 60% of the export earnings (DAO, 2011). A further 27% is contributed through its links with manufacturing, distribution and service related sectors (GoK, 2010). This has been specified in its Strategy for Revitalizing Agriculture policy paper targeting improved farming system and methods like use of proper farm record, best agricultural practices etc (GoK, 2004).

Farm records are written facts or events for latter use or reference, (FMG, 2013). It can also be the art as well as the science of recording in books business transactions in a regular and

systematic manner (Kayode, 2002). Such include financial records that are readily available at any time of the year for use in monitoring and evaluation of enterprises (FMG, 2014). It furnishes farm owners and managers with written facts or history of the business transaction with special reference to its financial side (Armstrong, 2002). Worldwide, farm records are kept by farmers to aid farm business analysis and assist them know how enterprises are performing (Carlson, 1988), whether on profit or loss (FMG, 2012).

METHODS AND MATERIALS

The main objective of this study was to assess the efficiency and use of farm records keeping by farmers. The research design used was an exploratory case study approach which was adopted as it was appropriate for collecting both primary and secondary data necessary to accomplish the tasks set out in the study. The design describes the phenomenon, examines actions as they are or as they happen rather than manipulation of variables. The population in the Sub-county was 189,367 persons in the two wards of Kaplamai and Cherangani with average farm size of 2.05 Ha, and a rural house hold of 15,351.

Sampling Design and Procedure

The research was conducted in Cherangani ward with five locations namely; Cherangani, Milimani, Chepsiro, Suwerwa and Kiptoror Locations. The ward has a population of 15,000 farmers. The sampling design used was systematic random sampling. From the 15,000 farmers in locations, the researcher randomly sampled 50 farmers from each location totaling to 250 which was a fair representative sample. These farmers were visited in their farms as per the random sampling technique and asked various questions using a structured questionnaire. Their responses were recorded down for each individual farmer then summarized. Among the data collected from the farmers include; age, gender educational level of the person and the number of enterprises and types of records kept among others.

Data Analysis

Data from the various instruments, transcripts and schedules were validated, edited and then coded appropriately. Data analysis was then performed using both quantitative and qualitative techniques. Quantitative data was analyzed using the Statistical Package for Social Sciences (SPSS) to produce mean scores, frequencies and percentages. Percentages are the most widely used and understood standard proportions. The analyzed data was then presented using tables, charts and graphs accompanied by appropriate descriptions or explanations. Besides that, qualitative data which would not be quantified such as personal opinions were analyzed as guided by objectives of study whereby they were narrated or even quoted and where appropriate were incorporated into the recommendations of the study.

RESULTS AND DISCUSSIONS

Demographic information

Gender distribution of the farmers (Table 1) established that majority of the farmers, an average of 79% in the ward were male compared to 21% who were female. Suwerwa had the highest males (86%) and lowest female (14%), while Chepsiro had the lowest males (68%)

and highest female (32%) in the ward. This means that farming in ward was male dominated a fact complicated by cultural instigated land ownership which was 100% male owned.

Table 1: Gender Distribution of the Farmers

Location	Male	Female	Total
Cherangani	42	8	50
Milimani	38	12	50
Chepsiro	34	16	50
Suwerwa	43	7	50
Kiptoror	41	9	50
Average	40	10	50

The age distribution of the farmers (Table 2) established that over half of the farmers (54%) had average age of 27 and were within the age bracket of 36-45 years followed by those with above 45 years (32%), 26-35 years (12%) and below 25 years (2%). This finding indicated that in the ward, farming was a reserve for the people who were already advancing in their ages and that the youth were not at all involved in farming. This was because cultural practices barred the youth from owning land. Such therefore made the aging people to hold on land for a long time, denying the youth an opportunity to practice farming.

Table 2: Age distribution of Farmers

Location	<25 Years	26-35 years	36-45 years	above 45 years	Total
Cherangani	2	7	21	20	50
Militnani	0	3	31	16	50
Chepsiro	3	9	28	10	50
Suwerwa	0	7	36	7	50
Kiptoror	0	5	19	26	50
Average	1	6	27	16	50

Source: Field Data (2015)

The results on types of farming practiced by the farmers (Table 3) showed that majority of the farmers 61% practiced crop farming compared to 24% who practiced livestock farming and 15% who practiced mixed farming. The area highest on; crops was Milimani (82%), livestock was Chepsiro (40%) and mixed was Kiptoror (26%). This finding showed that the majority of the farmers were dependent on crop farming which is a risk factor in food considering environmental un-certainties.

Table 3: Type of farming practiced by farmers

Location	Crops	Livestock	Mixed	Total
Cherangani	38	7	5	50
Milimani	41	7	2	50
Chepsiro	21	20	9	50
Suwerwa	34	9	7	50
Kiptoror	19	18	13	50
Average	31	12	7	50

Source: field data (2015)

Records kept by farmers.

Results on **records kept by farmers** (Table 4) show that 68% of the farmers did not keep any records at all, 23% kept between 1-2 types of records, 6% kept between 3-4 types of farm records and 3% kept more than 4 types of records in the ward. The area with highest record keeping was Cherangani (40%) and the least was Kiptoror (20%).

Table 4: Records Kept by Farmers

Location	0 record	1-2 records	3-4 records	> 4 records	Total
Cherangani	30	13	4	3	50
Milimani	33	11	5	1	50
Chepsiro	36	10	4	0	50
Suwerwa	31	16	1	2	50
Kiptoror	40	7	2	1	50
Average	**34**	**11**	**3**	**1**	**50**

Source: field Data (2015)

The low level of keeping farm records can confirm that they did not have information or knowledge sources for making critical farm decisions. This elutes the fact that farm decision they made on the farming were erratic and not based on scientific facts that modern commercialized farming requires as envisaged by (Osburn and Schneeberger, 1983).

Effective use of records kept by farmers

Effective use of farm records (Table 5 below) was low with only 12% farmers kept and used physical records. The area with highest effectiveness in records kept and used being Chepsiro (94%) and lowest in Milimani (30%). This showed that many farmers in the ward did not keep and use physical records which are very crucial in monitoring and evaluating farm production levels.

Table 5: Physical Records Kept and used by farmers

Location	Maps	Land use	Production	Labor	Machinery	Total
Cherangani	0	5	19	3	1	28
Milimani	1	4	7	2	1	15
Chepsiro	0	1	23	2	21	47
Suwerwa	3	7	18	6	2	36
Kiptoror	0	6	22	7	2	37
Average	1	5	18	4	5	33

Financial records kept by farmers (Table 6) were 44% in the ward. The area with highest financial records was Kiptoror (100%) and least was in both Cherangani and Milimani (24%) respectively. This showed that most farmers did not keep financial records which are very crucial in monitoring and evaluating farm production levels. The study therefore confirms that the level of farm records keeping by the farmers was not effectively in use.

Table 6: Financial Records Kept by farmers

Location	Inventory	AC	Cash	Financial	Total
Cherangani	9	1	2	0	12
Milimani	2	0	9	1	12
Chepsiro	15	1	8	0	24
Suwerwa	3	2	5	4	14
Kiptoror	25	9	13	3	50

Average	11	3	7	2	22

The Utility challenges faced by farmers for effective records keeping and use.

Results show that 30% of the farmers who kept some of the physical and financial records used them compared to 70% who did not use the records. This shows that although the farmers in the ward kept some sort of records, they did not use them for the intended decision making process to enhance production, which is a crucial tool in enterprise farming and precision farming as also outlaid by (Backmore, *et., al*., 2006). In the ward, 34% of farmers used the records for generating information useful in effective production compared to 66% who did not. 19% used the records for gathering marketing intelligence compared to 81% who did not. 12% used the records for hatching competitive edge over other farmers compared to 88% who did not. 8% used the records for profitability analysis compared to 92% who did not and 7% of the farmers used the records for intelligence sourcing compared to 93% who did not. This finding showed that the farmers in the ward did not use the records for important applications such as: competitive edge over competitor, profitability analysis, intelligence sourcing, gathering market intelligence information for increased production as out by (Grant, 1991).

Challenges faced by farmers for effective records keeping and use.

Farmers in the ward faced many challenges in adapting effective records keeping in enterprise farming. These include; 56% of them faced lack of adequate knowledge in record keeping, 32% were engraved in poor farming cultures which did not recognize records keeping and 12% lacked tools for effective records keeping. Records' keeping in farming and enterprise setup is the key to modern commercialized farming and is very important in all sapphires of effective and profitable farming.

CONCLUSIONS

It is concluded that farming in Trans-Nzoia East sub-County was male dominated and advanced in age, land ownership by only for male. Majority of the farmers were dependent on crop farming, kept some farm records for monitoring and evaluating farm production, although do not use them efficiently as a decision making tool for enterprise improvement and farming.

Farmers faced challenges in adapting record keeping in their farming businesses thereby leading to ineffective and inefficient farm record keeping and use thereby hindered them from knowing whether their enterprise /farming practices was profitable.

Recommendation

It is recommended that farmers be trained on keeping and use of farm records as a farm management tool to improve farm enterprises as well as commercialize farming as it will

enhance effective and efficient use thereby gearing enterprise production towards farming as a business.

The Ministry of Agriculture to start farmers field schools, where they will be reached as a group to address issues on agriculture like, keeping proper farm records as a management tool in production to avoid making losses and endeavor on the enterprises that bring profit.

There is need to carry out a comparative study on the same topic in other sub-counties in the country in order to obtain a comparative information that can add more weight to the findings of this study.

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THE RELEVANCE AND EFFICACY OF BUSINESS INCUBATION CENTRES ON BUSINESS START-UPS: A CASE OF KENYA INDUSTRIAL ESTATES, NAIROBI, KENYA.

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Abstract
Small and large businesses play a vital role to the economic growth and development of any country. For them to flourish, they must exist in a favorable environment with access to entrepreneur finance and culture, market and office space. In this regard, Business Incubators tend to be effective on providing a condusive environment for start-up growth and development. The main aim of this study is to determine the relevance and efficacy of business incubation centers on business starters in Kenya. The researcher endeavored to employ an exploratory research design, targeting a population of ten (10) business incubator managers and fifty (50) incubates at Kenya Industrial Estates. These formed the sample by employing simple random sampling technique. Data was collected using structured questionnaire and analyzed through percentages. The study established that business incubators play a key role on start-up, growth and development through training, financing, offering office space and support in technology and market research. The recommendation arrived indicated that entrepreneurs with viable business ideas but lack the required resources for the implementation should make wise use of the incubation centers for support and training for relevant skills. The researcher therefore concluded that even with the services provided by the incubation centers, some entrepreneurs are not still registering in their business with taxation adversely affecting their profit margins and lack of entrepreneurship leadership skills leading to high employee turnover.

Keywords: Incubation, Business Start-ups, Business growth, Business environment, Training

INTRODUCTION

According to Diogenes business incubator (2011), (University of Cyprus); business incubation is a unique and highly flexible combination of business development, process, infrastructure and people designed to nurture new and small business by helping them to survive and grow through the difficult and vulnerable early stages of development. The business dictionary defines a business startup as an early stage in the life cycle of an enterprise where the entrepreneur moves from the idea stage to securing financing, laying down the basic structure of the business and initiating operations or trading.

Business incubation provide business startups with the nurturing environment needed to develop and grow their businesses, offering everything from virtual support rent – a – desk through to state of the art laboratories and everything in between. They provide direct access to hands of intensive business support, access to finance and experts and to other entrepreneurs and suppliers to really help businesses and entrepreneurs to grow. Incubators provide a nurturing, instructive and supportive environment for entrepreneurs during the critical stages of starting up a new business.

The role of incubators is to increase a chance that a start- up will succeed and shorten the time and reduce the cost of establishing and growing a business. If successful, business incubators can help to nurture the companies that will form the true creators of regions or nation's future wealth and entrepreneurs. They serve as a launching pad for young and small

business start- ups which are innately dynamic. Entities need access to support and incubators are means of providing this.

According to Kenya bureau of statistics report 2015, it has been realized that about 60% of businesses either fails at start up or during their development stages. This has been a stumbling block to traditional businesses and uprising entrepreneurs due to lack of nurturing the vibrant business ideas until they take off competition and marketing. In order to deal with this setback and ensure successful business development, business incubators have come to limelight to at least solve these issues by supporting entrepreneurs and start- ups technology based enterprises in the development, assimilation, absorption and utilization of requisite technology to accelerate their successful development. It brings all necessary ingredients or resources including raw materials, human resource training and market support and conducive environment for doing business. These are all directed to the achievement of millennium development goal of vision 2030 under the economic development agenda.

Business incubation has been there for several decades but has gained momentum in recent years. Throughout its history it has been applied to a variety of industries and contexts necessitating constant adaptation. Incubator nurtures a business through its "childhood" by offering support services and resources such as network, finance, office space and mentorship to local startup businesses. Their core objectives being offering these services towards creation of jobs, developing entrepreneurship, growing a particular industry, retaining business and economic diversification all within a particular locale or community.

NESTA (2011) did a review of the impact of business on new ventures with high growth potential. The main purpose was to identify models of incubation that have the greatest impact on the mission of building high growth, innovative firms using a report based on a review of the academic business literature with additions from industry reports. They found that incubators often have a very mixed revenue stream and incentives as a result they strongly attract/encourage peer-to –peer networking, address multiple needs of new ventures without prioritizing just one and offer continual exposure to the incubation and services. Incubators influence new firms by:

- ✓ Lending credibility through association and through shared (and therefore affordable) access to professional facilities and identifiable and flexible incubation space.
- ✓ Offering business support and coaching which are often subsidized e.g. strategic insights, market research e.t.c
- ✓ Providing access to additional resources and talents e.g. finance and legal help.

Thus, business incubator is a valuable tool as part of entrepreneurial support infrastructure. Incubators deliver the most value when to respond and adapt to the new needs of new ventures.

Kinoti (2011) evaluated entrepreneurs' perception of business incubation services in Kenya. The main purpose of the study was to answer the question; "are there any discrepancies between the entrepreneurs perception of the importance of the business incubation process (training business support, facilities, and infrastructure, networking and monitoring and after care services) with how they perceive the services to be rendered?" He compared perceptions of 124 entrepreneurs and found out that significant relationships exist between the mean ratings of entrepreneurs' perceptions of the importance of the business incubation process with how they perceive the services to be rendered and actually received less than they anticipated.

Nicola Dee, David Gill, Robert Lacher, FinbarrLivesey and Tim Minshall (2012), did a research on role and effectiveness of business incubation on high growth startups. The main aim was to provide an overview of current knowledge on the role and effectiveness of business incubation in supporting the development with high growth potential. Using a

literature review on regional innovation they found out universities are often highlighted as influencing many aspects of innovation activities, including support for new and growing ventures. (Rothohild and Darr, 2005 ; Ratinho and Henriques, 2010) . Universities and other research institutions may be able to offer incubates access to advanced technology laboratories , equipment and other research and other technical resources , but also offer access to "talent 'such as faculty , staff and students. However the accessibility of university's resources is likely to be influenced by the entrepreneurial orientation and support structures of the university and region. The incubator building and facilities can themselves be valued by entrepreneurs, especially if designed for business incubation (UKBI 2009) shared facilities enable incubates to use professional facilities without the burden of being wholly responsible for their cost. They also found out that typical incubator services and resources reflect the needs of the entrepreneurial process for example: strategic input to the business model access to resources including capital, organizational and recruitment support to build the productive and commercial base, access to technical facilities , advice on capturing value from innovation through intellectual property rights , and so on these services can be delivered in varying degrees of quality and intensity. The incubator also acts as a mediator between the entrepreneur and networks.

International journal of scientific and engineering research volume 3 (2012)-on incubation of micro and small enterprises – an approach to local economic development examined the importance of incubators for establishment of micro and small enterprises. They found out that incubators are available in various types rendering a range of long and short term assistance and they help in establishment of new enterprises in one way or the other by providing guidance, technical assistance and consulting to entrepreneurs and offer business development services. ICT incubators being a major example where clients access appropriate rental space, shared basic business services and equipment. Other incubators assist only developing new ideas and arrange for venture capital funding. These findings contribute positively in establishing the importance of business incubators on business startups.

International Journal of Education and Research (Vol.1 No 8 2013) –relationship between entrepreneurship training on the growth of the enterprise . The aim of the study was to determine the effect of entrepreneurship training on the entrepreneurial development in Kenya. Using a random sampling of 1670 legally registered SMEs in Githuguri market it found out that entrepreneurs were able to do simple book keeping of business transactions but were not to do complex financial statements. This made that though the entrepreneur may be reporting an increase in Sales and profits and may seem to be registering growth, lack of training on financial, strategic manage4ment and marketing will mean that the SMEs will not grow beyond the first stage of enterprise development to other stages and will hence eventually fail within its first five years of existence. These findings are relevant in establishing the role played by business incubators on business startups.

Looking at the role of incubators in entrepreneurial process, Wiggins and Gibson (2003) argued that incubators must do five things well in order to succeed (i) establish clear matrices for success, (ii) provide entrepreneurial leadership, (iii) develop and deliver value-added services to member companies,(iv) develop a rational new company selection process and (v) ensure the member companies gain access to necessary human and financial resources.

Joshua *et al*.,.(2010). Researched on the state of business systems in different countries (Lessons for Uganda) part of their purpose was to assess the contribution of the incubators to startup firms by review of relevant publications, workshop reports and discussions of stakeholders a case study of Uganda. The study found out that successful entrepreneurs and viable business ideas come from all sources from universities, corporations and the

grassroots. Hence business incubators can contribute to stimulating more entrepreneurs to pursue their dreams of creating their own company. These findings relate positively to the influence and role played by business incubators on business startups.

Miemie Struwing and Abel Meru (2011) did a research on the relationship between business environment and business incubation. The main purpose of the study was to establish whether the business environment has a relationship with business incubation to see whether the controlled environment within which the incubator operates eliminates the influence of business environment. Using two models, they found out that the internal factors including incubators vision, mission, values and goals, functions and policies, culture, management styles and ethics as well as the incubator resources had a positive impact on business development within the incubator. The external factors such as customer and technological factors were favorable and adversely affected by political/legal issues, economic forces, socio-cultural factors and demographic factors.

The International Journal of scientific and Engineering Research (2012) examined incubation of micro and small enterprises using an approach to local economic development and came up with the following types of business incubators. Non-profit and for profit incubators are the main types; each with objectives and targets.

Table 1. Business incubators

	Local economic Development	Academic and scientific	Corporate	Private investor
Goal	Non-profit	Non-profit	For profit	For profit
Main activity	Generalists	High-tech	High-tech	High-tech
Objectives	✓ Job creation ✓ Re-industrialization ✓ Economic development ✓ Support to particular target group of industries ✓ Development of SMEs and clusters	✓ Commercialization of technologies ✓ Development of entrepreneurial spirit ✓ Civic responsibility ✓ Image ✓ New sources of finance	✓ Development of entrepreneurial spirit among employees ✓ Keep talents ✓ Monitoring ✓ Access to new technologies, business models and new markets.	✓ Profits by selling stock from portfolio companies allowing risks to be shared
Targets	✓ Small commercial craft service companies ✓ In some cases high-tech companies	✓ Projects internal to institutions prior to company creation ✓ External projects	✓ Internal and external projects generally related to the activity of the company	✓ Technological startups, generally ICT and/or biotechnology related.

According to this journal, incubators are now set in areas of ICT,food processing,light engineering, health care technologies, packaging, ceramics technologies, arts and crafts, product design and knowledge management. Many of which provide an opportunity to first

generation entrepreneurs to acquire skills for enterprise building and also incubating them to successful small business owners.

Conceptual framework

Independent Variable Dependent variable

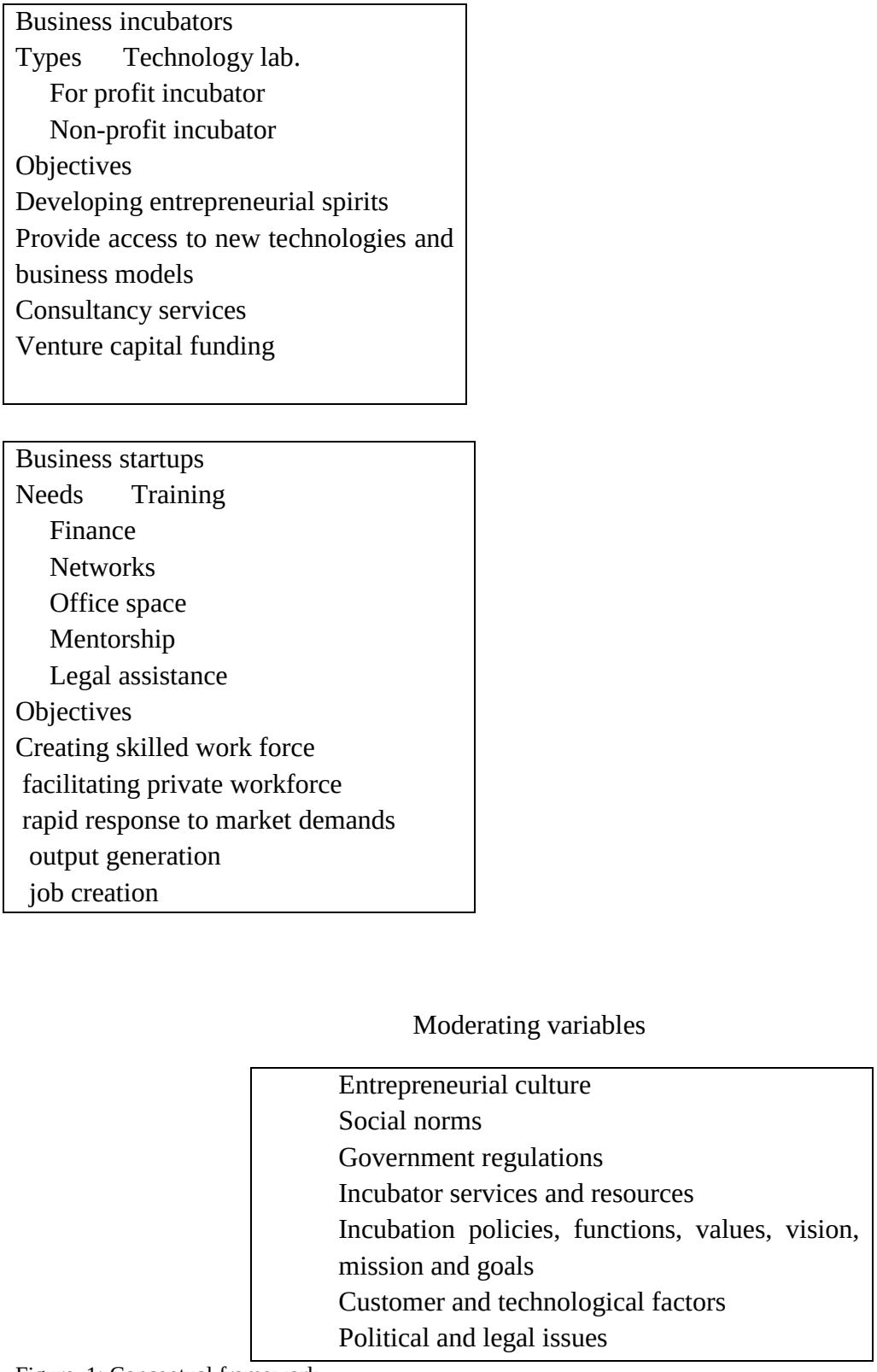

Figure. 1: Conceptual framework

Figure1 clearly explains that small business owners should incubate their business ideas to take advantage of the services offered by business incubators including financing, networking, market support, space for business location and business planning. This will spearhead their success and development in terms of advancement in technology, expansion in market share, growth in revenue and gain of business independence. Both the incubation

centers and entrepreneurs should be aware of the environmental factors that affect their performance including government regulations, economic factors and cultural factors.

The objectives of this research paper are: To determine the influence of business incubation on business startups growth, to identify the role of business incubators on business startup success, and to determine the most appropriate business incubation model for startup development In accomplishing the objectives of the study, it is focused to determine how business incubation will effectively improve the development of business startups. The research will concentrate only in Kenya Industrial Estates (KIE) head office in Nairobi with the aim of its findings representing other business incubator in Kenya.

METHODS

A case study of Kenya Industrial Estates (KIE) main branch was used because it is an incubation center and provided deeper insights of the impact of the incubation centers on business startups. Entrepreneurs are direct beneficiaries of the incubation models and systems and are better placed to give out more information on how the centers have impacted on and the role they play on their idea/startup development. The management of KIE Main branch, Nairobi was able to offer information on how they are able to influence business startups and on how to incubate and whether they are able to meet the needs and expectations of their incubates.

The target population involved in this paper was. Managers, grandaunts and those still under incubation from KIE because they are the main customers and were better placed to give all needed information on the impact of incubation centers and how they have been able to achieve customer satisfaction.

Random sampling technique was employed by using fifty incubates (both grandaunts and those still under incubation) and ten managers from the Incubation Centre. The center has many customers and thus it was inappropriate to employ a census design. It was impossible also to meet and interview every client and thus randomly sampled fifty entrepreneurs from the centre and ten managers from Centre was appropriate for this research paper.

Primary and secondary sources of data and information collection were useful. The data was collected using survey method where sixty copies of questionnaire forms were issued to enable the researcher to acquire required information from the target population. Two sets of questionnaires were issued, one set for incubated entrepreneurs and the other set for Centre managers. Visitations were made to the center to observe how the small business owners were trained and mentored on incubation and, also interrogated them to find out some of the challenges they face. The collected data was presented inform of tables to enable the users of the research to easily comprehend it, and percentages were used to analyze the findings.

RESULTS AND DISCUSSIONS

A total of sixty questionnaire forms were sent out and at the end of the data collection period, a total of fourth eight questionnaire forms had been returned. This constitutes 80% response rate. Out of the sixty questionnaire copies, fifty were sent out to business incubates who returned fourth questionnaire copies representing 80% response rate of the business incubates. The other ten were sent out to business incubation managers who returned eight questionnaire copies comprising of 80% of the response rate.

Table 2. Response rate

Questionnaires	Number of copies administered	Number Returned	% Rate
Business Incubates	50	40	80
Incubation Managers	10	8	80
Total	60	48	

Table 2. shows that majority respondents were the business incubates. This is in line with the fact that entrepreneurs are the majority in the incubation centers while those who are employees with the incubation centers are few.

Influence of Incubation centers on business startups

The study sought to determine the impact of business incubation centers on business startups and the respondent were therefore asked to indicate **YES/NO** on the questions asked regarding the impact of incubation on startups.

Table 3. Influence of Incubation centers on business startups

Particulars	% Agree (Yes)	% Disagree (No)
Access to leading credibility	90	5
Access to business support	80	20
Access to coaching	100	0
Access to market research	80	20
Access to legal help	100	0
Access to financial & technology support	90	10
Those who sought financial support	75	25
Those who sought training	5	95
Those who sought to create jobs	5	95
Those who sought technological support	5	95
Those who sought growth and development	10	90
Those who valued the incubation as good	70	30
Those who valued the incubation as fair	30	70

Table 3, Indicates that the incubation center provided all services examined in the questionnaire including training, business and financial support, after care services legal support, technology and market support and research. All the businesses operate on a legal

base since all the 40 incubates 100% received legal support. 36 respondents (90%) were able to access lending credibility while 2 respondents did not yet receive any lending support. 2 respondents (5%) indicated that they were funding themselves.

All the respondents (100%) went through business couching, those who received support in market research were 32 respondents (80%) and that did not receive an support were 8 respondents (20%).it is also clear that different firms had different objectives when they incubated their businesses with majority having an objective of seeking financial support i.e.30 participants (75%). Those who wanted to get training were only 2 participants (5%), those had objective of creating jobs were 2 respondents (5%) and those who wanted to technological support and growth and development were 2 participants (5%) and 4 respondents (10%) respectfully.

It was also established that the number of years the incubate can take in the incubation is determined by the size and type of the firm. Manufacturing and service industries stayed in the incubation for more than 10 years. The objectives of the firm also determined the firms stay at the incubation center after the accomplishment of which the firm would quit

The role played by business incubators has great impact on the growth of business startups. Business incubators impacts business startup through the services they offer.

Table 4. Role of business incubation center

Types of industry	Manufacturing	Processing	Service	Others
Rental space	60%	30%	5%	5%
Technical assistance	100%	100%	75%	50%
Entrepreneurial training and coaching	100	100	75	50
Venture capital funding	100	100	75	50
Facilities and infrastructure	100	100	75	50

From Table 4. Manufacturing firms received rental space within the center and all other roles played by the center (100% service administration). 12 out of 40 incubates were processing industries and received rental space together with administration of other services. Only 2 incubates were service and 2 incubates were art and craft industries and received 75% and 50% service delivery respectfully.

Types of business incubators appropriate for business startups:

Table 4. Indicates that majority of incubates are manufacturing (60%) and processing (30%) industries. Service and other incubates are few within a local economic development incubation center, .this means that these type of center is best suitable for manufacturing and processing business startups. It was also established that incubator objectives lays down a clear matrix for them to ensure success for incubates. Business incubator targets range from government projects, projects internal to the institution prior to company formation, technological startups and craft service companies.

CONCLUSION

The study concluded that even with the services provided by incubation center some business did not register growth with taxation adversely affecting their profit margins and lack of entrepreneurial leadership skills which lead to high labor turnover. Given the variety of business incubator strategies, business models and stakeholders, there is no standard measure for accessing incubators performance.

Incubation does not always lead to better outcomes for incubates but the process can help shield incubators from competitive forces of the external environment and increase the likelihood of long-term survival. The process too can weaken a firm's ability to compete and survive when graduating out of the incubator. Managers therefore have to establish clear strategy matrices to balance the environmental factors that affect the services of the incubation centers.

It was also concluded that the Kenya government's encouragement of indigenous entrepreneurship among its rural population could be helpful by marketing of entrepreneurial development programs. The county's level of entrepreneurial activity and consequent economic prosperity can be enhanced by establishing more incubation centers to avail entrepreneurial training and coaching towards startup growth and development.

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AN EVALUATION OF REWARD SYSTEMS AND EMPLOYEE SATISFACTION IN NYERI COUNTY REFERRAL HOSPITAL IN KENYA

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Abstract

The objective of this study was to assess the effect of various reward systems on employee satisfaction in the Nyeri County Referral Hospital. This is because the public health sector service delivery has been less than satisfactory for the last couple of years. The specific objectives were to evaluate the impact of extrinsic, intrinsic and social rewards on employee satisfaction. Research design was stratified random sampling and duration-wise, cross-sectional approach was adopted. Self-administered questionnaires were issued to doctors, clinical officers and nurses in the Hospital. The target population for this study was the 284 medical staffs, consisting of doctors, clinical officers and nurses, from the Hospital. The sample size consisted of 85 respondents. Bivariate and multiple linear regression analyses were done to establish the nature and significance of relationships between independent and the dependent variables in the study.

The results indicated that when extrinsic, intrinsic and social rewards were combined, they had a positive and significant effect on employee satisfaction. The study recommends that the Hospital should strengthen all the rewards as there was a weak relationship between them and employee satisfaction. Specifically, more attention should be paid to the extrinsic rewards due to their dismal contribution to the employee satisfaction. For further research, this study recommends that future researchers should focus on combinations of other factors that affect employee satisfaction, sources of employee satisfaction and the challenges faced during implementation of various reward systems in the Hospital. Lastly, further studies should investigate ways of giving the employee satisfaction process a head-start.

Keywords: Rewards systems, employee satisfaction, extrinsic rewards, intrinsic rewards, social rewards.

INTRODUCTION

The Constitution of Kenya provides for the right to the highest attainable standard of health for every Kenyan. This mandate is implemented by the government of the day. The government does this through having the rightly qualified personnel in the health sector, rewarding them and ensuring that they are adequately motivated and satisfied to perform their respective duties. But between the promise of the constitution and the reality on the ground, there is a big gap. This is because the employees are not satisfied and hence the un-ending industrial disputes.

According to Gerald and Dorothee (2004), employee satisfaction and smooth running of an organization are directly and positively affected by the rewards provided by the organization. Employee satisfaction is manifested in positive attitudes that employees exhibit towards their jobs as a result of a complex mixture of factors within and even without the organization. According to Silbert (2005), giving rewards to employees enhances their feeling that they are valued. Additionally, according to Hay Group (2007), rewards and recognition are major factors influencing employee's decision to either stay with or quit an organization.

There are several types of rewards that an employer can use to attract, retain and motivate their employees. According to Dailey and Kirk (1992), these employee rewards are categorized into three main classes which are the extrinsic, intrinsic and the social rewards. These rewards are provided as per the rewards system in place. According to Armstrong (2010), a reward system is an aspect of reward administration that comprises of policy guidelines, activities, and procedures that provide direction on ways of rewarding the employees of an organization. Pratheepkanth (2011) pointed out that it is important that an

organization has a reward system that it can use to direct the employees' energies towards a particular strategic goal.

One of the theories used in this study was the expectancy theory. According to Robbins (2003), expectancy theory refers to the intensity and appeal of employee's hope of a positive and attractive outcome out of an engagement with the employer. Ramasodi (2010) acknowledged that job satisfaction is an issue of utmost importance in healthcare sector as its presence leads to better performance. Additionally, Wubuli (2009) noted that performance of organizations depends on how satisfied their employees are. Thus if health care workers are satisfied they will be more dedicated to caring for patients and this will ultimately lead to good performance which is wanting in the public health sector.

Scheffler (2010) stated that health care systems in most countries in the world were not doing well. Mwanzia (2013) wrote in KPMG (2013) that in Africa, the health sector is undergoing major restructuring and that the process has been less than smooth. The MOH (2011) further indicated that little funding is available to pay salaries, finance day to day operations hence provision of health services is less than satisfactory. The Kenyan daily nation (Dec 2015), reported that a whole 12 per cent of all patients in Nyeri County did not receive services they sought from hospitals. Nyeri County Referral Hospital (NCRH), where this research was carried out has not been left out in the unending employee grievances being experienced in Kenya due to poor working conditions and inadequacy in rewards. This study thus aimed at investigating the effect of various reward systems on employee satisfaction in the NCRH.

METHODS

Sampling and sample size

The research adopted a case study design, which assured me of getting a rounded view of the situation under study, (Selltiz, *et al* 1959). The target population was 285 medical staffs (22 doctors, 28 clinical officers and 235 nurses) working in the hospital. Stratified random sampling was used to select samples for the study from three strata (doctors, clinical officers and nurses). The doctor stratum consisted of the specialists and the general practitioners. The clinical officers' stratum consisted of the senior clinical officers and the ordinary clinical officers.

The nurses' stratum consisted of the registered nurses and the enrolled nurses. A representative sample for each stratum was calculated at 30% of the target population thus giving sample size as shown in Table 1.

Table 1: Population and Sample Size

Categories of Employees	Target Population	Sample Size
Doctors	22	7
Clinical officers	28	8
Nurses	235	70
Total	285	85

Data Collection

The study collected primary data using a self-administered questionnaire. A pilot test of the data collection instrument was undertaken in the Mukurwe-ini District Hospital. The decision to pilot the data collection instrument away from NCRH was informed by the fact that the medical staffs, especially doctors, were few and closely knit and piloting in the same hospital would have negatively affected the target population where an attitude study was concerned.

Data Analysis

Data obtained from the questionnaire was coded and analyzed using descriptive and inferential statistics using the Statistical Package for Social Scientists (SPSS) software. Descriptive analysis involved calculation of the means as well as standard deviations while inferential statistics was used to identify the nature and significance of relationships by use of bivariate and multiple linear regression coefficients. The bivariate model used for the three reward systems was:

$$Y_i=\beta_{0i}+\beta_i X_i+\varepsilon$$

Where Y_i = employee satisfaction

β_{0i} = constant amount of satisfaction independent of reward

X_i = reward type

β_i = the regression coefficient of the particular reward.

ε = the error term.

Multiple linear regression analysis was used to calculate the regression (β) coefficients for each reward system. Kothari (2014) indicated that multiple linear regression analysis is done when there is one dependent variable, which is influenced by many independent variables. The multiple linear regression equation used was:

$$Y=\beta_0+\beta_1X_1+\beta_2X_2+ \beta_3X_3+\varepsilon$$

Where,

Y = employee satisfaction

β_0 = constant amount of satisfaction that is independent rewards

X_1, X_2 and X_3 = extrinsic, intrinsic and social rewards respectively.

β_1, β_2 and β_3 = the regression coefficients of extrinsic, intrinsic and social rewards respectively.

ε = the error term. The error term represents employee satisfaction due to other factors that were not being investigated in the study.

RESULTS AND DISCUSSION

Identification of types of rewards awarded to employees

The research first sought to establish whether health workers in NCRH were aware of the rewards (extrinsic, intrinsic and social) offered by the hospital. This is in line with the expectancy theory of motivation where knowledge of the expected reward is necessary for an employee to be motivated, (Robbins, 2003). Findings of the study showed that respondents were aware of various benefits received from the hospital which may affect their level of satisfaction.

Table 2: Employees knowledge of types of rewards available in NCRH

Reward Type	SD (%)	D (%)	U (%)	A (%)	SA (%)	Total (%)	Mean	Std. Dev.
Skill-based pay	6.8	18.1	18.1	43.1	13.9	100	3.389	1.145
Payment by result	18.1	37.5	36.1	2.7	5.6	100	2.403	1.002
Base rate pay	2.8	12.5	8.3	16.7	59.7	100	4.181	1.191
Employees benefits	4.2	13.8	12.5	66.7	2.8	100	3.500	0.919
Recognition	9.6	18.1	65.3	5.6	1.4	100	2.708	0.777
Feed back	5.5	15.3	13.9	61.1	4.2	100	3.431	0.990
Promotion	2.7	30.6	59.7	5.6	1.4	100	2.722	0.676
Work-life balance	1.4	8.3	15.3	58.3	16.7	100	3.806	0.870
Reputation	1.4	2.7	18.1	65.3	12.5	100	3.847	0.725
Acceptance	4.2	6.9	25.0	55.6	8.3	100	3.569	0.901

SD=Strongly Disagree D=Disagree U=Uncertain A=Agree SA=Strongly Agree

Skilled based pay

According to Ledford and Heneman (2011), skill based pay is a reward offered to a worker after formal certification of extra skills, knowledge and competencies. Its emphasis is on skills and knowledge necessary for a firm's production processes and what employees are expected to do to prove that they have them. Results obtained showed that 57.0 % of the respondents agreed that the hospital had skill based pay while 18.1% were uncertain with a mean score of 3.389 and a standard deviation of 1.145 (Table 2). In this regard NCRH has specified rates for all medical staffs that have a variety of skills, knowledge and competencies in various aspects.

Payment by result

Armstrong (2010) stated that payment by results is given to employees depending on the items or units produced or the duration taken in working. This form of reward assumes that if an employee is offered monetary rewards for a job well done, their performance will be better. Responses showed that 55.6% disagreed that NCRH offered payment by result, 36.1% were uncertain while 8.3% agreed with a mean score of 2.403 and a standard deviation of 1.002. This scheme has a demerit due to its tendency to reward quantity and hence quality can be compromised. In a hospital setup medical staff are expected to apply due diligence in all cases and hence this explains the lack of payment by result reward in the hospital.

Base Rate Pay

According to Paauwe and Boselie (2005), basic pay is the non-variable monetary compensation given to a worker for performing their specific tasks. Results indicated that 76.4% of the respondents agreed that NCRH had a base rate pay, 15.3% disagreed while 8.3% were uncertain with a mean score of 4.181 and a standard deviation of 1.191.

Employee Benefits

Results indicated that 69.5% of the respondents indicated that NCRH offered employee benefits with a mean score of 3.500 and a standard deviation of 0.919. Armstrong (2010) defines benefits as rewards of many forms given to employees above the cash pay. According to the author, benefits encompass retirement schemes, security provision, favourable loans, personal effects, transport to and from work, car fuel and other rewards which raise the living standard of employees.

Employee recognition

According to Cho *et al*., (2006) recognition creates a feeling of importance and uniqueness in a person. The authors add that this reward mainly operates in people occupying higher cadres and positions in the organization, such as managers and supervisors. Data obtained showed

that 65.3% of the respondents were uncertain of their recognition as employees with a mean score of 2.708 and a standard deviation of 0.777.

Promotion

Promotion may be viewed as an important career advancement to an employee (Sageer, *et al*., 2012) for it gives, promises and brings more pay, status, position and autonomy. Naveed *et al* (2011) states that promotion leads to increased satisfaction. Results obtained indicated that 33.3% of the respondents stated that there were no promotions in NCRH with a mean score of 2.722 and a standard deviation of 0.676. Moreover, 59.7 % of the respondents were uncertain about existence of promotions.

Work life balance

It was recorded that majority of the respondents agreed that they were comfortable with work-life balance at NCRH with 75.0%, a mean score of 3.806 and a standard deviation of 0.870. Clark (2000) defines work–life balance as the measure of how well employees are able to perform their duties at workplace and also fulfilling their family roles. Most medical staffs in NCRH indicated that they were able to balance the two aspects of their lives.

Reputation

Reputation is summed up as perceptions made by stakeholders of what an organization stands for and the accompanying associations (Chun, 2005). It was established that 77.8% agreed that NCRH was a reputable organization with a mean score of 3.847 and a standard deviation of 0.725. They thus considered that working at NCRH which as a reputable organization had a great impact on their job satisfaction.

Acceptance

According to Hayes *et al* (1996), acceptance involves treating with respect even when one is aware of their weaknesses. At least 63.9% of the respondents indicated that they felt accepted in NCRH with a mean score of 3.569 and a standard deviation of 0.901. This implied that NCRH employees treated each other with respect and dignity regardless of their position and they accepted the hospital as the workplace of choice in spite of its challenges.

Effect of extrinsic rewards on employee Satisfaction at NCRH

The study sought to evaluate impact of various extrinsic rewards (skill based pay, payment by result, base rate pay and employee benefits) on employee satisfaction at NCRH.

Table 3: Rating of extrinsic rewards on employee satisfaction at NCRH

Extrinsic Reward	N	Minimum	Maximum	Mean	Std. Deviation
Skill based pay	72	1.00	5.00	4.181	1.191
Payment by result	72	1.00	5.00	2.708	.777
Base rate pay	72	1.00	5.00	3.389	1.145
Employee benefits	72	1.00	5.00	2.722	.676
Valid N (list-wise)	**72**				

Results obtained showed that skill-based pay was highest rated with a mean score of 4.181 and the lowest rated was employee benefits with a mean score of 2.722 (Table 3).

Table 4: Determination of effect of Extrinsic Rewards on Employee Satisfaction

Model	Un-standardized Coefficients	Standardized Coefficients		
	Std. Error	Beta	T	Sig.

1	(Constant)	2.594	.643		4.035	.000
	Extrinsic rewards	.201	.196	.123	1.028	.307

a. Dependent Variable: Employee satisfaction

From the regression analysis, it was established that extrinsic variables had a positive but insignificant effect on employee satisfaction. The bivariate model showed that there was an employee satisfaction of 2.594 that was independent of extrinsic rewards (Table 4).

Effect of Intrinsic Rewards on Employee Satisfaction at NCRH

The study sought to evaluate impact of various intrinsic rewards (recognition, promotion, feedback and work-life balance) on employee satisfaction at NCRH.

Table 5: Rating of intrinsic rewards on employee satisfaction at NCRH

Intrinsic Reward	N	Minimum	Maximum	Mean	Std. Deviation
Recognition	72	1.00	5.00	3.431	.991
Promotions	72	1.00	5.00	2.403	1.002
Feed back	72	1.00	4.00	2.278	.736
Work-life balance	72	1.00	5.00	2.722	.676
Valid N (list-wise)	72				

Results obtained indicated that employee recognition was highly rated with a mean score of 3.431 and a standard deviation of 0.991 (Table 5). Employee promotions had a low mean of 2.403 and a standard deviation of 1.002. Since employee job satisfaction was positively influenced by the prospect of a promotion it is thus critical for NCRH to consider staff promotions in order to enhance their satisfaction. Results presented in Table 5 show that feedback had the lowest mean score of 2.278 and a standard deviation of 0.736. Work-life balance had a mean score of 2.722 and a standard deviation of 0.676 which implied that most employees agreed that there was existence of work-life balance in the hospital hence increased satisfaction.

Relationship between Intrinsic Rewards and Employee Satisfaction

The study sought to determine the relationship between intrinsic rewards and employee satisfaction. Using a bivariate model it established that intrinsic rewards had a positive and significant effect on employee satisfaction (Table 6).

Table 6: Determination of effect of intrinsic Rewards on Employee Satisfaction

Model		Un-standardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.737	.498		3.492	.001
	Intrinsic rewards	.559	.181	.349	3.095	.003

a. Dependent Variable: Employee satisfaction

The bivariate model showed that employee satisfaction there had a constant value of 1.737 that was independent of intrinsic rewards. There was also a part of satisfaction that depended on intrinsic rewards for which a unit change in intrinsic rewards led to a .559 change in employee satisfaction.

Effect of Social Rewards on Employee Satisfaction at NCRH

According to Anantha *et al* (2013), social rewards emanate out of employees' interactions in the course of doing their job and include supportive and healthy relationships among colleagues. Results obtained indicated that acceptance of the organization recorded highest mean score of 3.903 which meant that respondents had a positive attitude with NCRH as their workplace (Table 7).

Table 7: Rating of social rewards on employee satisfaction at NCRH

Social Reward	N	Min.	Max.	Mean	Std. Dev.
Reputation among workmates	72	1.00	4.00	2.319	.766
Reputation of the organization	72	1.00	5.00	2.444	.803
Acceptance by colleagues	72	1.00	5.00	3.861	.678
Acceptance of the organization	72	1.00	5.00	3.903	.715
Valid N (list-wise)	72				

This was followed by acceptance by colleagues which recorded a mean of 3.861 which implied that respondents treasured one another as colleagues which is commendable for any healthy work environment. Reputation among workmates recorded a mean score of 2.319 while reputation of the organization had a mean score of 2.444. These results align with similar results obtained by Alniacik *et al* (2011) that showed that organizational reputation had a direct correlation with job satisfaction.

A determination of relationship of social rewards on employee satisfaction using a bivariate analysis showed that social rewards had a positive and significant effect on employee satisfaction(Table 8).

Table 8: Determination of effect of Social Rewards on Employee Satisfaction

Model		Un-standardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.131	.712		.184	.855
	Social rewards	.994	.225	.469	4.412	.000

a. Dependent Variable: Employee satisfaction

The model indicated that there was an initial employee satisfaction of .131 though insignificant that was independent of social rewards. There was also a part of satisfaction that depended on social rewards for which a unit change in social rewards led to a .994 change in employee satisfaction. This is a strong relationship which indicates the hospital had done quite well in that aspect.

Combined Effect of Reward Systems on Employee Satisfaction

According to the Kenya Institute of Management (2009), it is important to test not only the extent to which the independent variables influence the dependent variable individually but also their combined affect. A regression analysis showed that all variables affected each other and the regression coefficients are as shown in Table 9.

Table 9: Regression Coefficients of Independent Variables and Employee Satisfaction

Model	Un-standardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.

1	Constant	-.030	.819		-.037	.971
	Extrinsic rewards	.078	.188	-.048	-.418	.025
	Intrinsic rewards	.332	.195	.207	1.703	.009
	Social rewards	.841	.246	.397	3.421	.001

Dependent Variable: Employee satisfaction

Predictors: Constant, extrinsic rewards, intrinsic rewards and social rewards

Results of the regression model (Table 9) indicated that extrinsic rewards had a positive and significant effect on employee satisfaction when combined with other variables. The intrinsic rewards showed a positive and significant effect on employee satisfaction when combined with other variables. This was an indication that employees working with NCRH were relatively satisfied with most of the intrinsic rewards though not all.

According to Jeffrey and Shaffer (2007) extrinsic rewards are effective because they are visible and thus their value is higher than other rewards.

Social rewards were found to have positive and significant effect on employee satisfaction. This implies that employees working in NCRH were relatively satisfied with the social rewards such as reputation of the organization and acceptance by colleagues. This is in line with argument by Evetts (2006) that good reputation influences professionalism in a major way, enhances self esteem and employee motivation hence it's an important part of rewards to employees.

CONCLUSION

This study established that medical staffs in NCRH were not adequately satisfied with extrinsic rewards which affected their job satisfaction and performance negatively. It is worth noting that, though the study revealed that NCRH medical staffs were dissatisfied with the extrinsic rewards, this was mainly due to their absence or inadequacy. Particularly, the study established that NCRH payments were not result based. The study also revealed that the relationship between intrinsic rewards and employee job satisfaction was not satisfactory and thus had a dismal effect on their job satisfaction. However, there was a relatively strong relationship between social rewards and employee satisfaction in the NCRH. For instance, the medical staff indicated that they could comfortably balance work and family commitments leading to job satisfaction. The Hospital must be commended for that. From the results of this study it is evident that NCRH should consider the reward expectations of its medical staff in line with the expectancy theory of motivation.

Based on results obtained this study gives the following recommendations;

- NCRH needs to come up with policies that address the issue of extrinsic rewards especially for skill based and payment by result.
- NCRH should establish intrinsic rewards such as recognition of best performing staff. This would be done in line with the instrumentality theory of motivation where recognition would be contingent upon good performance.
- Proper feed-back mechanisms, both from management and clients, should also be put in place so that good performance may be detected and rewarded adequately.
- Promotions should be fair and the hospital should consider fast tracking the long overdue promotions. This can be done through cooperating with the national government so that files for the health staff can be transferred to the county government.

- Although social rewards had contributed positively and significantly towards employee satisfaction they could be enhanced through good public relations that would enhance the reputation of the hospital and the reputation of the medical staff.
- Plans should be put in place to give the satisfaction process a head-start. This can be done through proper and thorough vetting of those who wish to train as medical staffs so that only those with a passion for their job, and would gladly do it even with minimal rewards, are hired as medical staffs.

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ENGINEERING TECHNOLOGIES AND INNOVATIONS FOR INDUSTRIALIZATION

APPLICATION OF HFMEAIN RADIOLOGY PROCESSES IN PUBLIC HOSPITALS: A CASE STUDY OF NYERI COUNTY REFERRAL HOSPITAL

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Abstract

Use of radiology medical devices in hospitals pose a risk to the patients and medical practitioners. The device risks may be as a result of technical, operational, logistical or maintenance reasons. For this reason, risk management practices should be employed in healthcare systems to ensure that risks hazards inherent in medical devices and those that come up as a result of interaction do not become a source of additional suffering to patients. Some of the reported unavailability of medical devices is attributed to non-adherence to risk management measures and failure to identify risks on time. Application of Healthcare Failure Mode Effect Analysis (HFMEA) technique in risk assessment of radiology processes is important because it ensures; that process mapping is done, hazards identified, risks from the identified hazards are assessed and a risk mitigation framework developed. This is otherwise referred to as risk impact assessment.It ensures that the risks identified are reduced and/or controlled to prevent recurrence. HFMEA as an assessment tool is preferred because it is well structured and healthcare specific.The technique determinesthrough 1-10 scale rating; the probability of hazard occurrence, the severity or the consequence of the hazard if it occurs to either the patient or the system and finally the detectability of the hazard before occurrence. The hazard ratings generated from risk assessment determine the hazard score and risk priority number. Depending on the rating results of each device and the clinical processes involved, the risks are ranked from the most critical to the least critical. This assists the stakeholder to prioritize resources towards the high probability/high consequence risk events and develop mitigation strategies to optimise device availability.

Key words: Healthcare risk assessment, HFMEA, radiology risk assessment, risk impact assessment.

INTRODUCTION

The healthcare system in Kenyan public hospitals have been marred by reported breakdowns and unavailability of critical medical devices, occasioned by long queues and prolonged waiting times. It is important to establish the root cause of this problem from the risk management point of view and especially the management of medical devices. The goal is to

determine and analyse the risk factors or hazards that are inherent and those resulting from interaction with medical devices that can render them unavailable taking in consideration the life cycle of the devices. The motivation of the study was to come up with mitigation framework of reported breakdowns. The study focused on imaging devices in the radiology department at Nyeri County Referral Hospital.

A systematic application of management policies, procedures and practices to the tasks of analysing, evaluating, controlling and monitoring risk is vital in the use of medical devices. It is important that medical device manufacturers implement a full risk assessment process of a medical device and ensure that a solid risk management is also implemented (Dumbrique, 2010). This way, the potential risk of a product is readily addressed throughout the life cycle of the equipment including post-market phase.

The source of risks in medical devicesare caused as a technical, operational, logistical to maintenance reasons. Technical risks relate power rating, loading capacity, rate of production and reliability of the device such as mechanical, electrical supply failure, design failure or use of wrong accessories. Operational risks relate to operation of the equipment, maintenance and the environment of use, human error and input and output data interpretation.Maintenance risks occur during different maintenance schedules or after the maintenance. Workers who carry out maintenance are exposed to a wide variety of hazards. These are: noise, vibrations, heat exposure, fumes, radiations, injuries, dust and electrical shocks among others (Work, 2009). Logistical risks relate to transportation of medical equipment, installation and disposal. Logistical delays of spare parts leads to prolonged downtime, delayed healthcare service and lost revenue (mfontanazza, 2012).

A pilot study carried out established that there are numerous challenges that the radiology practitioners in the Nyeri County referral hospital experienced. These challenges formed the justification that this study.Maintenance and repair topped the list with 26.09% followed by shortage of staff at 21.74%, need for capacity building and power outages at 17.39% and lastly lack of radiologist and parts (consumables) at 8.7% as shown inFigure 2.

Figure 2: Challenges in the Radiology department

Risk Management framework

This is a systematic application of management policies, procedures and practices to the tasks of analysing, evaluating, controlling and monitoring risk (ISO-14971, 2007). According to the standard it is a requirement that an organisation should establish, document and maintain throughout the life-cycle an on-going process for identifying hazards associated with a

medical device, estimating and evaluating the associated risks, controlling these risks, and monitoring the effectiveness of the controls. In other words risk management refers to the principles, framework and process for managing risks effectively. It is within the risk management framework that risk assessment is carried out to identify, analyse and evaluate risks (ISO-31000, 2009). Risk assessment is an important component of managing equipment failures risks in hospitals. Its role is discussed in the next section.

Risk Assessment

The Figure 3 shows the relationship between risk management and risk assessment, otherwise referred to as risk impact assessment. It involves assessing the probabilities and consequences of risk events if they are realized. The results of this assessment are used to prioritize risks to establish a most-to-least-critical importance ranking. Ranking risks in terms of their criticality or importance provides insights to the project's management on where resources may be needed to manage or mitigate the realization of high probability/high consequence risk events (Mitre., 2017). In the context of medical devices, risk assessment entails tracing and identifying device failure modes, analysing their probability of occurrence, severity or consequences, detectability and evaluation in relation to prescribed levels. Several techniques are prescribed in several studies as discussed below.

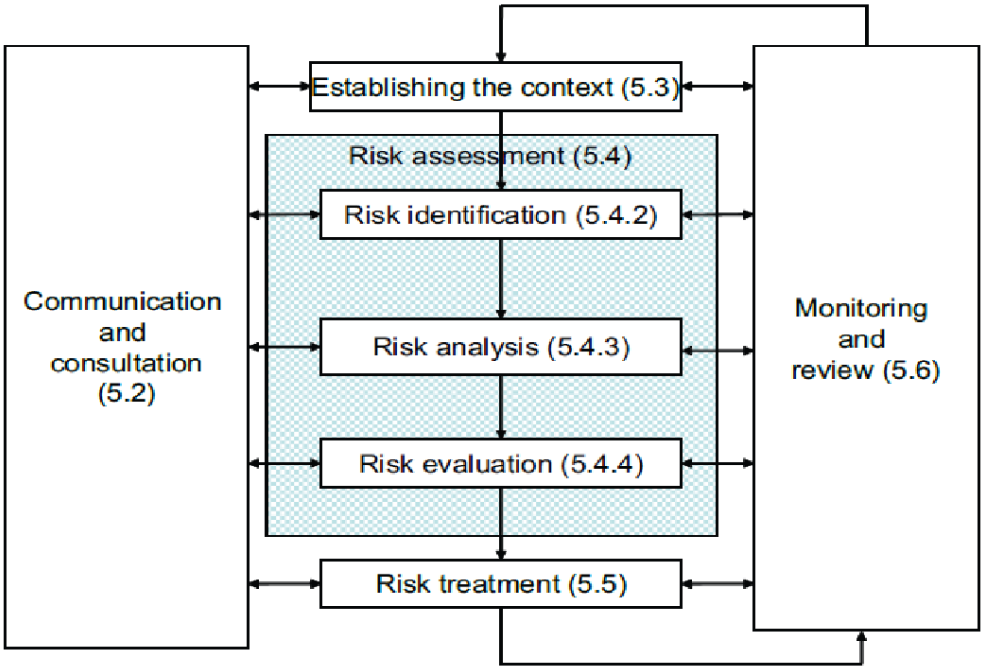

Figure 3 — Risk management process

Figure 3: Risk Management process (Source: ISO-31000, 2009)

Risk assessment techniques

The ISO/IEC 31010 standard for risk assessment techniques propose several attributes necessary for applying generic risk assessment techniques (International Electrotechnical Commission, 2009). However, the proposed attributes are rather general and seldom linked to specific competencies (Chemweno, P., *et a*l, 2015). These techniques follow asimilar pattern (Cohrssen & Covello, 1989) but modified depending on individual situation and applicability of the tool to capture data accurately and the intended purpose (Duc Dang Vu, Tom Trappeniers, 2010). In this study, HFMEA was used, which is a modified form of FMEA

developed by National centre for patient safety of the US; department of Veterans Affairs (NCPS, 2001). It is a systematic approach to identify and prevent problems in products and processes before they occur (Dyro, 2004) that improves steps in a process thereby reasonably ensuring a safe and clinically desirable outcome (NCPS, 2001). HFMEA streamlines the hazard analysis steps found in the traditional FMEA into an algorithm presented in a decision tree. It also replaces the calculation of the risk priority numbers with a hazard score that is read directly from a hazard matrix. It is a preferred technique because it is well structured and healthcare specific. Several studies indicates that HFMEA is a promising technique, but its disadvantage is time consuming however itresults in thorough risk analysis and understanding of the process. The multidisciplinary team approach ensuresthat no failure modes are neglected or forgotten.

HFMEA Application process

The HFMEA process follows five steps graphically shown in Figure 4.According to (NCPS, 2001) and (ISO/IEC-31010, 2009) the five steps followed in HFMEA are:

a) *Definition of the HFMEA*: Clearly defining the topic and narrowing down to manageable size;
b) Assembling a multi-disciplinary team of experts;
c) Graphically describing the process and sub-processes through a flowchart and recording in HFMEA worksheet as in Table 2
d) *Conducting a hazard analysis by*:
    i) Listing all possible failure modes per sub process and recording it in the HFMEA worksheet through brainstorming sessions, database reviews, usability tests and patient safety rounds;
    ii) Determination of probability of occurrence and severity rating using respective ratings on Table 1.
    iii) Determination of hazard score by multiplying the occurrence rating and severity rating, and the results is filled in the HFMEA worksheet. The hazard score is presented in form of a matrix for evaluation purposes Table 3.
    iv) Determining if further action is required by using the decision tree shown in Figure 5 and record in the HFMEA worksheet.
    v) Listing all causes for the important failure modes on the HFMEA worksheet and deciding whether they need to be taken care of or not.

Actions and outcome measures: Recording corrective or preventive actions for each of the causes and define mitigation measures. If the measures are applied to reduce risks, they should be retested again to establish if the control measures are effective or they have generated other risks.

Risk evaluation was done to review the results of risk analysis and making a judgment of whether a risk is acceptable or unacceptable and applying the criteria for risk acceptability given in the risk management plan (AAMI, 2015). Decisions have to be made on the degree acceptability of risk, whose criteria is based on the hospital standards, prescription by the product specific standards of the manufacturer and international regulatory bodies such as WHO(WHO, 2003).This process informed the methodology applied to collect and analyse data as discussed in the section below.

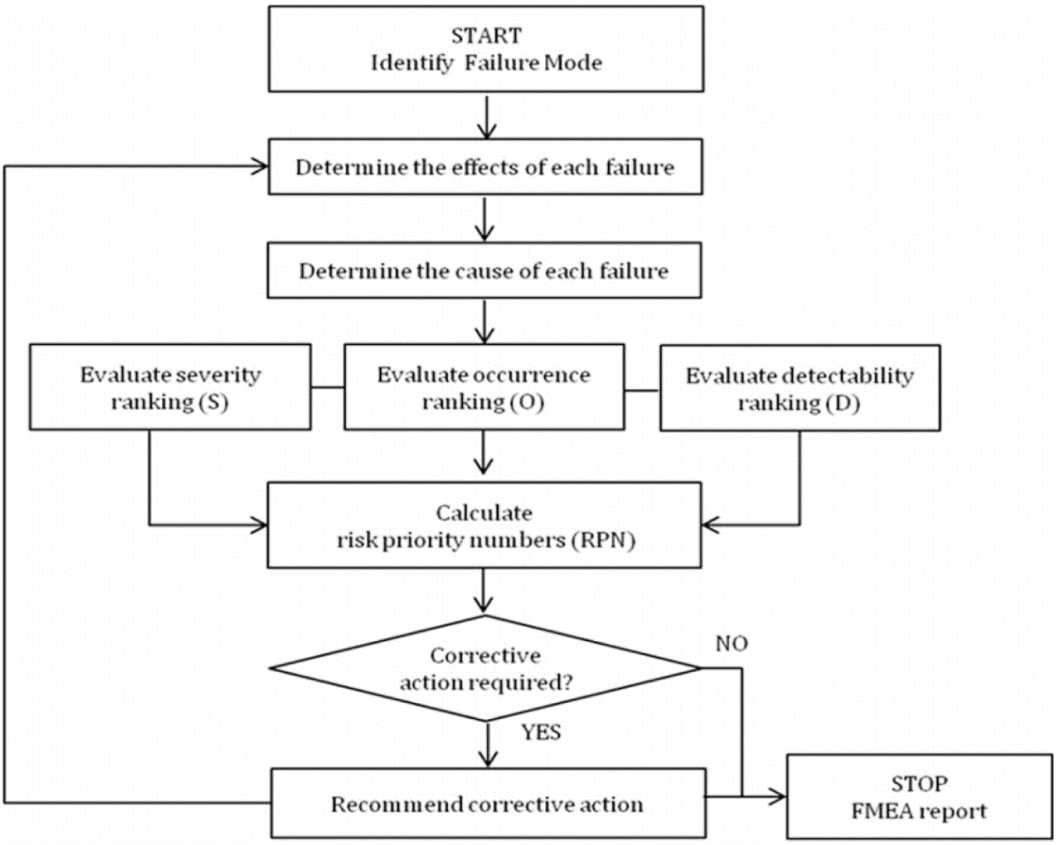

Figure 4: HFMEA Process

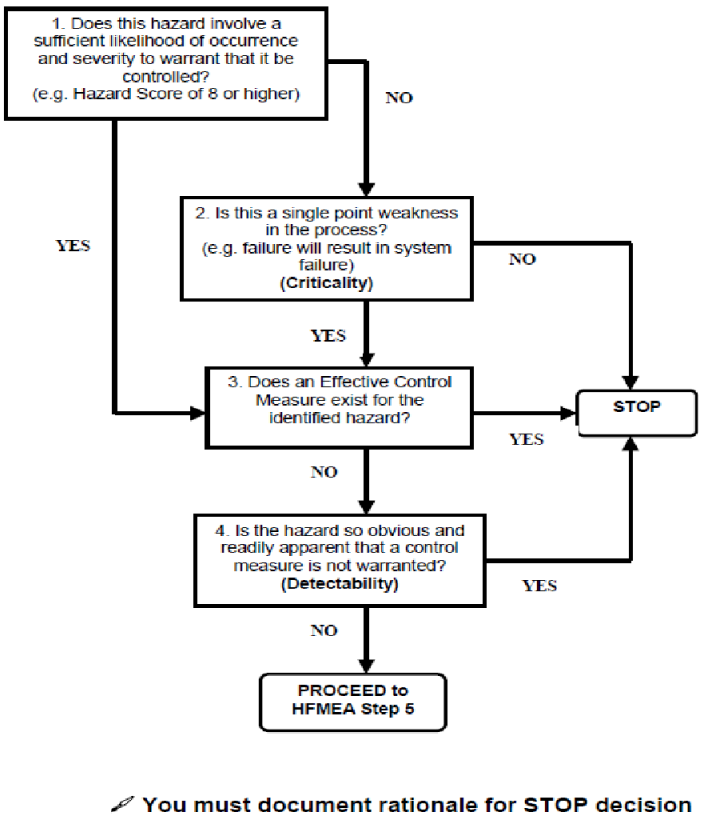

Figure 5: Decision tree (NCPS, 2001)

METHODOLOGY

The study approach employed two designs; a survey methodology and a targeted group discussion forum in reference to a prescribed HFMEA application process with minor variations without compromising the validity of the results.Due to shortage of staff in the department, the discussion forum was conducted in the evenings when the patient traffic was low with two or three radiographers on duty, and the findings recorded were subjected for validation by whole group. Where there were conflict of views and opinions, further discussion was carried out for clarification and agreement. This ensured that the opinions of every person in the group was factored in and agreed upon. The group comprised of; the lead researcher, the hospital biomedical engineer, five radiographers and a master's student in engineering. The team was selected based on relevant experience and expertise in radiology. The methodology followed the process as shown in the Figure 6, and outlined below as process mapping, identification of risks, risk assessment and development of risk mitigation framework.

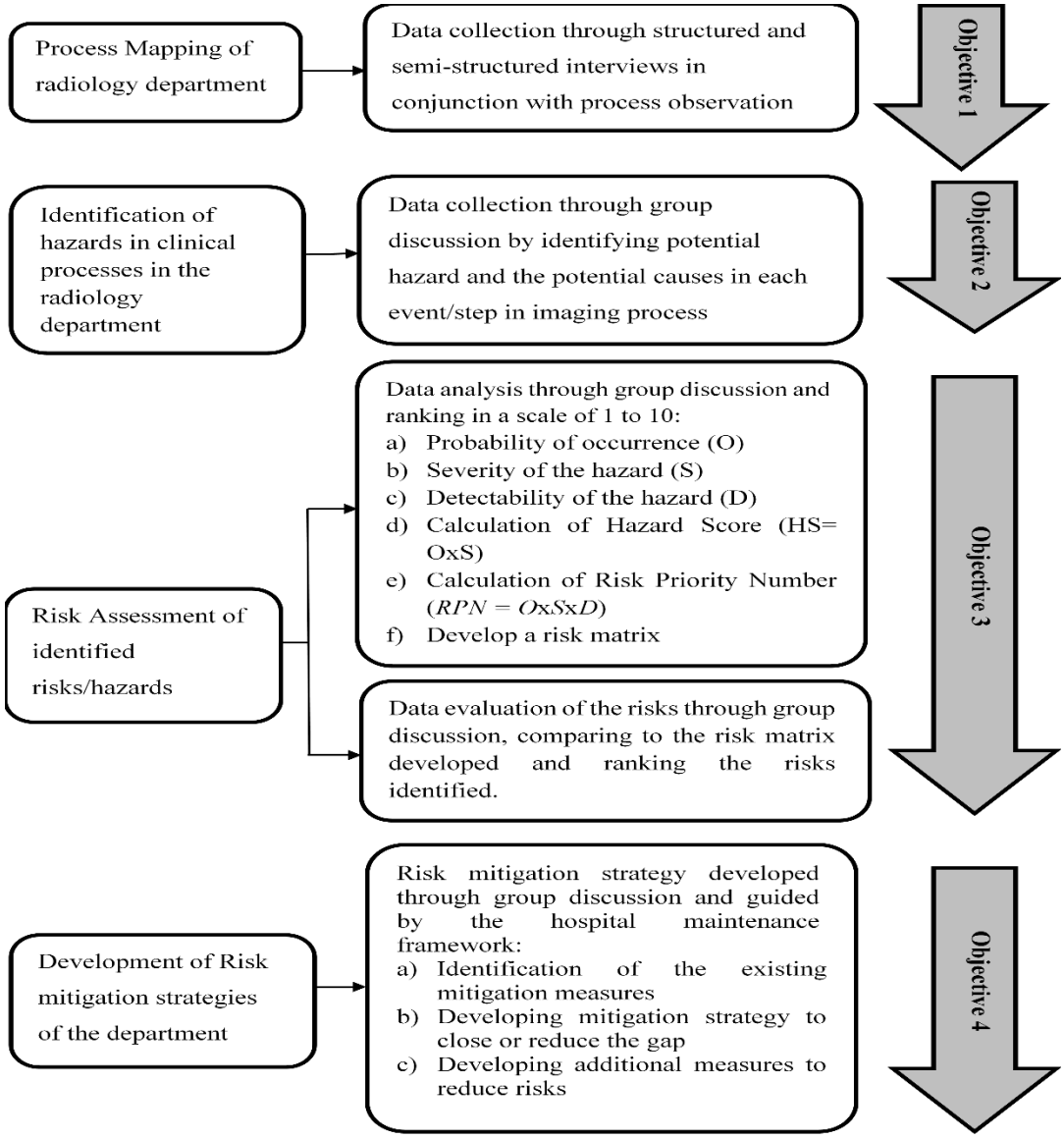

Figure 6: Steps followed in methodology

Process Mapping of Radiology Department

This stage was achieved through structured and semi-structured interviews and process observation. The output was to generate a process flow diagram shown Figure 7: Process map. This was done by looking at activities and events in the department to determining the healthcare process of each device.

Identification of risks and hazards in processes and events

Through discussion forum, every mapped event in the imaging process was looked and a potential hazard identified together with its potential causes.

Risks analysis and prioritization

On identified hazards and risks, assessment was done that started with risk analysis and then risk evaluation of the same. Risk analysis entails analysis and ranking probability of occurrence (O), severity of the hazard (S) detectability of the hazard (D), and all ranked in a scale of 1 to 10 using ranking criteria shown in Table 1. The calculation of the hazard score (HS = OxS) was calculated to determine the effect of the risk on the system. The Risk Priority Number was also calculated.

Risk Evaluation of identified hazards

To evaluate the risks, acceptable evaluation criteria was formulated since the hospital had no documented procedure or guideline. The criteria was based on a requirement that any hazard in a medical device that is likely to cause an injury to the patient, user, the device or the system was unacceptable. For the foregoing reason the decisions below were arrived at:

Acceptable risks: Any severity rating below a scale of 4 was considered acceptable. Equally probability of occurrence below a Scale 5 (Moderate Probability) was also considered acceptable. Therefore any hazard score below 20 (4x5) was considered acceptable.

Unacceptable risks: The severity rating of 7 and above is considered dangerous thus not acceptable. The frequency of occurrence scaled 7 (Very High probability) and above is unacceptable. Therefore a hazard score above 49 (7x7) is unacceptable

Acceptable if reduced to "As Low as Reasonably Possible" (ALARP): Between the totally acceptable and totally unacceptable hazard scare rating, there is a range between 20 and 49 that is always considered acceptable if it is reduced to acceptable levels. This range is characterised severity rating that is above 4 that happens frequently thus patients denied services. Equally the frequency may be low with high severity. This situations happens as a result of device breakdown of failure. Mostly hazards in this range can be reduced by correcting the root cause.

With the Hazard score determined, the product of hazard score with detectability determines the Risk Priority Number (RPN). The detectability score of 4 (High probability of detection) and below is acceptable. Therefore the most acceptable Risk Priority Number is 80 or (4x5x4). The criteria was used to rank and evaluate the results obtained in the study.

Table 1: Probability, Severity and detection rating (Source (Eavan Thornton et al, 2011)

PROBABILITY OF OCCURRENCE RATING	SCORE	SEVERITY RATING	SCORE	DETECTION RATING	SCORE
Remote – no known occurrence	**1**	**Slight annoyance** – No injury to the patient or impact on the system	**1**	**Certain** – error will always be detected	**1**
Low probability – rare failures (Yearly)	**2**	**Slight danger** – No injury to the patient	**2**	**Very high probability** that error is detected	**2**
Moderate probability – occasional failures (quarterly)	**3,4**	**Low to moderate danger** – Very minor or no injury to the patient	**3,4**	**High probability** of detection	**3,4**
Moderately high probability (monthly)	**5,6**	**Moderate Danger** – Minor or no injury to the patient	**5,6**	**Moderate chance** that error is detected	**5**
Very high probability – frequent (weekly)	**7,8**	**Dangerous** – Minor to moderate injury to the patient	**7**	**Remote chance** of detection only	**6,7**
Inevitable and predictable failure	**9**	**Very dangerous** –May result in major injury to the patient	**8,9**	**Remote or low** likelihood of detection	**8,9**
Certain probability – daily or every time	**10**	**Extremely Dangerous** – May cause death to the patient	**10**	**No chance** that error is detected; no mechanism exists	**10**

RESULTS

The process mapping generated a nearly common feature for all the radiology devices, and summarized as shown in Figure 7: Process map. This process map was used to generate potential failure modes, potential causes and subsequently analysis of the processesusing criteria on Table 1. All these data was recorded in the worksheet as shown in Table 2: Analysis worksheet. The interpretation of the results was done using the hazard score matrix Table 3 and RPN ranking Figure 9. Interpretation of the results is discussed in section 4.1 below.

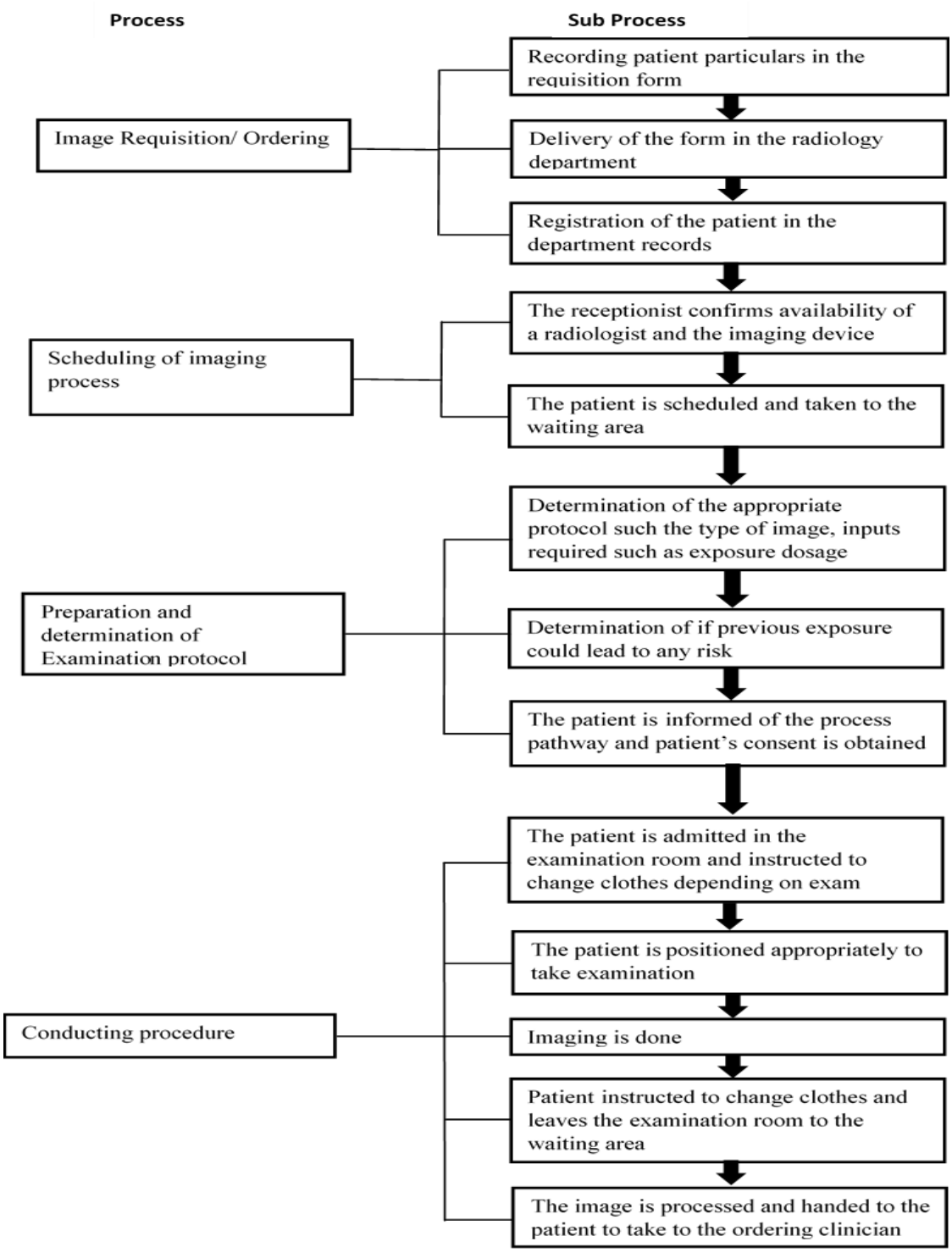

Figure 7: Process map

Table 2: Analysis worksheet

Problem Area or Activity	Potential Failure Mode	Potential Causes	Probability of Occurrence (O) 1 to 10	Severity Rating (S) 1 to 10	Hazard Score (O×S)	Detectability (D) 1 to 10	RP (O×
Image Requisition	Insufficient patient's clinical data on image requisition Form	The form does not have a provision for the data	8	5	40	2	80
		The hospital records do not have patients biodata	7	4	28	5	140
		oversight by the clinician requesting the image	5	5	25	6	150
	Failure to record patient's contraindications	patient with conditions or gadgets that may cause a risk upon imaging is unknown to the clinician or the patient does not divulge the information	4	8	32	4	128
	Incorrect Image requested	The manifestation of the ailment according to the patient may indicate a position away from the actual position	4	5	20	4	80
Registration	insufficient entry of patient information in the radiology register	oversight during entry of patient data or incomplete/ incorrect patient data on the RRF form	5	4	20	4	80
Scheduling of diagnosis/ examination	Unavailability of a radiographer	Due to unforeseen reasons the radiographer scheduled is not available	1	7	7	1	7
	Unavailability of the imaging device	The imaging device on demand is not operational or the image required cannot be carried	7	9	63	2	126

		out with the devices available					
	Directing the patient to the wrong section or device	The patient fails to follow instructions on where he/she is directed or the personnel directing fails to understand the kind of examination required	6	2	12	4	48
Preparation and selection of examination protocol	Failure to select the correct protocol for the exam	The image request might be ambiguous or oversight of the radiographer	2	4	8	5	40
	Failure to select the correct image output or film	Unavailability of the correct image output or the radiographer is not conversant with the type of output required	3	5	15	5	75
	The image quality is not clear or does not give required details	The image quality is not set properly	5	6	30	3	90
	Applying incorrect dosage/exposure during examination	Failure to apply appropriate radiation dosage to the appropriate position of the patient's body	5	7	35	4	140
	Imaging the wrong position	The radiographer takes an image as prescribed by the requesting clinician or due to oversight takes an image on the wrong position	4	4	16	4	64
	Overexposure of patients to radiation	Failure to establish if the patient had previous exposure to radiation	6	6	36	6	216
	The patient is not aware steps to be followed during imaging exam	Failure to inform the patient of the process pathway	3	2	6	2	12

	The patient is unaware of the benefits and risks of the imaging process to be carried out	Failure to inform the patient of the risks versus benefits of the process by the requesting clinician and the radiographer	6	6	36	4	144
	The imaging process is carried out without the consent of the patient	Failure to seek consent of the patient or immediate family members before carrying out the imaging process	5	6	30	5	150
	The patient undergoes imaging with the wrong attire	The patient is not instructed to dress appropriately for the examination	2	5	10	4	40
Conducting procedure	The imaging device fails to function as required	The device malfunctions due to several factors that require repair, maintenance or calibration	2	2	4	4	16
	The posture of the patient during examination is inappropriate	The patient is not properly guided to take appropriate posture, or patient becomes unstable during the examination or the patient cannot maintain the appropriate posture	3	4	12	3	36
	Failure of the patient to carry out breathing instructions	Clinical condition of the patient may render him/her unable to perform breath in-out-hold instructions	3	6	18	4	72
	Safety precautions are not observed	Failure to protect/shield the patient on the gonad, thyroid and breast areas	2	7	14	4	56

	The patient is dropped or injured during transfer	Failure to secure or handle the patient during transfer	1	7	7	4	28
	Appropriate labels are not placed during image taking	Failure to place or mark the image taken to signify the correct side or direction	2	4	8	4	32

Table 3: HFMEA Hazard Score matrix

		Severity rating						
		Extremely Dangerous	Very dangerous	Very dangerous	Dangerous	Moderate Danger	Moderate Danger	Low to moderate danger
Probability of Occurrence	Certain Probability	100	90	80	70	60	50	40
	Inevitable / Predictable failure	90	81	72	63	54	45	36
	Very High Probability	80	72	64	56	48	40	32
	Very High Probability	70	63	56	49	42	35	28
	Moderately High probability	60	54	48	42	36	30	24
	Moderately High probability	50	45	40	35	30	25	20
	moderate probability	40	36	32	28	24	20	16
	moderate probability	30	27	24	21	18	15	12
	Low Probability	20	18	16	14	12	10	8
	Remote	10	9	8	7	6	5	4

KEY

Unacceptable

As Low as Reasonably Possible (ALARP)

Acceptable

Risk ranking and mitigation measures

Hazard Score

A total of 25 potential failure modes were identified in the study as shown in Figure 8. It was noted one risk (Unavailability of imaging devices) was ranked unacceptable at 63. Nine risks were ranked ALARP, three of which are related to the request form and the rest are potential failures during imaging procedure and related to oversite on the part of the radiographers or the requesting clinician. These are risks that can be reduced through capacity building and sensitization. The 15 failure modes ranked 20 and below were considered acceptable, though mitigation measure should put in place to ensure they do not escalate to the ALARP or unacceptable region.

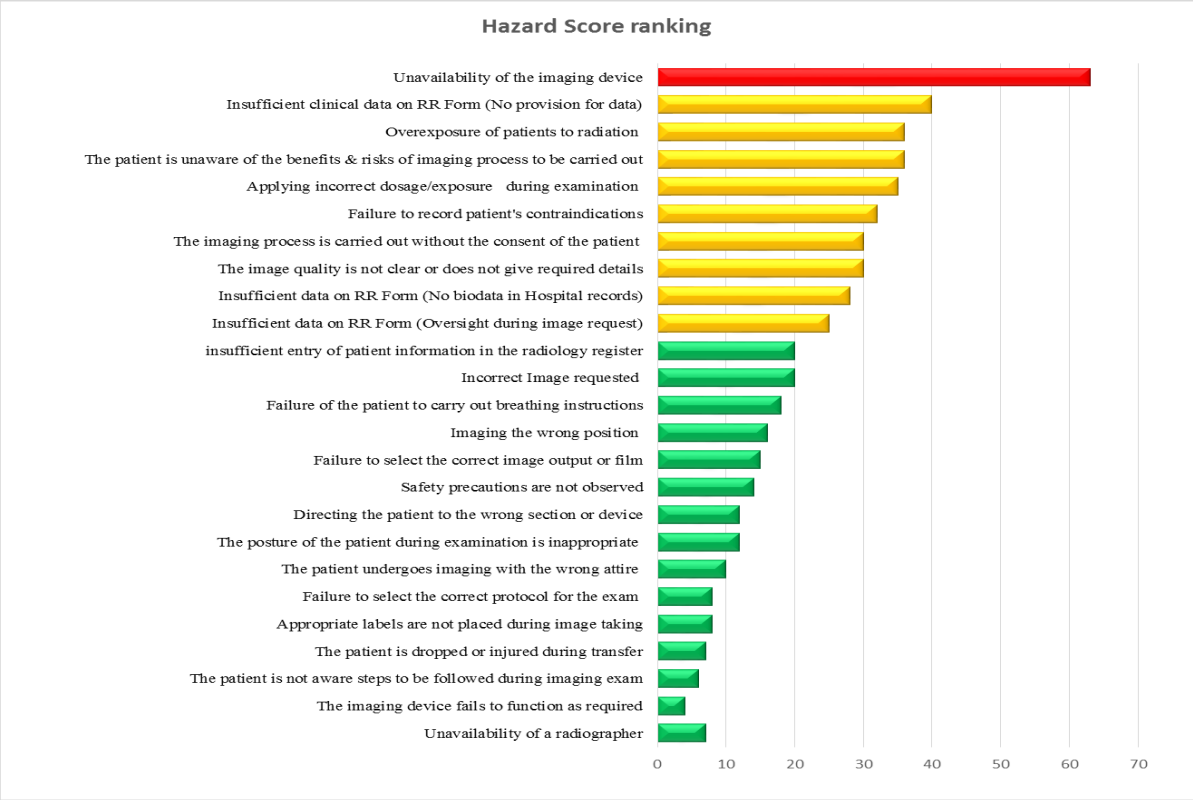

Figure 8: Hazard Score ranking

Risk priority number

The RPN ranking as shown in Figure 9, added a factor of detectability on the potential failure modes identified and analysed. Based on the acceptability criteria discussed in section 3.4, any RPN over 80 is deemed unacceptable. “Overexposure of patients to radiations” ranked highest among the risks at 216, followed by “failure to obtain consent from the patient before the procedure is done”. It can be noted that risks related to the radiology request form information causes a trail of other risks thus ranked higher. It was noted that some hazard scores that were in ALARP region and due todetectability developed unacceptability. Like hazard scores, mitigation measure should be employed to reduce the risks. Individual mitigation measures are discussed in Table 2: Analysis worksheet) and general recommendations given below. Most of the potential failure modes can be prevented without incurring very high costs.


Risk Priority Number Ranking
Overexposure of patients to radiation
The imaging process is carried out without the consent of the patient
Insufficient data on RR Form (Oversight during image request)
The patient is unaware of the benefits & risks of imaging process to be carried out
Applying incorrect dosage/exposure during examination
Insufficient data on RR Form (No biodata in Hospital records)
Failure to record patient's contraindications
Unavailability of the imaging device
The image quality is not clear or does not give required details
insufficient entry of patient information in the radiology register
Incorrect Image requested
Insufficient clinical data on RR Form (No provision for data)
Failure to select the correct image output or film
Failure of the patient to carry out breathing instructions
Imaging the wrong position
Safety precautions are not observed
Directing the patient to the wrong section or device
The patient undergoes imaging with the wrong attire
Failure to select the correct protocol for the exam
The posture of the patient during examination is inappropriate
Appropriate labels are not placed during image taking
The patient is dropped or injured during transfer
The imaging device fails to function as required
The patient is not aware steps to be followed during imaging exam
Unavailability of a radiographer
0
40
80
120
160
200
240

Existing Measures and Mitigation strategies

From data available and through the discussion forum, it was observed that the hospital has some mitigation measures to some of the risks potential failure modes, but in some cases there were no measures put in place. It is prudent that all risks should be reduced to as low as reasonably possible. As shown in Table 2: Analysis worksheet, where there were no measures in place, mitigation measures were suggested. The table thus forms the risk management profile of the radiology department of Nyeri County referral hospital. The ranking of risks will inform the hospital management on the risks that they will give high priority.

Conclusion and Recommendations

The study findings necessitated several recommendations, that once addressed will mitigate the risks in the radiology department and in some cases spill over to other departments with similar procedures. The recommendations suggested are:

a) Insufficient data in the radiographic request form is the source of high risks, a correction measure should be put in place by either amending the form to have sufficient data or putting in place a management information system that can capture the data.
b) The hospital administration should consider taking radiographer, biomedical engineers, clinicians and any other medical personnel directly involved with radiology process through some refresher training on emerging trends and imaging requirements. This will ensure that some minor hazards such as requirements of knowing the patients contraindications, previous exposure or the right devices for the different ailment diagnosis is mastered. This can also include a forum whereby radiographers and clinicians discuss and standardize procedures
c) The hospital should consider developing a comprehensive maintenance strategy to ensure that all medical devices are available at optimal level. The strategies should include periodic maintenance, and preventive maintenance.
d) The hospital can also consider developing a process chart in several departments to inform patients the general treatment pathway. This ensures that the patients have an idea of the steps they will take and thus reduce stress and anxiety.
e) It will be prudent to implement a policy that ensures safety of patients, users and the machines are guaranteed. This includes ensuring that the radiation leakages are within the legal limit.
f) The study itself was limited to the radiology department, and can be extended to other departments that highly require risk assessment. A general survey of other departments, revealed that the HFMEA tool can be used in the Physiotherapy, Hospital laboratory, renal department, and maintenance department.

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WAYFINDING TOOLS FOR ADDRESSING WAYFINDING CHALLENGES IN HEALTHCARE ENVIRONMENTS

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Abstract

Improving the quality of healthcare service provision in large Hospital facilities requires the adoption of strategies for assisting patients to transit efficiently to designated departments after arrival at healthcare facilities. This necessitates an understanding of the hospital environment i.e the patient care pathway. This pathway has constraints that may make it difficult for patients to access different areas in order to be served. These constraints are human, operation as well as environmental factors that influence wayfinding in public hospitals. Some of the human influencing factors are language barriers, cultural differences among patients and healthcare practitioners, physical disabilities and literacy levels of patients seeking healthcare services. Operation factors are those attributed to management of wayfinding related services whereas environmental influencing factors are layout of hospitals and lack of incomprehensible wayfinding tools for instance vaguely described signage or symbols. The signage or symbols constitutes examples of wayfinding tools commonly implemented in healthcare facilities. The wayfinding tools need to incorporate the human factors to generate a wayfinding system. The purpose of this paper is to review wayfinding strategies discussed in literature and establish which ones are best suited for healthcare facilities in view of optimizing the patient's time right from arrival to exit from healthcare facilities. Secondly to propose how choice of the wayfinding tools should be done in coming up with the place wayfinding system. Non-systematic review of literature was utilized for gap analysis. Key findings were identification of wayfinding tools applicable for healthcare environments based on the wayfinding goal strategy and the need for framework to address wayfinding challenges in Kenyan public healthcare environments.

Key words: Hospital environment; Healthcare facilities; wayfinding tools; wayfinding system

INTRODUCTION

Locating places in big and complex environment settings is problematic and chances of getting lost become high for any visiting person. These complex settings include among others hospitals. The process through which the person uses to identify the way to any destined location in familiar or unfamiliar surroundings being aided by indications given by the environment is wayfinding (Farr *et al.*, , , 2012).

Wayfinding concepts in Healthcare

Wayfinding in healthcare environments is categorised as either resolute or emergency since patients, visitors and staff are required to reach their destined locations with minimal delay and effort (Greenroyd *et al.*, , , 2017), therefore prevalence of inhibiting wayfinding factors in these settings would culminate to the hospital not realising the benefits of good wayfinding hence resulting in the decline in the quality of healthcare service provided at the healthcare facility.

Understanding wayfinding issues of healthcare environment has been vital to researchers because of the importance of good wayfinding which is beneficial to the navigating persons by eliminating confusion and dis-orientation (Farr *et al*., 2012), ensuring that they create accurate mental maps which makes navigation easier (Giannopoulos *et al.*, 2014), offering assistance therefore improving their overall experience (Cooper, 2010; Farr *et al*., 2012), promote patient healing by eliminating stress, anxiety and fear (Morag *et al*., 2016) and promote safety (Huelat, 2007).

Good wayfinding has also benefited hospitals by enabling them to comply with regulations (Farr *et al*., 2012), reducing wayfinding costs (Morag *et al*., 2016), improving operational efficiency (Huelat, 2007) and increasing staff satisfaction because of minimal interruptions in their work brought about by lost patients asking for direction hence leading to reduction in medical errors and staff turnover (Pati *et al*., 2015).

The best way of achieving good wayfinding especially in existing built up healthcare environment is through improvement of facility communication which according to NSW (2014) is having the right wayfinding tools forming part of the wayfinding system to relay information well. Wayfinding tools affect wayfinding by communicating information (Boonyachut *et al*., 2012) to the person through visual, audible, tactile, and smell (Morag *et al*., 2016; Apelt, Crawford, & David, 2007).

The several wayfinding tools available are classified differently by authors for instance Muhlhausen (2000) classified them based on communication where we have graphic, audible and tactile tools. (Thieren, 2015) classified them based on the way it disseminates the wayfinding information where we have static and adaptive tools. (Mclaughlin, McNeil, & Sebald, 2005) classified them based on the technology where we have existing technology as well as new and upcoming technology.

Considering the classification on the way it disseminates information; the available static wayfinding tools are signs (categorized as identification, orientation, regulatory and directional) (Gibson, 2009), symbols (Boonyachut *et al*. 2012; Lee *et al*., 2014), physical maps (Hughes & Brown, 2015; Cooper, 2009) and color coding (Hughes *et al*., 2015; Morag et al., 2016). Others are Naming Systems which can be alphabetical or numerical or both (Hughes *et al*., 2015), Hospital Letters with directions (Hughes *et al*., 2015), Guidance of hospital staff (Morag *et al*., 2016), self-help telephones, braille and audible chimes in elevators (Muhlhausen, 2000). The available adaptive wayfinding tools include Personal devices (Thieren, 2015), Interactive kiosks (Mclaughlin et al., 2005), Radio-Frequency Identification (RFID) (Alarifi et al., 2016; Thieren, 2015), Liquid crystal displays (LCD)

(Mclaughlin *et al*., 2005) organic Light emitting diode (LED)(Mclaughlin *et al*., 2005), Robotic systems (Thieren, 2015), Everywhere Displays (ED) Projector (Pinhanez, 2001) and audile sounds or public address systems (Muhlhausen, 2000).

The influence of wayfinding tools collectively as a system in relaying information thus aiding people to make right decision on how to move between two points according to NSW (2014) is the wayfinding system.

The wayfinding system utilizes the wayfinding tools placed at predetermined positions in a facility. Determining the right wayfinding tools for a given healthcare environment as well as the points of Placement of these wayfinding tools forms the basis of the place wayfinding. Several healthcare settings improved the place wayfinding by developing the wayfinding system to address wayfinding challenges. Grady Memorial Hospital according to Cooper (2010) used signs, symbols, color coding, naming system and electronic kiosks to address human and operation wayfinding challenges of culture, language diversity, impairment and maintenance cost. Finley Hospital in Dubuque according to Cooper (2010) used numbering system, signs, and electronic kiosk to address operation wayfinding challenges of customer complaints, safety and energy management.

In carrying out the improvement of the hospital wayfinding trough determination of an appropriate wayfinding system made up of selected wayfinding tools, considerations should be made on the influence of the three factors namely human, environment and operational system or administrative factors which have been found to contribute to wayfinding success or lack of in place.

Human factors in Healthcare wayfinding

Human factors are those that play the role of making decisions based on the information about the environment and the decisions made are transformed into actions for one to reach a desired destination or location. Human factors in wayfinding include spatial orientation, cognitive mapping ability, route strategies, language, culture, gender, age, biological factors, various forms of inability, human needs such as need for water in case of thirst, food when hungry, and so forth, literacy levels, place familiarity levels and human capabilities in terms of perception, memory and problem solving capabilities.

Cognitive mapping entails both environmental and spatial cognitions where spatial cognition is the internalized reflection of space in thought and environmental cognition is the people's awareness over the environment. Cognitive mapping influences spatial orientation (Casakin, Barkowsky, Klippel, & Freksa, 2000). Spatial orientation affects route choice by enabling one to quickly identify the shortest and the most efficient route to destination from the current position. Route choice is also influenced by absence of correct decision in moving in the environment (Hochmair & Karlsson, 2005) and by people's route preferences (Brunye´, Mahoney, Gardony, and Taylor, 2010) which according to Carlson, Hölscher, Shipley and Dalton (2010), people desire straight routes with minimal turns. Spatial orientation itself is also hampered by language used to communicate the directions and culture which influences the use of spatial information. Using language with a lot of differentiation leads to higher perception of reality (Frank, 2009) and a combination of cultural and social situation of an individual affects wayfinding for instance differences exist in people's geographical style, vocabulary and terminology, conversation style, and cultural meaning of terms and according to Frank (2009) Gender and spatial abilities also affect wayfinding. Male perform better than females in spatial navigation and performance (Chai & Jacobs, 2009). Female have been found to display a lot of spatial anxiety as compared to male even though there is a negative correlation between spatial performance and the effects of stress. In terms of navigational strategies, it has been shown that while male rely on indicators that provide information on direction as well as orientation females prefer exact pinpoint indicators such as landmarks to

form spatial orientation. Additionally, male have also demonstrated to be more accurate in navigating tasks when directional information is provided (Lawton, 2010). On the other hand, female have a better object memory and object-location memory than male. Differences in gender exist with regards to spatial ability in terms of spatial perception, mental rotation, objection location memory, spatial visualization, and dynamic spatial ability (Lawton, 2010). Males are very good in spatial perception tests, mental rotation, and spatial dynamic ability and are only slightly better than female on spatial visualization. Female perform better on object location memory tests (Lejbak et al., 2009). Biological factors have also been associated with the differences observed in spatial performance and ability between the males and females. These are attributed to the varied levels of testosterone and oestrogen levels with oestrogen levels exhibiting mixed results due to variation in a female's menstrual cycle (Lawton, 2010; Gabriel et al., 2011). Age of the person according to Zijlstra, Hagedoorn, Krijnen, van der Schans, and Mobach, (2016) has an effect on both cognitive mapping and route strategies. This is due to the fact that elderly people have poor Memory and physical capabilities compared to the younger people. Familiarity level of the person about the environment is a skill which influences wayfinding (Morag *et al*., 2016). According to Hölscher, Buchner, Meilinger and Wiener (2009), familiar people perform better in navigating a place compared to unfamiliar ones due to high degree of environment spatial knowledge. Literacy level affects wayfinding as demonstrated by Martins & de Melo (2014) and illiteracy is prevalent in the elderly and young people. Furthermore, in Kenya and according to Kenya National Bureau of Satistics, (2014), 12% of women and 8% Men are illiterate. Wayfinding according to Symonds, Brown, and Iacono (2017) has been noted to be affected by experiences of the human body like the need for water in case of thirst, food when hungry and so forth and capacities which are to be avoided like taking long route or those which cannot be ignored.

Environmental factors in Healthcare wayfinding

Environmental factors inhibiting the performance of place wayfinding system are the built environment factors namely the layout of the facility and built environment clues.

Movement of patients in healthcare environment is affected by the Layout of the facility which is based on how the facility is arranged or zoned. Arrangement or zoning of the facility is in two aspects. The first entails grouping of spatial units into zones according to their similarities of services, facilities, functions or type of users (Martins et al., 2014). The second aspect is grouping the facility based on built environment elements of paths, districts, nodes, landmarks and edges (Lynch, 1960). Paths refer to streets, walkways, railroads, canals and transit lines (Farr *et al*., 2012). Nodes are Points where pathways meet (NSW, 2014) and which are also called decision points (Mclaughlin et al., 2005). Edges are boundaries between two areas like walls whereas districts are sections within the facility with common recognizable features (Farr *et al*., 2012). Landmarks are those which act as points of reference (NSW, 2014). Studies done by (Mclaughlin *et al*., 2005) showed influence of decision points to wayfinding.

Built environment clues as the other element of environmental factor in wayfinding plays a role of revealing the identity and function of each section of the environment and include Lighting, Colours and Finishing. Finishing include use of materials to distinguish visitor and staff pathways (Apelt *et al*., 2007) thereby contributing to legibility of paths and subsequently the wayfinding tools (Total Alliance Health Planners, 2016). Clues affect wayfinding by enhancing information dissemination about the place and their Shortcomings results in difficulty in movement due to disorientation brought about by boredom, fatigue, drowsiness, unwillingness & decreased attention (Martins *et al*., 2014).

Operations or administrative factors

These factors emanate from how organizations manage space and services (Martins et al., 2014). Management of space (layout) and services (including wayfinding related services) is an operations management issue. Management of operations in wayfinding has not been studied extensively and little information is known. Studies on airport signage by Airport Cooperative Research Program, Federal Aviation Administration, & National Research Council (U.S.), (2011) revealed that signage system as an investment requires an asset management plan strategy. Management of space and services is a function of management of operations in facilities which according to Heizer & Render (2007) requires consideration of ten key decisions related to design of product and service, design of process and capacity, selection of location, design of layout, job design in human resources, management of inventory and supply, maintenance, assurance of quality and scheduling.

Purpose of the study

The focus of this study therefore seeks to first establish which wayfinding tools are best suited for healthcare facilities in view of optimizing the patients time right from arrival to exit from healthcare facilities and secondly to propose how choice of the wayfinding tools should be done in coming up with the place wayfinding system.

METHODS

The study utilized a non-systematic literature review in which the search for literature was done with the assistance of books, conference proceedings and online search sites of Google, Google scholar, MEDLINE and SocINDEX. The searched key words and the various combinations utilized were; wayfinding, healthcare wayfinding, wayfinding factors, wayfinding tools and wayfinding system. Snowball method of reviewing the reference lists for relevant articles was also used and this led to Preliminary search yield of 75 articles which were reduced to 51 based on their importance.

RESULTS AND DISCUSSIONS

Human and environment factors have direct influence in the place wayfinding and in consequence wayfinding tools, however operation factors have indirect influence since its influence is on the environment. It is possible to consider all the three factors if the facility is being designed and has not been built up since at the design stage, decisions are made on who the building users are, how the layout is to be arranged and how operations are to be effected, however, it is difficult to consider all the three factors for an existing facility which is functional for instance revising the layout of the facility to eliminate wayfinding challenges is difficult due to resulting interruptions and costs whereas changing the facility users to eliminate human related wayfinding challenges is impossible.

In establishing which wayfinding tools are best suited for healthcare facilities, there is no documented method used by system designers for wayfinding tool selection. (Airport Cooperative Research Program, *et a*l., 2011) proposed system analysis approach in developing an airport signing system. In healthcare environment, wayfinding system is more than signage (Muhlhausen, 2000) and application of the approach would expand its use beyond signage to selection of several wayfinding tools applicable to healthcare.

The system analysis approach is in five stages of fulfilling the goal of the system, catering for all categories of facility users, identifying the user wayfinding tasks and information required to perform the wayfinding tasks, knowledge on features and limitations of the users and how they affect the way information is presented and lastly potential errors made by users.

The goal of the wayfinding system in healthcare environment according to Morag et al. (2016) is made up of four roles and the wayfinding tools which are capable of supporting the four roles of the system in healthcare environment were determined in the study and results tabulated in Table 1 below.

Table 1. Summary of wayfinding tools capable of supporting the goal

Goal of the system	**Wayfinding tools which are able to support the goal from past studies**
Providing people with ways to prove that they are at the right beginning or end point	Maps (Bianconi & Andreani, 2011; Mollerup, 2009), signage (Bianconi et al. 2011), symbols (Rousek & Hallbeck, 2011), electronic kiosks (Bianconi et al. 2011), hospital staff (NSW, 2014), Personal devices (NSW, 2014; Thieren, 2015), Liquid crystal display (LCD) system (Mclaughlin et al., 2005), Light emitting diode (LED) system (Mclaughlin et al., 2005), Naming systems (United states Department of Veterans Affairs, 2012) and Radiofrequency Identification devices (RFID)(Aschberg & Moesgaard, 2016).
Ensuring people are able to pinpoint their locality and orient within a building or an outside space;	Maps (Specialist clinics wayfinding guidelines, 2008), signage (Bianconi et al. 2011; Gibson, 2009), Colour coding (Elif, & Nilgün, 2010; Martins et al. 2014), electronic kiosks (Bianconi et al. 2011), hospital staff (NSW, 2014), Personal devices (Thieren, 2015), Liquid crystal display (LCD) system (Mclaughlin et al., 2005), Light emitting diode (LED) system (Mclaughlin et al., 2005), Naming systems (Aga, 2008), Radiofrequency Identification devices (RFID)(Aschberg & Moesgaard, 2016), Audible sounds (public address system) (Bruce, Welsh, and Wiener, 2010) and self-help telephones (NSW, 2014)
Ensuring people are able to strengthen the fact that they are moving in the correct direction;	Maps (Konkol, Kray, & Fechner, 2015), Signage (Basri & Sulaiman, 2013), Colour coding (Rangel & Mont'Alvão, 2011), electronic kiosks (Thieren, 2015), hospital staff (NSW, 2014), Personal devices (Calori, & Vanden-Eynden, 2015), Liquid crystal display (LCD) system (Mclaughlin et al., 2005), Light emitting diode (LED) system (Mclaughlin et al., 2005), Naming systems (Aga, 2008), Radiofrequency Identification devices (RFID) (Thieren, 2015), Audible sounds (directional sound) (National fire protection association, 2016), self-help telephones(NSW, 2014)
Enabling people to know probable hazards and in what way to safely escape emergencies.	Maps (Hölscher et al., 2009), Signage (Basri et al. 2013), Colour coding (Rangel et al. 2011), symbols (National fire protection association, 2016), electronic kiosks(FWI, 2017), hospital staff (NSW, 2014), Personal devices (HCPro, 2016), Liquid crystal display(LCD) system (FWI, 2017), Light emitting diode (LED) system (FWI, 2017), Naming systems (NSW, 2014), Audible sounds (National fire protection association, 2016), flashing strobe lights (National fire protection association, 2016)

For determining the categories of users of the wayfinding system in healthcare environment, literature review shows users as including patient, family member, friends and relatives to the patient, new or casual staff, people making deliveries, people providing services, administrative staff and healthcare providers including volunteers, medical students, ward sisters (Huelat, 2007; Hughes *et al*. 2015; NSW, 2014). The key user in a hospital setup for which the hospital wayfinding is designed for should be the patient and it's necessary to fulfill the patients wayfinding needs prior to anybody else. The demographic study of the patient population of a given healthcare setting should be done to determine which of the identified tools meeting the goal of the system are able to solve the place human wayfinding factors. The user wayfinding tasks which helps in establishing the content of the wayfinding system is best understood by knowing the place layout issues so that the level of progressive disclosure of information required is determined. Layout issues are best understood by undertaking perfomance measurement of how Movement of patients in healthcare occurs.

This is done based on the two concepts of patient care pathway and the patient's physical journey (Khan., 2012).

Patient care pathway entails quantifying flow of people in order to establish relationships between spaces (Tomkins *et al*., 2010) with a view of understanding the logical movement of people between spaces in order to establish circulation system. The patient's physical journey has been studied by measuring the people navigational perfomance in movement. (Hölscher *et al*., 2009) measured wayfinding performance of recruited participants with a view of determining distances covered and time taken including distance and time wasted due to wayfinding gaps. Studies utilizing navigational performance of actual users of the facility and not selected participants should be used and the patient tracks are to be captured and placed in diagrammatic form called spaghetti diagram which according to (McCullough, Cynthia S., 2010) identifies visually any needless travel distances and wasted time and movement for people in wayfinding.

Information required by users in order to perform the wayfinding tasks, knowledge on features and limitations of the users and how they affect the way information is presented and lastly potential errors made by users is place specific and studies ought to be done.

CONCLUSION

Factors affecting wayfinding in healthcare have been reviewed and found to result from human, environmental and operational issues. Much emphasis from past researchers has been focused on Human and environment factors but less on operation factors. Future research ought to focus more on operation factors which include among others the comparison of asset management strategies for the various wayfinding tools as well as the effect in wayfinding of the ten key decisions in operation areas of product and service design, process and capacity design, location selection, layout design, human resources job design, inventory and supply management, quality assurance, scheduling, and maintenance.

The wayfinding tools applicable to the healthcare environments have been identified by utilizing the wayfinding goal satisfaction strategy of the system analysis approach. It is worth noting however that not all of the identified wayfinding tools can be implemented as a wayfinding system in one hospital environment because of the resulting system overlap, contribution to information overload, cost etc. the use of the rest of the items in systems analysis approach like users of the system, and understanding their wayfinding tasks, limitations and potential errors would help in reducing the number however, further analysis through future research is therefore required to reduce the tools through a framework.

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POTENTIAL BENEFITS OF ADOPTION OF LASER MATERIALS PROCESSING IN EAST AFRICA'S MANUFACTURING INDUSTRY

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Abstract

Laser technology is applied in a wide range of applications in various sectors, including industrial manufacturing, medical, and communication, among others. The laser is a versatile tool for materials processing as it is a non-contact tool that is CNC programmable and can be utilized in various industrial production processes. One of the most important and unique features of laser radiation is that it can be focused into a microscopic spot size generating high power densities in tens MW/cm^2 that are capable of melting and vaporizing metals at fast rate yielding high speed production processes. Different types of laser sources - differing in features such as operating wavelength, maximum output power, beam quality, and method of beam delivery - are now widely deployed in specific applications with realization of benefits in process performance and product quality. The laser characteristics that benefit various laser materials processing applications include kilowatt output power, high beam quality, fiber optic beam delivery, and small footprint (compact laser systems). Lasers are used in the manufacturing industry for materials processing applications such as cutting and welding of metals, surface hardening and cladding of metals, joining of plastics, marking/engraving, drilling/micromachining, etc. Equipment manufacturers often use the laser in production processes such as profile cutting and welding of metals; the laser is often utilized in profile cutting of sheet and plate metal whereby a large number of parts are nested to improve material usage and avoid wastage. The laser is also used for maintenance and repair works involving surface hardening and surface cladding of worn out machine components. Uganda and Kenya have recently started to exploit their oil deposits and there are prospects of industrial growth in the region to service the oil sector as well as other sectors that will benefit from the oil proceeds. Large multibillion-dollar infrastructure projects - such the Standard Gauge Railway, SGR, the Lamu Port, Southern Sudan-Ethiopia Transport Corridor, LAPSSET and Uganda-Tanzania oil pipeline – are also underway in the region. Consequently, East Africa's manufacturing industries need to position themselves to meet the stringent demands for high quality equipment and machinery for the oil and gas industry as well as meet the maintenance requirements of such an ultramodern infrastructure. The process benefits that will be realized from utilization of laser technology in East Africa's manufacturing industry include high productivity through high processing speeds, reproducibility of high product quality, and flexibility of manufacturing as the same laser source can be used for different production processes.

Key words: Laser technology, laser materials processing, cutting, welding, micromachining, surface hardening, surface cladding

INTRODUCTION

The East African Community (EAC) is a regional intergovernmental organisation of 6 Partner States: the Republics of Burundi, Kenya, Rwanda, South Sudan, the United Republic of Tanzania, and the Republic of Uganda, as shown on the map in Figure 1, with its headquarters in Arusha, Tanzania. The EAC is home to 150 million citizens, of which 22% is urban population; with a land area of 1.82 million square kilometres and a combined Gross

Domestic Product of US$ 146 billion (East African Community Secretariat, 2016), the realisation the renewed and reinvigorated EAC bears great strategic and geopolitical significance and prospects. The EAC aims at widening and deepening cooperation among member states in key spheres of national development, namely political, economic and social for mutual benefit of member states. (East African Community, 2016). Consequently, the national development strategies of each of the member states of the EAC have identified the manufacturing sector as one of the top priority areas for socio-economic transformation due to its potential to create jobs, generate foreign exchange, and attract foreign direct investment (Complete Vision Burundi 2025; Kenya Vision 2030; Rwanda Vision 2020; Uganda Vision 2040; and The Tanzania Development Vision 2025).

Figure 1 A map of the East African Community (Domestic Tourism Safaris Home)

The manufacturing sector is sub-divided into several sub-sectors including: food processing, and beverages (agro-industrial), refined petroleum products, textiles apparels and footwear, forest products, chemicals, machinery and equipment production, metal fabrication, rubber and plastics, furniture, etc. To meet the desired development goals and in an effort to raise productivity per unit of input (labor and capital) closer to international competitors, the manufacturing sector is expected to become more efficiency-driven by use state-of-the-art technology that is both efficient, cost-effective and environmentally-friendly. Consequently, the machinery and equipment production and general metal fabrication sub-sectors are expected to play a vital role in stimulating and boosting growth in other manufacturing sub-sectors through provision of the necessary high quality, efficient machinery and equipment. However, the machinery and equipment fabrication sub-sector is almost inexistent and this makes it difficult for the manufacturing sector in EAC member states to play a larger role in their economies. The factors that have contributed to the lack of competitiveness in the metal fabrication sub-sector include the inexistence of basic steel metallurgy industry, high input costs for imported raw materials, high cost and unreliable energy supply, lack of skilled labour, low quality products, low productivity levels compared to global productivity levels, inefficient flow of goods and services; and unfavourable business environment that is not conducive for investment in capital-intensive industries such steel production.

Laser technology is used worldwide in the areas of industrial manufacturing (i.e. laser material processing), communications, medical, lithography, optical Storage, military, R&D, Instrumentation, and Sensors, displays and printing. A high power laser is a CNC programmable versatile tool that is utilized in various industrial production processes - such as cutting, welding, surface treatment, marking, etc - resulting in an efficient non-contact automated process that produces high quality products. Different types of laser sources - differing in features such as operating wavelength, maximum output power, beam quality, and method of beam delivery - are now widely deployed in specific applications with realization of benefits in process performance, cost and product quality. The leading commercial types of lasers used in materials processing applications include: carbon dioxide (CO_2) laser, Nd-YAG laser, ytterbium (Yb) doped fiber laser, ytterbium (Yb) doped disk laser, and high-power diode lasers (Steen, 2003; Schopphoven, 2017; Ready 2001).

Laser technology in communications has been adopted in East Africa through the extension of the optical fibre networks that are being widely deployed by the telecommunications companies in the region. However, laser technology in manufacturing industry is not widely used in East Africa's industrial activities. Consequently, this paper explores potential laser applications prospects in East Africa's industrial manufacturing industry and the associated benefits that can be realized. The objective of this paper is to highlight the potential benefits of laser technology in East Africa's manufacturing sector and initiate an intellectual discussion on the role of laser materials processing in contributing to improving the global competitiveness of the nascent East Africa's manufacturing sector.

Types of Lasers Used in Manufacturing Industry

Lasers are used in the manufacturing industry in materials processing applications such as cutting and welding of metals, surface hardening and cladding of metals, joining of plastics, marking/engraving, drilling/micromachining, etc. Some of the laser characteristics that benefit the various laser materials processing applications include kilowatt output power, high beam quality, fiber optic beam delivery, and small footprint (compact laser systems). The common commercial lasers for materials processing include: CO_2 laser, Nd: YAG laser, fiber laser. Diode lasers are based on semiconductors (e.g. GaAlAs, InGaP, etc.) and emit light beam over spectral range of 375nm to 1600nm wavelength depending on the semiconductor compound material used; the main industrial application of diode lasers is pumping of other solid state lasers but they are increasingly also being directly used in materials processing applications (Belforte, 2014). Commercial lasers compete in the materials processing marketplace in terms of their operating wavelengths, maximum available output power, efficiency, technological improvements and designs, and new application prospects.

CO_2 Laser

The CO_2 laser emits a far infrared laser radiation of 10.6 μm wavelength and has overall efficiencies up to 30%. The different designs of the CO_2 laser - transverse flow (cross-flow) laser, fast-axial flow laser, diffusion-cooled slab laser and sealed-off laser, use different modes of gas flow and cooling, different orientations of the discharge electric field and gas pressure levels. This enables effective CO_2 laser beam outputs over a wide range of output power in CW mode or pulsed mode. The output power level that can reach tens of kW and the beam quality of the CO_2 laser is favorable for thin to thick section metal cutting and welding applications (Whitehouse, 1993; Anon, 2003, 2005; and Ready and Farson, 2001).

Nd: YAG Laser

The Nd: YAG laser is a solid-state laser consisting of a synthetic single crystal of yttrium-aluminum- garnet (YAG) that is doped with a low percentage of the rare earth neodymium (Nd^{3+}) ion and emits near-infrared laser radiation at a wavelength of 1.064 μm. Unlike CO_2

laser, the output beam quality of the Nd:YAG laser can be affected by the thermal lensing effects caused by variation in the optical characteristics of the YAG crystal rod with increasing output power which limits the output beam quality at high power levels. Nevertheless, the Nd:YAG laser finds wide application in sheet metal cutting of complex geometries especially in highly reflective sheet materials (Whitehouse, 1993; Kugler, 2001; and Ready and Farson, 2001).

Fiber Laser

The ytterbium fiber laser - operating at near-infrared spectral range (1060 – 1080 nm) - is a cladding-pumped optical fiber laser delivering a unique combination of kilowatt power output, high beam quality, and high wall plug efficiency; thus the fiber laser offers increased performance flexibility in materials processing applications than realized by the more traditional solid-state Nd:YAG laser (IPG Photonics, 2010; O'Neill, 2004; Canning, 2006). IPG Laser GmbH, a subsidiary of IPG Photonics Corp, provides high-brightness short pulsed lasers of up to 1 kW and CW lasers up to 10 kW average power in compact systems. IPG single-mode fiber lasers with outstanding wall-plug efficiencies of 40 % are delivered in compact 19" racks for YLR series up to 2 kW and in cabinet systems for the YLS series up to 10 kW are delivered (Streek, 2017). The high brightness fiber laser - with its combination of high beam quality and kilowatt power output coupled with its additional beneficial attribute of lower wavelength than the CO_2 laser - is now challenging the CO_2 laser in heavy industry laser materials processing applications. The fiber laser market is expanding due to its advantages in materials processing such as higher efficiency, higher beam quality and the ability to process highly reflective material (such as copper and copper alloys) which are difficult to process with the CO2 laser due to the high reflectivity and lower absorption of metals at CO_2 laser wavelength (Keller, 2017; Kliner, 2016)

Production Benefits of Laser Technology in Manufacturing Industry

The laser is used in various processes in manufacturing industry including sheet metal cutting, metal welding, and creation of wear resistant surfaces on components by surface treatment and cladding. Laser materials processing is a non-contact CNC controlled process that is integrated with the CAD and can be rapidly utilized in production of original parts and spare parts through rapid prototyping and also production of re-engineered spare parts through reverse engineering**.**

Production Benefits in Laser Cutting

Sheet metal cutting is an important process in the manufacture of many everyday products, such as household items like fridges, cookers, furniture; transport vessels like aircrafts, ships, cars, railways; industrial equipment and machines, etc. (Ion, 2005; and Ready and Farson, 2001). Traditionally, cutting of contours in the sheet metal is achieved by either mechanical cutting by use of mechanical tools to shear through the metal material or thermal cutting by use of a heat source (a flame or arc or beam) to melt the metal in a localized zone followed by removal of the melted material to create a cut. Sheet metal cutting using mechanical tools - e.g. power press or shear cutter - causes tool wear, deformation of delicate workpieces, dimensional inaccuracies, and generation of noise. Meanwhile, thermal cutting using conventional thermal energy sources - oxy-acetylene flame cutting or plasma arc cutting (PAC) - has shortcomings of excessive heat buildup in the workpiece which induces thermal stress in the workpiece resulting in distortions and unfavorable alteration of microstructure in the vicinity of the cut with subsequent undesirable modifications in material properties. Additionally, the thermal cutting using conventional thermal energy sources are limited in achievement of the actual dimensional tolerances. Laser beam cutting is a thermal sheet cutting processes that is capable of creating complex geometries in various metallic materials

and attain stringent design dimensional tolerances in a wide range of workpiece thickness with negligible heat buildup in the workpiece. The various commercial laser technologies - including CO_2 laser, Nd; YAG laser, ytterbium (Yb) doped fiber laser, and ytterbium (Yb) doped disk laser - are widely used in sheet metal cutting. The performance of the laser cutting process is influenced by a number of laser cutting parameters that can be optimized to obtain a good cut quality at maximum processing speeds (Sparkes, 2008; Sparkes, 2006; Himmer, 2007; Mahrle (2008), Wandera[a] and Kujanpää, 2010; Wandera[b] and Kujanpää, 2010; Wandera and Kujanpää, 2011; Wandera *et al.*, 2011; Wandera *et al.*, 2009). Thin to thick section precision cutting of various profiles in making components parts out of sheet and plate metal improves versatility in production of high quality equipment for the automotive industry, agro processing and increased production lead times.

David Larcombe reported that the UK based factory of trailer manufacturer, Indespension, has doubled their sheet metal cutting productivity by replacement of a CO_2 laser-powered cutting machine with a 4kW fibre laser powered profiling centre having a 6.5 × 2m capacity bed (shown in Figure 2) and costing approximately $1.3 million. Indespension's factory cuts mainly mild steel, and some aluminium, from 1mm to 12mm thickness and the fibre laser reportedly cuts three times faster than the CO_2 laser of equivalent capacity for up to 3mm sheet thickness. The fibre laser speed advantage reduces as the sheet thickness increases but overall the fibre laser cuts twice as fast as the CO_2 laser across all the sheet gauges processed thus enabling Indespension to manage their ever-increasing laser cutting workload. Investment in laser cutting enhances in-house control over production, saves expenses of subcontracting sheet metal work; and streamlines the design and prototyping process during product development and design change/modification enabling faster introduction of new products to market by reducing the lead time and costs for introducing a new or a modified product (Larcombe, 2017).

Laser-cut features are used extensively in trailer assembly and there are several benefits of incorporating laser machining in trailer manufacture. The laser machining process is so fast and accurate so that laser machined components fit together precisely and quickly during assembly without the need for time-consuming fitting-up. Laser machining also enables a cost-effective way of reducing weight of components by incorporating numerous holes and slots (see Figure 3) which would be too labour-intensive and uneconomical when done manually. Furthermore, laser machining allows nesting of similar parts or even different component parts within the same sheet when the sheet gauge for the parts is the same and allows a wide range of component sizes to over 5.8m. The operator can use a manual, suction-pad lifting system (shown in Figure 4) for sheet metal handling when loading blanks onto the shuttle cutting table or off-loading large size components. The laser machine control software contains 3D CAD/CAM functionality so a cutting program can be generated with full simulation capabilities, nesting of the maximum number of parts on a sheet, creation of cutting plans, and provision of an overview of the manufacturing process - including access to production and machine data - thus providing an increase in production capacity (Larcombe, 2017). The lasers are also used in creating slotted steel pipes used in the oil industry for oil exploration and heavy oil production whereby the laser cutting enables fast and easy piercing with high dimensional accuracy in creating slots in the steel pipes as illustrated in Figure 5. Heavy oil is relatively viscous and contains a significant amount of sand and gravel particulates. Therefore, the slotted steel pipes are used to line parts of a drilled oil well in the production zone so that oil flows through the slots into the pipe and up to the wellhead and the slots act as a sieve to exclude about 95% of the particulates (see Figure 5) (Rath and Gaebler, 2017).

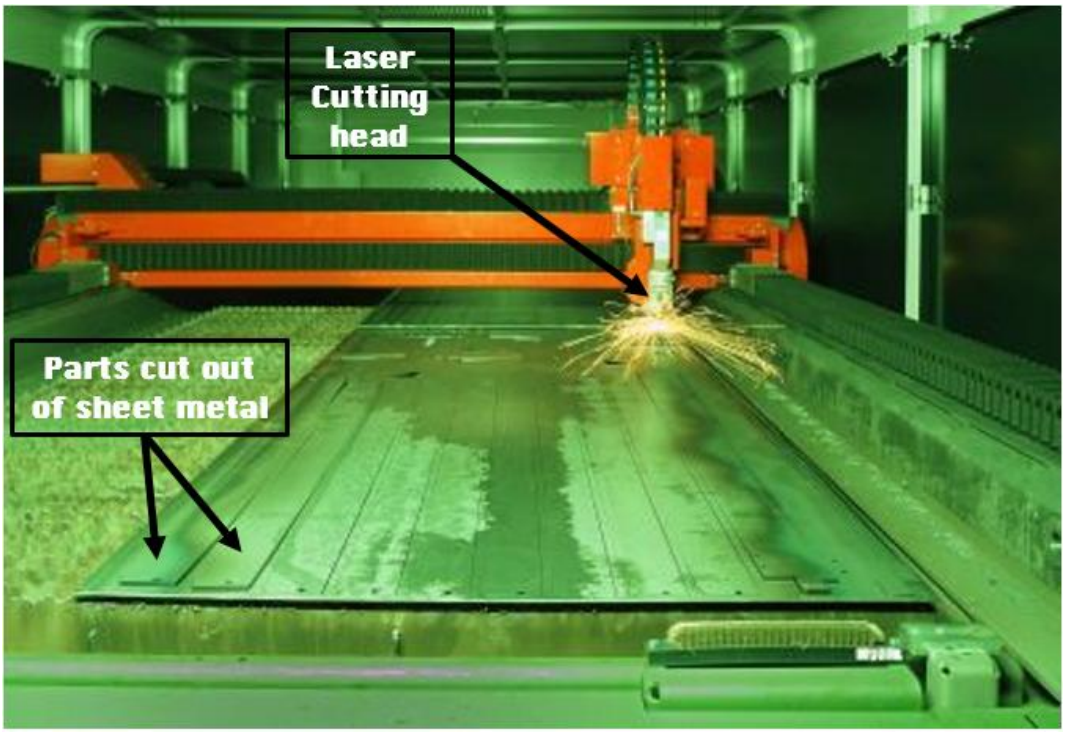

Figure 2 Laser Cutting Workstation (Larcombe, 2017)

Figure 3 Trailer body with sheet metal component parts having laser-cut holes and slots (Larcombe, 2017).

Figure 4 A suction-pad lifting system for manually transferring sheet metal on and off the laser cutting shuttle table (Larcombe, 2017).

Figure 5 A slotted steel pipe used in the oil industry for heavy oil production; the slots are created by laser cutting (Rath and Gaebler, 2017).

Production Benefits in Welding

The predominant use of laser welding in the automotive manufacturing industry is enhanced by the many benefits of laser welding such as high speed, high productivity, creation of very deep and narrow welds and low heat input leading to small heat affected zone and low residual stresses. During the laser welding process, changes in process parameters can affect the size and properties of a welded joint which effects may compromise the mechanical behavior of the welded component leading to failure in performance; therefore, monitoring and controlling the laser welding process ensures the quality of the weld. Lessmüller Lasertechnik in Germany has reported of an Optical Coherence Tomography (OCT) sensor 3D measuring system for real-time seam tracking during laser welding to enable consistent and high quality welds by facilitating laser beam positioning, process monitoring, and quality control with the required precision (Dupriez , 2017)

Production Benefits in Application of Wear Resistant Surfaces

Some machine components wear out while others corrode; therefore, refurbishment of worn machine parts by applying special coatings is an important procedure in operational and repair industries. Machine components operating under combined action of wear and corrosion as well as high temperature operating environment are usually refurbished to improve their wear and corrosion resistance. Various surface treatment methods - involving the use of heat to change the metallurgical properties of the surface - are used to improve the hardness, strength and fatigue life of components and also reduce friction and wear of parts by selective surface hardening. Some of the processes used to modify the surface properties of components, include: surface heat treatment, surface alloying, surface cladding, surface melting, surface texturing, etc (Ion, 2005). Cladding is a process for applying wear-resistant and corrosion-resistant metal coatings on machine components that are prone to wear and corrosion. The aim of the cladding operation is to produce a clad layer by overlaying a substrate metal with another metal (cladding metal) by forming a sound interfacial bond or weld between the two metals but without diluting the cladding metal with the substrate metal. During the cladding operation, the degree of mixing of the filler material with the base material has a significant impact on the chemical composition of the surface layer and its resulting mechanical properties. The presence of a significant amount of the base metal in a cladding layer leads to a reduction of the desirable operational (functional) properties - such as wear resistance and corrosion resistance - of the modified surface layer thus multiple layers of the coating material often must be applied if much of the coating material mixes with the base material. Therefore, the depth of fusion of the base material with the filler material should be regulated; the mixing ratio - represented by the ratio of area of molten underlying metal to the area of the entire molten metal in the fusing cross section - must be limited (Kargapoltsev, 2017).

Laser cladding of a component surface involves production of a wear resistant and corrosion resistant surface layer by introduction of a high quality powder filler metal under the action of a laser beam. Laser cladding is an innovative cladding technique applicable to a diverse range of metal alloys with quality and high speed benefits resulting in cost savings due to increased productivity and reduction in the cost of the clad layers. Laser cladding can be used for applying wear-protection coatings on large and small rotating parts by fusing metal powder on existing metal components under action of a directed laser beam such that the applied wear-resistant coating layer is metallurgically bonded to the underlying material with optimal adhesion but minimal structural intermixing. Wear resistance of surface layers formed by the laser cladding method exceeds the wear resistance of surface layers formed by other cladding methods, e.g. gas-flame melting, chrome plating, or high-velocity oxygen fuel spraying (thermal spraying), due to the specific conditions of crystallization and formation of a fine structure during the laser cladding process. Additionally, the efficiency and wear resistance of surface details renovated with the help of laser cladding have been shown to

exceed those of new surface details causing a reduction in labor costs for subsequent repair and improvement of reliability of the machines. The laser cladding method produces a high quality clad layer, reduces the amount of high-quality filler metal used for cladding the component surface and also significantly reduces the labor costs for production of spare parts. (Kargapoltsev, 2017)

High-speed laser cladding having a capability to reliably apply a coating on a metal component clamped on a lathe machine is a cost-efficient alternative to the more conventional cladding techniques such as chromium, flame spraying, and hard-facing. The melting process in laser cladding is optimized using enhanced optics and vision systems to monitor clad geometry, metallurgical properties, and temperature information in order to develop superior coating adhesion. Additionally, laser cladding is suited for rotating parts which are clamped on a fast rotating lathe and coated with chosen metallic layer to produce high quality coatings that increase the lifetime of components that are susceptible to wear. Typical laser cladding applications include application of clad layers on axles, shafts, bearings, tubes, crankshafts, rollers, wheels, etc; and typical cladding materials include nickel, stellites, and stainless steel alloys, with or without carbides. A state-of-the-art high-speed laser cladding installation can apply coatings on components up to 10m and 3500kg for diameters below 120 mm and up to 4m and 750kg when the diameter exceeds 120mm. Some examples of applications laser cladding in industry include 3D printing of gears in gearbox prototyping as reported by automotive supplier VCST in Belgium (see Figure 6), and laser cladding of extrusion screws for pet-food manufacturing by Vatis (See Figure 7) extends the lifetime of the extrusion screws by up to 300% compared with conventional hard-facing methods thus enabling considerable savings on maintenance and investment costs (Laser Cladding Venture, 2017). Researchers from the Fraunhofer Institute for Laser Technology ILT and RWTH Aachen University in Germany have reportedlydeveloped an extremely high-speed laser material deposition process (*known by its German acronym EHLA*) that is economical and eliminates drawbacks of conventional chrome plating or thermal spraying techniques; the EHLA process that permits high processing rates of 250 cm^2 per minute is shown in Figure 8. Laser material deposition allows for far thinner layers (between 0.5 and 1 millimeter) since laser material deposition requires considerably lower heat input compared to conventional processes (Schopphoven , 2017)

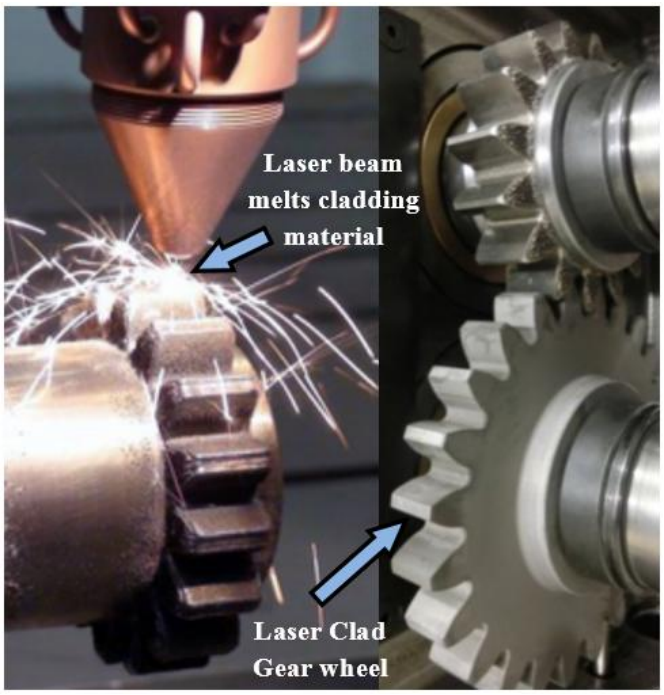

Figure 6. 3D printing of gears through laser cladding enables development of automotive gearbox concepts (Laser Cladding Venture (LCV), 2017).

Figure 7. Laser cladding of pet-food granulate extrusion screws extends screw lifetime (Laser Cladding Venture (LCV), 2017)

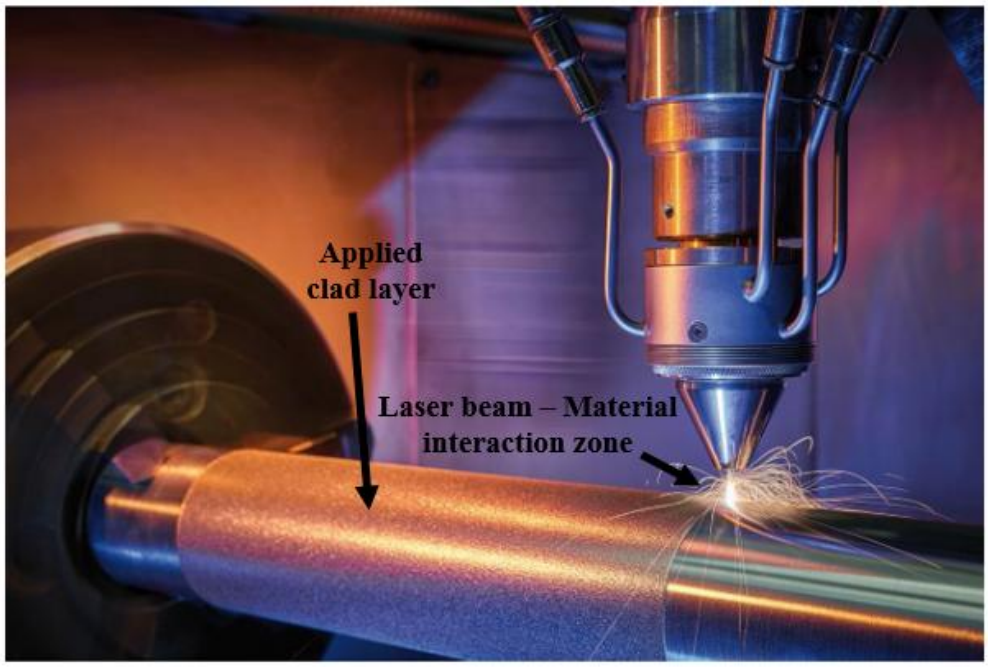

Figure 8. Coating of a piston rod using the EHLA process (Schopphoven, 2017)

East Africa's Industrial Development and Prospects for Laser Technology

Automotive Manufacturing Industry

Africa's automotive industry is expected to experience transitions in many countries, notwithstanding the slower economic growth rates in Africa in 2016 due to sustained lower oil and commodity prices. As key industries begin to emerge as drivers of Africa's economic growth and East Africa is emerging as the fastest growing region on the continent, the opportunities for Africa's automotive industry are looking increasingly attractive. In sub-Saharan Africa cities where the automotive market is relatively new and vehicle ownership still seems to have an aspirational value when compared to that of more mature European and American markets where car ownership concepts in congested cities is changing to car-pooling and ride sharing. Although Africa's automotive industry is relatively underdeveloped in comparison to Europe, Asia and North America, the improvements in local manufacturing, infrastructure development, and economic growth are increasing the continent's industrial prospects (Parker, 2017). Automotive manufacturing industry has a strong job multiplier effect in industry as research has shown that every automotive manufacturing job creates up to seven additional jobs (Centre for Automotive Research, 2015). It is also known that economies with established automotive sectors tend to be more economically complex in terms of the measure of knowledge translation into products made in the society resulting in more prosperity (Centre for International Development, 2016)

Kenya - with her growing economy, physical position and regional market access within the East African Community (EAC), and history of automotive assembly industry - is well positioned as a potential automotive manufacturing hub in the East African region (Deloitte, 2017). Uganda's Kiira Motors Corporation (KMC) is an automotive industry development initiative supported by the government through the presidential initiative on science and technology and is aimed at setting up and operating a vehicle assembly plant in Uganda (www.kiiramotors.com, 2017). There is demand for transportation in the various sectors including construction, mining, agri-business, tourism, energy, health, education, and retail sectors in East Africa; and government institutions in East Africa are significant buyers of new vehicles.

Although, Kenya's automotive market is largely focused on retail and distribution of vehicles, and after-sales support in servicing and sale of spare parts, Kenya also currently has three small scale motor vehicle assembly plants, which include: General Motors East Africa (GMEA) plant in Nairobi, Associated Vehicle Assemblers (AVA) plant in Mombasa, and Kenya Vehicle Manufacturers (KVM) plant in Thika. These three motor vehicle assembly plants are operating below their capacity as indicated in Table 1; however, counties in Kenya - such as Machakos County - have been lobbying investors to set up manufacturing hubs in their regions to provide employment and promote trade within their jurisdictions. Kenya's domestic automotive production is dominated by commercial vehicles; close to 10% of the 9,295 vehicles assembled in Kenya in 2015 were light commercial vehicles such as pick-up trucks, and the rest were heavy commercial vehicles such as trucks and buses. The motor vehicles assembly in Kenya grew by 31.4% from 2013 to 2014 with the highest growth being registered in the production of pick-ups followed by trucks and buses, respectively; and Kenya's growth in vehicle assembly is anticipated to almost double between 2013 and 2019. (Deloitte, 2017)

Table 1. Automotive Assembly Plants in Kenya, 2015 (Deloitte, 2017)

Plant	Location	Installed Annual Capacity	Operating Capacity (2015)	Ownership	Brands
GMEA	Nairobi	16,000	5,015	General Motors East Africa (100%)	Isuzu
AVA	Mombasa	10,000	4,168	Marshalls East Africa (50%) Simba Colt (50%)	Mitsubishi, Fuso, Scania, Toyota, Hino, Tata
KVM	Thika	6,000	202	Government of Kenya (35%) CMC Holdings (32.5%) DT Dobie (32.5%)	Eicher, Hyundai, Land Rover, MAN, Nissan, Mobius, Ashok Leyland

The 2010 National Industrialization Policy Framework of Kenya identified the automotive and auto parts industry as a major economic driver. In order to build up the Kenyan automotive industry, the framework specified five policy statements in-line with development of an automotive industrial park, provision of incentives to encourage locally assembled vehicles and production of auto parts, establishment of a national automotive industry committee, encouraging a local industry by imposing high tariffs on automotive components that could rather be manufactured locally, and setting up a joint venture with an established automotive manufacturer with a goal of domesticating the company (Deloitte, 2017). Furthermore, in 2015, the Kenyan Ministry of Industrialization proposed the Policy Framework for Motor Vehicle Assembly in Kenya to complement the National Industrialization Policy Framework with the aim of promoting new investments in the automotive industry and enhance Kenya's potential as a globally competitive vehicle manufacturer. The 2015 Motor Vehicle Assembly Policy Framework, like the National

Industrialization Policy Framework, aims at creating a National Automotive Council (NAC) which will be equipped to address aspects relating to the assembly and manufacture of vehicles, including capacity building and implementation of proposed incentives. However, the 2015 Motor Vehicle Assembly Policy Framework is specifically centered on the automotive industry with a structure to drive local production thus differing from the 2010 National Industrialization Policy Framework which focuses on industrialization as a whole and manufacturing more broadly. Furthermore, the East African Community (EAC) - in its draft East African Industrialization Strategy 2010-2030 released in 2010 - identified Kenya as a potential vehicle production hub for the region urging major car manufacturers that already imported vehicles into the region to produce locally. However, in consideration of 20 industries, the automotive assembly and vehicle spare parts manufacture was later identified as having the least growth potential in the region and was not included in the final EAC Industrialization Strategy 2012-2032. Nevertheless, automotive industry stakeholders recognize the opportunity of both the regional parts value chain as well as the EAC as a market for regionally produced vehicles and parts.[39] Products that are substantially transformed (i.e. from Completely Knocked Down state to full assembly state) within any of the East African Community (EAC) member states - Burundi, Kenya, Rwanda, Tanzania and Uganda - are to be sold on a duty-free basis in the other member states; and EAC member states in 2009 ratified a Common External Tariff (CET) of 25% on vehicles imported into the region with the aim of driving local assembly efforts. However, implementation of the CET was put on hold so other EAC countries continue to impose duties on vehicles assembled in Kenya with Tanzania and Uganda's argument being that Kenyan assembled vehicles do not abide by Tanzania and Uganda's local content requirement of 35% and thus do not qualify for duty-free access. Consequently, vehicles imported into the region are having an advantage over vehicles assembled regionally as cars imported into Uganda and Tanzania from Japan are cheaper than vehicles assembled in Kenya. (Deloitte, 2017) Regionally accepted definitions of local content, within the EAC, needs to be developed and aligned to the member states' automotive and manufacturing policies so as to enable establishment of an East African automotive manufacturing hub and export strategy. Additionally, development and promotion of auxiliary industries in partnership with automotive manufacture and assembly enables automotive companies to locally source high-quality inputs and meet the requirement for local content which further strengthens the case for local automotive assembly and marketing.

Frost and Sullivan identified manufacturing as one of the key future industries in Africa; automotive manufacturing and assembly has considerably promising prospects in Africa as the automotive manufacturers are adopting the practice of moving to produce vehicles within the African continent. This trend is primarily prompted by the local content promotion policies of countries - like Kenya and Nigeria - that have resulted in restrictions on imports of second-hand vehicles and heavy tariffs on new imported vehicles. Furthermore, the expanding transport infrastructure projects in East Africa are also expected to reveal greater logistics opportunities with significant increase in the demand for commercial vehicles in East Africa. (Parker, 2017)

Energy Sector

Improvement of the energy distribution systems have been identified as being a very critical in strategy for boosting the economy. Uganda is in the process of developing a number of new hydro power generation dams in various sites around the country including Bujagali dam, Karuma dam, Nsimbe dams. Furthermore, Uganda and Kenya have recently started to exploit their oil deposits and there are prospects of industrial growth in the region to service the oil sector as well as other sectors that will benefit from the oil proceeds. Tanzania has also developed their Natural Gas Utilization Master Plan 2016-2045 as an integral part of the

strategy for the implementation of the National Energy Policy 2015 which provides guidance on the utilization of the resources for improvement of infrastructures and human capital development in Tanzania. Consequently, the manufacturing sectors in these East African countries need to appropriately position themselves to meet the stringent demands for high quality equipment and machinery as well as meet the requirements equipment maintenance for high performance of the energy sector. (Kenya Vision 2030; Uganda Vision 20140; and the Tanzania Development Vision 2025)

Equipment manufacturers often use the laser in production processes such as profile cutting and welding of metals; the laser is often utilized in profile cutting of sheet and plate metal whereby a large number of parts are nested to improve material usage and avoid wastage. The laser is also used for maintenance and repair works involving surface hardening and surface cladding of worn out machine components. The process benefits that will be realized from utilization of laser technology in East Africa's manufacturing industry include high productivity through high processing speeds, reproducibility of high product quality, and flexibility of manufacturing as the same laser source can be used for different production processes.

Agro Processing Sector

A large proportion of East Africa's population is directly or indirectly engaged in agriculture as a source of their livelihood; therefore, the potential competitive advantage of the region lies in agro-industrial exports which require increased capacity for value addition in agro-based industries (Uganda Vision 20140). Therefore, there is need to attract strategic investors to boost agro-based industries in order to compete globally especially in new markets; the investments in agro-processing industry are expected to bring new skills and technologies for enhanced productivity and production of high quality products.

Transport Sector

One of the cross-cutting strategies that are critical for achievement of superior performance of the various sectors of the economy is improving transport infrastructure, such as ports, rail and highways. Kenya and Uganda (EAC, 2016), are in the process of reviving the high standard railways connecting the region for passenger and goods transportation across the region. Good examples are the Standard Gauge Railway and the Lamu Port and Lamu South Sudan Transport Corridor projects. This kind of projects involved heavy and expensive machinery that requires well-equipped installation for preventive maintenance and repair.

Mining Industry

The East African states are endowed with minerals - including gold, copper, iron ore, etc - that have not yet been optimally exploited for national gain. The mining sector is still undergoing development to improve efficiency and effectiveness of the mining operations (Uganda Vision 2040). The mining sector development requires improvement in the technologies and maintenance of the equipment used in the mining activities. Laser materials processes such as laser cladding and laser welding will be essential in ensuring efficient maintenance of mining equipment.

CONCLUSION

Despite the prospects for the manufacturing sector in the East African region, the sector is currently grappling with challenges in the areas of capital, skilled labour, and infrastructure. Additionally, the development of the manufacturing capacity of the East African region requires improvements in electricity access and improvements in transport infrastructure through both refurbishment and building new transport infrastructure. Therefore, the manufacturing sector will benefit from improved government policies promoting local manufacturing, private sector investment, infrastructure development, improved skills

development training programmes and facilities, and better business environments. Introduction of laser technology as enabling

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THE EFFECT OF GLASS POWDER AND FLY ASH ON MECHANICAL PROPERTIES OF RECYCLED REACTIVE POWDER CONCRETE AT STANDARD CURING

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Abstract

Today, the main emphasis of materials science in sustainable construction world is on enhancing the performance and functionality of conventional materials in environmentally friendly way using recent technologies and local materials. To address this issue, innovations on sustainable materials has been encouraged as a result of continual accumulation of different wastes and their consequent environmental complications due to population growth, global energy and excess materials use. The main objective of this experimental investigation is to study the influence of local wastes on mechanical properties of Recycled Reactive Powder Concrete (RRPC) at a standard curing for sustainable construction. In this study, finely dispersed local waste glass powder and fly ash were used in three different percentages (at 80-20%, 50-50% and 25-75%) as a raw material to replace silica fume fully for the development of RRPC. Moreover, waste ceramic powder was also utilized to replace Quartz powder fully. Locally available materials in Nairobi were used in this study to develop RRPC. Hand mixing was used throughout the entire study. Instead of steam curing at maximum temperature, standard curing method was employed at ambient temperatures. The performances of the three RRPC mixes were appraised in terms of compressive, split tensile and flexural strengths. The experimental results indicated that development of RRPC using hand mixing at standard curing from local wastes in this study was an interesting approach to solve raw material shortage for the current generation structural concrete, to fulfill the market demand of sustainable concrete products, to reduce waste disposal cost and related environmental issues. In this study, RRPC with an average compressive strength of 62.87 MPa were developed at standard curing by replacing silica fume fully with finely dispersed local waste glass powder and fly ash at 50%-50%. In general, 17.56% larger compressive strength can be produced compared to the control mix.

Keywords: Local Wastes, Recycled Reactive Powder Concrete, Mechanical Properties, Standard Curing, Sustainable Construction

INTRODUCTION

Today, innovations on sustainable construction materials have been encouraged as a result of continual accumulation of different local wastes and their consequent environmental complications. First and foremost, the rapid rise in concrete raw materials has led to serious environmental effects such as economical unbalances, resource shortage, biodiversity loss, habitat destruction, and desertification.

Moreover, it is also a challenge to produce high performance concrete for structural applications from locally produced waste materials since less costly components of conventional concrete are eliminated by more expensive elements (such as silica fume) to produce newly emerging concretes such as reactive powder concrete. In addition to this, waste disposal from different sources (industrial, agricultural areas, mining, households, etc.) in Africa have continued to be a complex challenge for the society, both environmentally and economically.

In view of rising raw material prices in the construction and threats of global climate change, waste management in the future needs efficient technologies. However, as per African Development Bank, surveys of waste management are essential for any future investments in equipment and technology to be sustainable (Palczynski, 2002). Globally, 90 billion tons solid wastes are expected to be generated annually by the year 2025 (Ajnavi, 2008). Likewise, based on the urban community consumption, the composition of wastes generated in East African urban centers is mainly decomposable solid waste materials (Okot-okumu, 2012).

In recent times, a new generation concrete called reactive powder concrete is under development as an ultra-dense mixture of water, Portland cement, silica fume, fine quartz sand, quartz powder, superplasticizer and steel fibers(Ahmad *et al.*, 2015; Bayard & Plé, 2003; Cheyrezy *et al*., 1995)through microstructural engineering (Bonneau *et al*., 2000).

Moreover, reactive powder concrete exhibits greatly ultra-high strength, improved durability and high toughness characteristics compared with traditional or even high performance concrete (Al-Attar *et al*., 2012; An *et al*., 2008). However, it is noticed that high Silica fume content is one of the characteristics of Reactive Powder Concretes (Cheyrezy et al., 1995) which is uneconomical for local construction. Chan and Chu also examines the effect of silica fume on steel fiber bond characteristics in RPC and investigates that the optimal silica fume content is between 20% and 30% (Chan & Chu, 2004) in which this quantity within the mix may lead to uneconomical mix.

In most African Countries including the East African countries where this study focuses, silica fume for local concrete work is imported from Middle East, Asian and other foreign suppliers which are too expensive. Beside its availability problems, usage of silica fume highly affects the concrete production costs. Furthermore, application of Reactive Powder Concrete for local construction activities has limitations due to its energy-consuming during the heat curing process and the milling of quartz sand (Gu *et al*., 2015). To solve these problems, locally available wastes were proposed in this study to reduce the silica fume requirement and related cost.

A number of studies have been studied on wastes to develop Reactive Powder Concrete (RPC) by replacing silica fume. Among those studies, Zhn and his associates(Zhu et al., 2016) investigated usage of recycled powder produced from waste of clay bricks with cement solids to develop environmentally-friendly and cost-saving RPC by replacing silica fume at 20%, 40%, 60%, 80% and 100% by weight. Accordingly, the results showed that as the replacement rate of silica fume in RPC by recycled powder increased, the compressive and

flexural strengths were tended to decrease, the shrinkage reduced, and the chloride-penetration resistance of RPC decreased.

It was also observed that RPC containing high volume ground granulated blast furnace slag (GGBFS) for replacement of silica fume has been producing a compressive strength of over 250 MPa after autoclaving which was a satisfactory mechanical performance. Additionally, the amount of silica fume were decreased with increasing amount of GGBFS (Yazici *et al*., 2010).

Thus, the magnitude and nature of waste generated across the world have prompted the need for innovative way of changing the environment and using its resources in a better way (Adebayo *et al*., 2014). Presently, reusing and recycling of wastes by proper management for conservation of natural resources in environmentally and economically sustainable ways is becoming one of the principal strategies for waste management (Safiuddin *et al*., 2010). Hence, by utilizing local wastes, one can attain an innovative strategy for multidimensional advantages in the construction industry.

In this study, to address the environmental as well as cost-related problems and to encourage innovations on sustainable materials, waste fly ash from the cement industries, finely dispersed waste glass powder and waste ceramic powder from construction sites were proposed as a result of continual accumulation of wastes in the East African region to solve their consequent environmental complications. Recycled Reactive Powder Concrete (RRPC) is developed by utilization of the proposed local wastes as full replacements of silica fume to evaluate the mechanical properties through experimental investigations. The replacement is made at three different proportions as ecofriendly material for future Civil Engineering projects.

METHODS

Materials

In this study, 42.5 N Portland cement, fine sand, finely dispersed waste ceramic powder, finely dispersed waste glass powder, fly ash, steel fibers, superplasticiser and water available around Nairobi area were used for the development of RRPC mix and for the entire tests.

Portland cement and waste fly ash were collected from Bamburi Cement Limited in Nairobi.For this study, fine sands obtained from Meru, Kenya and passing 600µm standard sieve size were used in all the mixtures and used in dry condition. Additionally, locally available waved wire steel fibres of 50 mm length with 0.22 mm thickness from Steel Wall Africa Nairobi branch were used for development of RRPC. Commercially available superplasticiser supplied by SIKA® Company Kenya Limited in Nairobi were used to attain workability. The ordinary drinking water was also used for preparation of the desired concrete mix following British Standard(BS EN-1008, 2002). Experimental results are presented comparatively with the control mix. To develop the control mix, MasterRoc MS 610 type densified Silica fume was used from BASF East Africa LTD in Nairobi.

For this study, waste ceramic and waste glass were collected from construction sites and crushed both through man power and crushing machine in Jomo Kenyatta University

Engineering Workshop. The chemical compositions of all raw materials were characterized in Kenya Ministry of Mining using X-ray fluorescence (XRF) machine.

Mix Design of RRPC Mixtures

For this study, RRPC was developed through preliminary tests based on the existing mix proportions of RPC by replacing the silica fume and quartz powder in full version by local waste materials (Ahmad *et al.*, 2015; Bayard & Plé, 2003; Cheyrezy *et al.*, 1995; Kushartomo, Bali, & Sulaiman, 2015). On one side, finely dispersed waste glasses together with fly ash were proposed to replace silica fume fully. Additionally, quartz powder was replaced by finely dispersed local waste ceramic powder. Since the mix design was employed using this three local waste materials together with other core raw materials, the name "Recycled Reactive Powder Concrete" was given for the concrete mixture.

Moreover, to replace silica fume fully, waste fly ash and finely dispersed waste glass powder were composed at 20-80%, 50-50% and 75-25% of the full silica fume weight respectively in three series (Table 1). The control mix was developed from silica fume, Portland cement (42.5N), finely dispersed waste ceramic powder, superplasticizer, fine sand, water and steel fibers. For all mixes, hand mixing, standard water curing and uniform water-binder ratio of 0.216 were used.

Hence, based on previous practices and preliminary laboratory works, the mix proportions described in Table 1 were employed for development of RRPC and for evaluation of the entire mechanical properties.

Table 1 Mix Proportions for 0.009 [M^3]

Mix Series	Cement (Kg)	Waste Ceramic Powder (kg)	Waste Glass Powder (kg)	Fly Ash (kg)	Fine Sand (kg)	Superplastcizer (kg)	Water (kg)	Steel Fibers (kg)	Silica Fume (kg)
Control	7.58	1.52			8.34	0.23	1.52	1.04	1.89
Series 1	7.58	1.52	1.52	0.38	8.34	0.23	1.52	1.04	
Series 2	7.58	1.52	0.95	0.95	8.34	0.23	1.52	1.04	
Series 3	7.58	1.52	0.47	1.42	8.34	0.23	1.52	1.04	

Specimen Preparation, Curing ProcedureandTesting of Specimens

For this study, watertight and non-absorbent 100X100X100 mm^3 cube, 100x200 mm^3 cylinder and 150x150x550mm^3 prism moulds were prepared. Then, RRPC specimens were prepared following BS standard, the methods for making and curing test specimens for strength tests(BS EN 12390-1 (2000); BS EN 12390-2 (2000)).

Hand mixing was employed throughout the entire specimen preparations. Standard curing of the test specimens were done till testing days for 28 days in water at a temperature of 20°C ± 2°C instead of steam curing at high temperature in conventional RPC.

Before placing the test specimens centrally in the testing machine, any excess moisture from the surface of the specimen were wiped. Then, three specimens were tested for the mechanical properties of RRPC as per the British Standard testing procedure for hardened concrete in Jomo Kenyatta University Structural Engineering laboratoryat the age of 28 days of standard water curing and the average values were reported(BS EN 12390-3 (2002); BS EN 12390-5 (2000); BS EN 12390-6 (2000)).

RESULTS AND DISCUSSION

For this study, 100X100X100 mm^3 cube, 100x200 mm^3 cylinder and 150x150x550mm^3 prism specimens were prepared for compressive strength, split tensile strength and flexural strength respectively.

The mean strength values of the three RRPC specimens produced from four categories (including control mix) were presented in Table2 and mode of crushing was observed in Figure 1.

After standard curing of 28^{th} days, 12.8% rise in compressive strengths were observed using 20% fly ash (FA) and 80% finely dispersed glass powder (GP) in the first seriescompared to the control mix. Similarly, the mean compressive strength was increased by 17.6% and 15.7% for mix series 2 and 3 respectively compared to the control mix at 28^{th} days standard curing.

Table 2 RRPC Test results at 28 days standard curing

Parameter	Series 1 (20%FA-80%GP)	Series 2 (50%FA-50%GP)	Series 3 (75%FA-25%GP)	Control
Mean Compressive Strength (MPa)	59.41	62.87	61.47	51.83
Mean Split Tensile Strength (MPa)	4.76	4.75	4.77	4.76
Mean Flexural Strength (MPa)	8.43	8.84	8.25	6.13




Figure 1 Compressive Strength test in laboratory Figure 2 Tensile Splitting strength test in laboratory

Figure 3 Flexural Strength test in the laboratory

Compared to the control mix, higher compressive strengths were attributed in the whole RRPC mix series. Considering the 28th days curing age, a maximum mean compressive strength of 62.87MPa were observed using 50% fly ash (FA) and 50% finely dispersed glass powder (GP); whereas in the control mix, 51.83MPa compressive strength, which lowers by 17.56%, were produced using MasterRoc MS 610 silica fume.

In addition to compressive strength, the effect of fly ash and glass powder on the performance of RRPC was evaluated by determining the tensile splitting strength of cylindrical specimens using the above series of mix proportions. The experimental results of tensile splitting strength for 28 days standard curing were presented in Table 2. Sample crushed cylindrical specimens with their failure mode were also shown in Figure 2.The test results show that RRPC produced using fly ash and glass powder can produce a maximum average tensile splitting strength of 4.773 MPa at 28th day's standard curing using 75% fly ash (FA) and 25% finely dispersed glass powder (GP) mix proportion. This maximum strength was higher than the control mix by 0.27%.

Table 2 and Figure 3 shows the flexural strength of RRPC beams with different percentages of fly ash and finely dispersed glass powder. From Table 2, a maximum flexural strength 8.8MPa was observed using series 2 mix proportion. Compared to the mix control, 30.6% was improved using the series.

The strength variation at each series of RRPC mix is due to the percentages of fly ash and glass powder in each series. However, thesestrength values were very low compared to the normal Reactive Powder concrete that was produced by Silica fume, quartz powder, very fine steel fibres using machine mixing and stem curing at high temperature. As shown in the earlier study (Kushartomo et al., 2015), by introducing 10%, 20% and 30% of glass powder to replace quartz powder, a Reactive Powder Concrete with 97.4MPa, 136.1MPa and 83.9MPa compressive strength; 14.4, 17.8 and 16.6MPa split tensile as well as 20.3, 23.2, 22.6 MPaflexural strength were produced respectively after 14 days of stem curing. Hence,

compared to the three percentages, maximum strength was obtained using 20% glass powder content.

The result obtained by theabove scholar is also true for this study with respect to the ratio of glass powder. There will be higher strength with respect to using higher amount of finely dispersed glass powder.

CONCLUSION

This study tries to use finely dispersed waste glass powder in combination with fly ash for silica fume replacement as well as finely dispersed waste ceramic powder for quartz powder replacement in full version for the development of Recycled Reactive Powder Concrete (RRPC). Based on the experimental results, the following conclusions can be drawn:

1) as a waste material and reuse for current generation concrete production, the finely dispersed glass powder, waste ceramic powder and fly ash revealed a wonderful pozzolanic property that can greatly affect the long-term performance of RRPC product;
2) In most mix proportion series, higher early mechanical strength was observed with increasing of finely dispersed glass powder;
3) The optimal FA-GP content in most mix proportion series for getting higher mechanical strength is by replacing silica fume fully is 50%FA-50%GP;
4) a maximum mean compressive strength of 62.87MPa at 28^{th} days curing age can be produced using 50% fly ash (FA) and 50% finely dispersed glass powder (GP) combinations. Compared to the control mix, 17.56% larger compressive strength can be achieved using 50FA-50GP Mix series.

In general, development of RRPC using hand mixing at standard curing from local wastes in this study was an interesting approach to solve raw material shortage for the current generation structural concrete, to fulfill the market demand of sustainable concrete products, to reduce waste disposal cost and related environmental issues.

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CLINICAL LEARNING EXPERIENCES: A STUDY AMONG UNDERGRADUATE NURSING STUDENTS, KENYA

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Abstract

Nursing education is an art and science which is practically oriented and skilled based course. For one to be a nursing professional, certain practical hours are mandatory to enable gaining knowledge in practical skills. Quality training is achieved if the clinical learning environment is conducive. There have been challenges in different settings regarding the clinical learning environment.

This was a descriptive cross-sectional study carried out among first to fourth year nursing students of Dedan Kimathi University of technology immediately after their clinical placement. Stratified sampling was used to obtain a sample size of 74 students. A self-administered questionnaire was used. Data was entered into an excel sheet. Data analysis was done using Stata version 11 software and descriptive statistics were reported. Presentation was done using Tables and Figures.

More than half of the students (66.7%) agreed that nursing was an enjoyable profession. And they enjoyed learning in the clinical environment. Those who received individual supervision from their clinical instructors and the ward staff were 59.2%. The ward provided a positive environment for learning for the majority (83.5%). Although most of the students (73.3%) intended to remain in the nursing profession after graduating, 14.6% did not intend.

The clinical learning environment is a stimulant in the nursing students' learning process. Individual supervision should be strengthened to enhance student learning.

Keywords: Nursing, clinical learning environment, supervision, clinical assessment, clinical instructor

INTRODUCTION

Nursing is a profession that is clinically oriented. In the nursing curriculum, more hours are allocated to clinical learning as compared to the theoretical learning since this is a skill-based course. For a nursing programme to be effective, clinical learning should be well organized (Nyangena, Mutema, & and Karani, 2011). Having conducive clinical environment is key in ensuring the success in the teaching/ learning among the nursing students. Once students have learned the nursing skills theoretically, having a clinical exposure is paramount in enhancing the skill learning (Jamshidi *et al*., 2016). Assessment of the clinical nursing environment is a step towards evaluation of the curriculum 2016). For quality care of patients to be achieved among the nurses, the students should be adequately prepared both theoretically and through clinical experiences. Clinical training provided by training institution is Kenya is of high quality (Nyangena *et al*., 2011).

Using the clinical learning environment assessment tool (Henriksen *et al*., 2012), the parameters evaluated include the nursing profession from the student's perspective, the pedagogical environment, the leadership style of the ward manager, premises of the nursing ward that is the physical space and the supervisor-student relationship. Other factors which affect student clinical learning include psychosocial and interaction factors and the organizational culture (Flott & Linden, 2015).

Effective learning in the clinical areas involves supervision and mentoring and also providing a feedback to the students (Mwai, 2014). In the clinical areas, especially if the students are being placed for the first time, there is always anxiety among them (Melincavage, 2011). This is the reason why they should have supportive mentors and clinical supervisors. Evidence indicates that supportive relationships provides positive learning outcomes and positive clinical learning experiences among the students (Ochieng & Kaseje, 2015). Having a mutual relationship with the clinical supervisors will enable them to freely interact, thus acquire knowledge and skills with ease. The clinical environment provides an opportunity for the students to learn the nursing culture, therefore it should be conducive (Gilbert & Brown, 2015). This includes the aspect of providing compassionate care

In Kenya, training of nursing students is very intensive since the course at the undergraduate level enables the students to graduate having learned about the general nursing procedures, midwifery and community health. The course takes duration of four years. This means that the students have limited time in the clinical areas to perfect their skills in all the key areas. This calls for critical supervision during the time of clinical placement. One way of ensuring success in the clinical learning is through feedback from the students (Sercekus & Baskale, 2016).

A study to assess gaps in clinical instruction among nursing students established that lack of supervision, delayed feedback from nurses and nurses' organization in their work affected the student's learning (Kaloki, Mwenda, & Omondi, 2016). Sometimes the clinical mentors are not adequately prepared to take up of mentorship while other times they feel the students should work on their learning rather being 'spoon-fed'(Emanuel & Pryce-Miller, 2013). This study sought to evaluate the clinical environment's suitability for providing conducive learning environment for the Bachelor of Science in nursing students of Dedan Kimathi University of Technology in Nyeri, Kenya.

METHODOLOGY

This was a descriptive cross – sectional study employing quantitative methods. A self-administered questionnaire was used to collect data from the students immediately after their clinical placement. The study was carried out among students who had undergone their placement in Nyeri County referral hospital, Karatina sub-County hospital, Nyahururu sub-County hospital, Kerugoya County referral hospital and Nanyuki teaching and referral hospital. One health centre, Gichiche was also included. The students were on different placements while in the clinical area which included out patient, medical-surgical wards, paediatric wards, maternity, theatre, maternal child health clinics, casualty department, mental health and psychiatry wards and the specialized units. A sample size of 74 respondents was used. The respondents were selected using stratified sampling to obtain a representative sample from each year. Authority to collect data was sought from the University management. Informed voluntary consent was sought from the respondents and the obtained information treated with utmost confidentiality. Anonymity was maintained by using coded numbers on the questionnaires instead of using the names of the respondents.

RESULTS

The study was carried out among first, second, third and fourth year students after completion of clinical placements. The hospitals used for the clinical placements were Nyeri County referral hospital, Nanyuki teaching and referral hospital, Nyahururu sub-county hospital, Kerugoya County referral hospital, Karatina sub-County hospital and Gichiche health centre. A total of 74 students participated in the study. The students were distributed per class as shown on figure 1 below:

Variable	**Frequency (n)**	**Percentage (%)**
The nursing profession is the most enjoyable		
Fully disagree	3	4.2
Disagree to some extent	7	9.7
Neither agree nor disagree	14	19.4
Agree to some extent	29	40.3
Fully agree	19	26.4
I enjoyed being in the clinical area		
Fully disagree	6	8.3
Disagree to some extent	7	9.7
Neither agree nor disagree	4	5.6
Agree to some extent	26	36.1
Fully agree	29	40.3
I always wished my shift ended because it was boring		
Fully disagree	20	27.8
Disagree to some extent	18	25
Neither agree nor disagree	12	16.7
Agree to some extent	14	19.4
Fully agree	8	11.1
Given an opportunity, I will always like to be in the clinical area		
Fully disagree	4	5.6
Disagree to some extent	11	15.3
Neither agree nor disagree	13	18.1
Agree to some extent	22	30.6
Fully agree	22	30.6

Figure 1: Distrubution of students per the year of study

Perception of the Nursing profession

Most of the students (40.3%) agreed to some extent that the nursing profession was enjoyable. More than half of them disagreed that it was boring to be in the clinical area. Over 60% of the students agreed that given an opportunity, they would always wish to be in the clinical area. The findings are illustrated in table 1.

Table 1: Perception of the nursing students on the nursing profession

Pedagogical atmosphere

Most students felt comfortable going to the ward at the start of their shift. Those who fully disagreed or disagreed to some extent were 5.5% and 8.2% respectively. Concerning students participating in the discussions during staff meetings, most of them fully agreed or agreed to some extent that they would participate freely in the discussion. Majority of the students (70.4%) agreed to some extent or fully agreed that there was a positive environment in the ward.

Staff – student relationship

More than half of the students (61.1%) fully agreed or agreed to some extent that the staff were generally interested in supervising them during the clinical placements. The staff learned to know the students by their personal names and majority of the students (83.6%) agreed to this as shown in figure 2.

Figure 2: Staff – student relationship in the clinical environment

The clinical learning environment

There were sufficient meaningful learning situations on the ward	**Frequency (n)**	**Percentage (%)**
Fully disagree	2	2.8
Disagree to some extent	4	5.6
Neither agree nor disagree	8	11.3
Agree to some extent	28	39.4
Fully agree	29	40.9
The learning situations were multi-dimensional in terms of content		
Fully disagree	1	1.4
Disagree to some extent	4	5.7
Neither agree nor disagree	10	14.3
Agree to some extent	33	47.1
Fully agree	22	31.4
The ward can be regarded as a good learning environment		
Fully disagree	1	1.4
Disagree to some extent	6	8.2
Neither agree nor disagree	5	6.9
Agree to some extent	32	43.8
Fully agree	29	39.7

Most of the students (80.3%) agreed that there was sufficient meaningful learning in the ward. Learning was multi-dimensional in terms of content as agreed by 78.5% of the students. The ward was a good learning environment as fully agreed or agreed to some extent by the majority (83.5%). The findings are illustrated in Table 2.

Table 2: The clinical environment situation

Leadership style of the ward manager

Most of the students (69.4%) agreed that the ward manager regarded student as a key resource while 13.9% were neutral. As a team member, majority of the students (74.3%) agreed that the ward manager was a team member while some of them (14.3%) disagreed. Regarding feedback from the supervisor, more than half of the students considered it a learning situation while 19.1% disagreed fully or to some extent. Most of the students (69.5%) agreed that their effort was appreciated by the staff in the ward, 20.8% disagreed while 9.7% neither agreed nor disagreed.

Premises of nursing on the ward

Regarding the ward's philosophy, most of the students agreed that it was clearly defined. According to most of the students (71.8%), the patients received individual nursing care. Although 59.7% of the students agreed that there were no problems in information flow to patients, 41.3% of them disagreed or neither agreed nor disagreed about it. Documentation of the nursing procedures was clear as indicated by 84.7% of the students (Table 3).

Table 3: The nursing philosophy in the clinical environment

The ward's nursing philosophy was clearly defined	**Frequency (n)**	**Percentage (%)**
Fully disagree	9	12.3
Disagree to some extent	4	5.5

Neither agree nor disagree	14	19.2
Agree to some extent	25	34.3
Fully agree	21	28.8
Patients received individual nursing care		
Fully disagree	5	7
Disagree to some extent	8	11.3
Neither agree nor disagree	7	9.9
Agree to some extent	28	39.4
Fully agree	23	32.4
There were no problems in the information flow related to patients' care		
Fully disagree	2	2.8
Disagree to some extent	13	18.1
Neither agree nor disagree	14	19.4
Agree to some extent	24	33.3
Fully agree	19	26.4
Documentation of nursing (e.g. nursing plans, daily recording of nursing procedures, etc.) was clear		
Fully disagree	2	2.8
Disagree to some extent	2	2.8
Neither agree nor disagree	7	9.7
Agree to some extent	28	38.9
Fully agree	33	45.8

The content of supervisory relationship

The students who agreed that their clinical instructor showed a positive attitude towards supervision were 65.7% while 23.3% fully disagreed or disagreed to some extent about the positive attitude of their clinical instructor. Those who received individual supervision were 59.2% while 25.3% did not receive. Continuous feedback was provided to 63% of the students by their clinical instructor. Overly, 70.9% of the students were satisfied with the supervision they received while 16.7% were dissatisfied (Figure 3).

Figure 3: Content of supervisory relationship

Supervision relationship

The supervision was based on a relationship of equality and promoted the students' learning and this was according to 70.8% of student who fully or to some extent agreed. 67.1% of students agreed that there was a mutual interaction in supervisory relationship. 74% agreed there was mutual respect and approval that prevailed in the supervisory relationship. In addition, half of the students agreed that the supervisory relationship was characterized by a sense of trust.

Perception of finalist students

Most of the students enjoyed being in the nursing profession and believed that the programme had adequately prepared them to be a BScN as agreed by 82.9%. Majority of them (73.2%) intended to remain in the nursing profession after qualifying and 75.7% would recommend the programme to someone else.

In addition, some of the comments raised by students that portrayed a good experiences and positive attitudes from clinical environments were the following:
"Clinical placement was generally good since there was conducive environment for learning and gaining clinical experience which will equip one to be a potential and competent BScN Nurse".
"It was a blossom experience being in clinical placement".
"The clinical experience was great was great"
"It was a good experience despite few challenges"
"The clinical experience was great and the staff/mentor were great and ready to help us"

There were few comments that highlighted challenges they experienced as well as the aspects of the environment that were not good. These comments were as follows;

"Somehow the mentor was harsh to students especially Kimathi students".
"Respect for students in the hospital by the senior nurses should be upheld".
"Bulling is real. This makes others hate nursing".

DISCUSSION

Clinical practice is essential to nursing education as it provides experience with patients and work environments that prepare students for future work as nurses. Satisfaction of students could be used as an important contributing factor towards the development of clinical learning environments in order to satisfy the needs and expectations of students.(Papastavrou et al., 2016) To assess clinical practice five parameters in clinical environment were evaluated in this study which included: the nursing profession from the student's perspective, the pedagogical environment, the leadership style of the ward manager, premises of the nursing ward that is the physical space and the supervisor-student relationship.

Students perspective of nursing profession was positive as majority of student agreed both fully and to some extent that nursing profession was enjoyable and that they enjoyed being in the clinical areas. This is in agreement with study done by (Sundler *et al.*, , 2014) and (Rehman *et al.*, , 2016) who found nursing students to have a positive perception on nursing profession. This was also reflected by finalist students who agreed that they enjoyed the nursing programme, felt prepared, and would remain in nursing profession as well as recommend the programme to others.

Many students agreed that the pedagogical atmosphere in the wards was conducive for learning and during staff meeting they were free to discuss. This is very significant as it enhances student preparation for the professional nurse role as well as improving confidence in the students and facilitating their learning. These finding agrees with findings by(Flott & Linden, 2015) who found clinical environment to promote student learning. Pedagogical environment often determine achievement of learning outcomes and student self-confidence. From comments made by students it was also noted that the environment was conducive.

Leadership style of ward manager can largely influence student learning and in this study it emerged strongly that student were positively influenced by ward in charges in that, majority of students agreed that the ward in charge regarded them as key resource, was a team member and appreciated their individual efforts. In addition majority of students agreed that feedback from the ward manager could easily be considered a learning situation which is a positive attribute for a ward in charge and portrays a supportive interpersonal relationship. This findings are in line with (Ochieng & Kaseje, 2015), who also found leadership style to influence student learning in clinical environment and (Betty et al., 2017) who found student nurses to have a good interpersonal relationships with the in-charges.

To document on the premises of the nursing ward, this study found out that standardized nursing practice is being adhered to in the clinical environment as majority of students agreed that patient receives individualized care and nursing procedures are well documented. This is a positive attribute toward student learning as it provides the learner with the best practical approach to provide standardized care as required. This attributes were also described by (Flott & Linden, 2015) and were found to affect student learning experiences.

Supervisor student relationship is vital in influencing student learning, in this study there was a positive relationship between the supervisors and students as majority of students agreed that their relationship with supervisors involved mutual interaction with respect and approval and these relationship promoted their learning. In addition most of the students were satisfied with the supervision they received. Similar finding were found by (Betty.M *et al*., 2017) who also found good relationship of students nurses with their supervisors. Although the findings did not reflect conclusion made by (Jamshidi et al., 2016) where students reported being discriminated in the clinical areas which contributed to poor relationships, there was a general comment by two of the participant in this study that may portray a similar finding. The students mentioned. "The clinical experience was great but somehow the mentor was harsh to students especially Kimathi students" and "Respect for students in the hospital by the senior nurses should be upheld. Bulling is real. This makes others hate nursing". Such comment may signify poor relationship which may consequently affect student learning in the clinical environment.

CONCLUSION AND RECOMMENDATIONS

The clinical learning environment is a stimulant in the nursing students' learning process and students are satisfied with various clinical environments they are placed in with few challenges.

It is therefore recommended that effort be scaled up to continue promoting student learning and feedback be given to clinical areas environment so as to support and recognise the efforts as well as address the few challenges mentioned.

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HEALTH INFORMATION SEEKING BEHAVIOURS AMONG HEALTH PROFESSIONALS IN PUBLIC HEALTH FACILITIES IN MARGINALIZED AREAS, KENYA

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Abstract

Information is inevitable in the health profession. Need to become informed and knowledgeable which leads to "information seeking behaviour processes" is an important among qualified health professionals (HPs) who have vital roles in achieving health goals of a given country. However, in Kenya, little effort have been made in understanding the information seeking behaviours of HPs compared to effort made towards developing new information technologies.

Therefore, the general objective of this study was to assess information seeking behaviours among health professionals in public health facilities in Garissa County.

The study used a cross-sectional study design employing mixed methods of data collection. Stratified sampling was used to select a study sample of 222 health professionals who had given informed consent to participate in the study. The study was conducted in Garissa County, Kenya.

The main information resources used by health professionals were informal resources (51.4%). The main information sought was updates on new health issues. The type of health information sought varied across professions. Most of the health professionals (86%) sought health information when need arises. Health professionals have no funds allocated to help address information needs of the health professionals.

Information plays a critical role in provision of quality and responsive health care. There is little effort done to understand information behaviours and address information needs of health professionals especially in marginalized areas. This has led to over-reliance on informal resources which are prone to source bias and quality-related problems. This point to the need of concerted policy and managerial efforts aimed at investing in positive health information seeking behaviours among health professionals to improve evidence-based care delivery.

Keywords: Health seeking behaviour, health professionals, information needs, information resources

INTRODUCTION

Information is inevitable in the health profession. The need to become informed and knowledgeable individuals is important among qualified health care professionals (HCPs) who have vital roles in achieving health goals of a given country (Pakenham-Walsh & Bukachi, 2009). Updating knowledge with relevant information is very important for health care professionals to deliver quality and sustainable health care services to their consumers. This is possible only when ther.e is a sustainable access to information resources (HIRs) in health facilities (Ghebre, 2005).

Information is important to improve knowledge based on which evidence-based decision is made to serve the clients of health facilities. Access to information facilitates the use of new medical technologies, proper handling of the necessary medical procedures and treatment of patients. Proper information management brings health workers to act harmoniously in a similar manner on medical and health practice (Dubow & Chetley, 2011). Information needs and seeking behaviour varies among HPs working in rural and urban areas due limited access to information outlets (Mohamed, 2009). Internet use, access to library, provision of training on use of audios and videos displays were the main means used to provide information to the users (Garcia, 2010).

The use of information may vary depending on circumstances. The need reaches pick during emergencies. Information needs of health professionals had become more urgent and mandatory due to the emergency of new infectious diseases like severe acute respiratory syndrome (SARS), Asian bird flu, HIV/AIDS, malaria and tuberculosis. It was also due to the increasing concern of bioterrorism (spreading anthrax spores via the US Postal Service in 2001) (LaPelle *et al,* 2006). Currently, resource limited countries face several health challenges that threaten the lives of millions of people (Ojo, 2006).

Lack of information communication creates such situations that produce medical errors, which are common in health facilities. This situation has the potential to cause miss-diagnosis, wrong treatment, increase multi drug resistance, severe injury and unexpected patients death (Dubow & Chetley, 2011). Mohamed (2011) reported that many deaths (Over 800 children and 40 women per hour) could have been avoided if HPs had access to appropriate and reliable HI updates in health care. Access to health information could be worse in marginalized regions such as Garrisa County, ranked as one of the top ten marginalized areas in Kenya, which have serious infrastructural and resource challenges which affects access to HI (Commission on Revenue Allocation, 2012). According to Gatero (2011), understanding information seeking behaviour of health professionals is the only realistic strategy for addressing their HI needs. Therefore, this study aimed to assess information seeking behaviour among health professionals in Garissa County.

METHODS

Anonymous self-administered questionnaires applied to randomly selected health professionals in Garissa County in March 2016. Questionnaires were pre-tested using a sample of 25 health professionals drawn from Iftini Sub-County Hospital, Garissa County. To select the study respondents, stratified sampling (proportionate) was used to group the facilities into three (3) strata categorized by the type of facility i.e. dispensaries, health centers and sub-county hospitals. This ensured that the sample size was representative of the respondents across the different tiers of health service delivery. This was followed by proportionate random sampling of 222 study respondents from the three stratums for the administration of the survey questionnaire. Data were coded and analyzed using descriptive statistics using the SPSS version 20 software package. Tables, graphs and pie charts were used to present the analysis results. Informed consent was obtained from all the study respondents and confidentiality of information collected maintained.

RESULTS AND DISCUSSION

Background Characteristics of Respondents

Slightly more than half of the respondents (51.8%) were aged 21-30 years. More than half of the respondents (58.1%) were males. Slightly more than two thirds of respondents (66.2%) were diploma holders. Close to two thirds of the respondents (62.6%) had work experience of up to 5 years. Majority of the respondents (40.5%) were nurses.

Table 1: Background Characteristics of the study respondents

Characteristics		N=222	Percent
Age (years)	21-30 years	115	51.8%
	31-40 years	70	31.5%
	41-50 years	37	16.7%
Gender	Male	129	58.1%
	Female	93	41.9%
Education Level	Certificate	21	9.5%
	Diploma	147	66.2%
	Higher Diploma	18	8.1%
	Degree	32	14.4%
	Masters	4	1.8%
Profession	Nurses	90	40.5%
	Clinical Officers	53	23.9%
	Nutritionists	17	7.7%
	Public Health Officers	31	14.0%
	Lab tech	14	6.3%
	Pharmaceutical Technologists	7	3.2%
	HROs	10	4.5%
Work experience	2 years and below	58	26.1%
	3-5 years	81	36.5%
	6-9 years	29	13.1%
	Over 10 years	54	24.3%

3.0 Health Information Needs of the health professionals

Type of health information sought

The main type of health information sought by health professionals were updates on new health issues (33.1%) across all the professions. The type of health information sought didn't vary across the professions

Reasons for seeking health information

Need to upgrade skills and knowledge (33.3%) was the main reason for seeking health information followed by motivation to answer questions from clients (19.9%) correctly.

Availability of Funds or Budget

All the respondents (100%) said that no funds are allocated to help address health information needs of health professionals at their respective facilities.

How health professionals seek health information

Most of the respondents (85.6%) sought health information related to their work when need arises.

3.0 Information resources used

Type of information resources used

Slightly more than half of the respondents (114; 51.4%) used informal resources (colleagues and senior staff/supervisors) to get health information related to their work. IT-based resources were the least used to get health informational resources.

Frequency of use of information resources

Further analysis showed that the frequency of resource use varied across the various sources available. Work colleagues, supervisors and senior staff were the main source of health information frequently used by the health professionals. E-resources (Electronic books, audio-visual materials and electronic journals) were the least frequently used resources. Informal resources are mainly consulted through informal consultations and inquiry and through formal meetings.

Table 2 Frequency of using information resources

Information Resource	Never		Seldom		Sometimes		Often		Always	
	N	%	N	%	N	%	N	%	N	%
Print textbooks	19	8.6%	94	42.3%	70	31.5%	32	14.4%	7	3.2%

Print Journals	76	34.2%	63	28.4%	69	31.1%	14	6.3%		
Colleagues					43	19.4%	126	58.8%	53	23.9%
Standard guides	13	5.9%	30	13.5%	79	35.6%	76	34.2%	24	10.8%
Newspapers	54	24.3%	93	41.9%	57	25.7%	18	8.1%		
Institutional data bases	37	16.7%	43	19.4%	88	39.6%	34	15.3%	20	9.0%
Senior staff	13	5.9%	12	5.4%	72	32.4%	105	47.3%	20	9.0%
Internet bases	40	18.0%	24	10.8%	111	50.0%	18	8.1%	29	13.1%
Electronic Journals	86	38.7%	73	32.9%	49	22.1%	10	4.5%	4	1.8%
Electronic books	204	91.9%	18	8.1%						
Mass media	42	18.9%	95	42.8%	60	27.0%	25	11.3%		
Audio visual materials	129	58.1%	93	41.9%						

DISCUSSION

This study showed that health professionals seek information to fulfill information gaps in their professional practice. Similar to a study by Case *et al*. (2005), information needs were found to drive HPs into an information seeking process aimed at fulfilling felt and identified information gaps. Different professional exhibit varying information needs. However, the study revealed a culture in which health information is not adequately prioritized in the professional practice. Most professionals sought information on need basis which indicate over-reliance on past experiences and knowledge acquired in their formal learning. Few health professionals, who included staff across the various cadres in line services, sought information on daily basis. This poses a risk in a medical practice environment in which regular update and continuous learning is crucial for evidence based medical practices free of errors and malpractices. The complexity of job roles and perceived medical interventions is a key motivation for information seeking.

Supported by Younger (2010) and Gonzalez-Gonzalez *et al*. (2007), the study found that HPs offering line health care services such as medical officers, nurses, and clinical officers, seek information mainly on new health updates, new treatment methods and disease diagnosis and treatment while those in support services seek information mainly related to new service planning and implementation. The type of information sought was well aligned to the roles and responsibilities assigned to the health professional. The motivation for seeking work-related health information was need to obtain new health updates for the purposes of updating one's knowledge followed by desire to respond and or answer client questions correctly and responsively.

However, the need for work-related health information reaches peak during health emergencies such as new disease outbreaks, serious illness complications and on emergence of new technologies/methods of service delivery such as Ebola disease and new treatment regimes. This was supported by a study by LaPelle *et al*. (2006) who found health emergencies to increase information seeking activities among health professionals. The study showed that delivery of quality and sustainable health care services is only possible where sustainable access to reliable health information resources is achieved. Due to time constraints, HPs needs timely; easy to digest and up-to-date information that is filtered and

summarized from authoritative content sources. This agrees with findings by Debra (2007), who advocated for customized information to HPs.

HPs use a variety of information sources to meet their information needs. Similar to study findings by Tannery *et al*. (2007), the use of an information resource is dependent on its availability, costs associated with access, convenience, skills required, and time involved in retrieving it and perceived relevance of information resource. Informal resources (colleagues and seniors) were the main source of information for HPs compared to IT-based and print resources. Staff consultations and meetings constitute the main channels of obtaining information from informal sources. This was consistent with a study by Andrews and Pearce (2005) and Younger (2010) in which colleagues were reported to be the main source of health information for HPs in facilities with poor internet network and infrastructure. Colleagues including supervisors are mainly used due to their availability, timeliness, affordability, and reliability. However, this contradicts a study from a multi Centre survey (China, Egypt, Kenya, India, Thailand) of hospital doctors which reported that print textbooks remain the most commonly used source of information about the management of common medical conditions; journals were less popular and computer searching were uncommon (Page & Hellers, 2000).

IT-based resources are the least used sources of health information among the health professionals particularly due to poor internet connectivity and lack of functional ICT infrastructure and equipment/tools to strengthen access. This is in line with a study by Revere *et al*. (2007) in which HPs are cited to rarely use electronic sources and new information technologies. However, advances and adoption of technology has been linked to improved information seeking behaviour in favour of IT-based resources (Avtgis *et al*., 2011). For instance, internet or electronic resources are emerging as popular sources of information among health professionals in developed countries and many developing countries which have adopted ICT in medicare. Poor health information infrastructure and limited access to reliable information resources can be attributed to lack of dedicated budget for strengthening health information seeking behaviour.

Lack of funds allocated to aid in addressing information needs of health professionals in public health facilities adversely affects achievement of health goals of universal coverage enshrined in WHO health systems strengthening framework, Kenya Vision 2030 and national health policy framework for Kenya, 2014-2030 which identifies health information strengthening as one of the key pillars. This was supported by past studies (Davies, 2007; Dubow & Chetley, 2011) which associated inadequacy of funding with potential of miss-diagnosis, wrong treatment, unexpected patients death and other undesirable health outcomes linked to limited evidence-based medical practices. Funding remains a crucial element in strengthening access and use of e-health information resources which continues to revolutionize advanced and evidenced-based health care delivery.

However, although the growth and popularity of internet-based resources has increased over time, there are many questions concerning the quality of health related information currently availabel online In addition, there are many concerns about access to the internet, particularly among marginalized areas and underprivelidged population whose ability to access internet is very low (Flynn & McGuinness, 2011).

CONCLUSIONS

Information needs varies across health professions with with health updates being the main information sought by health professional across all the professions. Informal resources (colleagues and senior staff) constituted the main source of health information for HPs. Informal staff consultations and meetings are the main channels of obtaining information

from informal sources. Most HPs seek health information on need basis such as during health emergencies which limits evidence-based practices. The type of information resource used to meet information needs depend on its relevance, availability, reliability and ease of access. Facilities lack of funds/budget for addressing information needs of staff. This has led to poor health information infrastructure, poor internet networks and related technical capacity in the facilities hence limited access and use of e-informational resources.

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AWARENESS LEVEL OF EFFECTS OF THIRD-HAND SMOKE ON NONSMOKERS AMONG STUDENTS- CASE OF KIAMBU INSTITUTE OF SCIENCE AND TECHNOLOGY

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Abstract

Tobacco plant contains nicotine, an addictive psychoactive chemical. Tobacco smoke contains more than 7000 chemicals (US Department of Health and Human Services, 2006). Of these, over 500 cause irritations, and over 70 are carcinogens. Tobacco smoking can cause different types of cancer and various chronic diseases in the life of smoker. In addition, second hand tobacco smoke can causes eight diseases in children and eight other different diseases in adults. Third hand smoke is the residual nicotine and other chemicals that cling to hair, skin, clothes, furniture, walls, beddings, carpets, dust, vehicles and other surfaces, even long after smoking has stopped. Infants, children and nonsmoking adults may be at risk of tobacco-related health problems when they inhale, ingest or touch substances containing third hand smoke,. This residue is thought to react with common indoor pollutants to create a toxic mix that contains carcinogens such as chromium, lead, hydrogen cyanide, toluene, and radioactive polonium-210 which can affect nerve and brain tissue.

The purpose of this study was to determine the extent of awareness level of effects of third-hand tobacco smoke on tobacco users and others by students in learning institutions.

Data was collected using author own formulated questionnaire and analyzed using SPSS. Majority of the students were aware of some of effects of tobacco on health of smoker. However, majority were not aware of how the chemicals in tobacco can impact on their brain. Further majorities indicated that tobacco can only make second hand smokers uncomfortable but were not sure of how it can affect their health. All respondents were not aware of what third hand smoke is and hence were unaware of its effects.

Despite the adverse effects of tobacco smoke and other products on the smoker and others, majority of the students in the Applied Sciences Department in KIST are not informed of the associated dangers. The concerned offices should make appropriate measures to ensure the students are kept abreast with trends of new knowledge as is dispensed.

Keywords: effects of tobacco; nicotine; second hand smoke; third hand smoke;

INTRODUCTION

Background to the study

Scientific analysis of the chemical constituents of tobacco leave has shown that it contains more than 7000 chemicals (US Department of Health and Human Services, 2006). Of these, over 500 cause irritations, 250 are known to be harmful and almost 70 are carcinogenic. One main chemical in tobacco leave is nicotine which is the highly addictive psychoactive chemical that produces the effect people look for in tobacco (Alexander *et al*., 2016). Other chemicals in the tobacco leave include hydrogen cyanide which is normally used in chemical weapons and interferes with release of oxygen to the body tissues once in the body and arsenic which is a highly poisonous substance used to kill mammals (rat). Tobacco leave contains highly radioactive carcinogens such as Lead-210 and Polonium-210 which have been associated with diminished Intellectual Quotient (IQ) in children even at tiny levels of exposure **(**Blackburn *et al*., 2003; Henderson *et a*l., 2003).

Smoking is the cause of over 6 million deaths per year worldwide (WHO,) with more than 126 million people exposed to second hand smoke which causes over 600,000 deaths annually. Long term exposure to compounds such as carbon monoxide and cyanide are believed to be responsible for pulmonary damage and loss of elasticity in the alveoli. This may lead to development of emphysema and chronic obstructive pulmonary disease (bronchitis) which is a permanent incurable reduction of pulmonary capacity characterized by shortness of breath, wheezing, persistent cough with sputum, and damage to the lungs.

Chemicals in the tobacco leaf can cause different types of cancer and chronic diseases in the life of smoker. These include cancer of the lungs, larynx, mouth, tongue, lip, throat, kidney, bladder, esophagus, and pancreatic. Studies show that the lifetime risk of developing lung cancer in men is 1.3% and 1.4% in women. The risk is alarmingly escalated by the chemicals found in tobacco where it hits 17.2% among male smokers and 11.6% among female smokers. Another effect of chemicals found in tobacco leaf is reduced overall life expectancy of 6.8 to 17.9 years.

Recent trends in tobacco market have seen more production and availability of user friendly tobacco products such as hookah, shisha, and e-cigars that are easy to consume for they cause less irritation. A Delphic analysis of 20 popular recreational drugs by addiction experts ranked tobacco 3rd in dependence, 12th in social harm and 14th in physical harm. Majority of the population are aware of harmful effects of second hand smoke therefore various measures are put in place to protect the general public from it effects such as smoking zones. The study was geared towards establishing how much students know about third hand smoke and its adverse effects on smokers and non-smokers.

Tobacco related diseases are one of the main causes of preventable early deaths worldwide. Tobacco use leads most commonly to diseases affecting the heart, liver and lungs. United States Centers for Disease Control and Prevention describes tobacco use as the single most important preventable risk to human health in developed countries and an important cause of premature death worldwide. In addition, second hand tobacco smoke causes diseases in children and adults non-smokers.

Third hand smoke is the cocktail of toxins that linger in carpets, sofas, clothes, hair, fingernails and other materials and surfaces long after smoking has stopped. This residue is thought to oxidize with common indoor pollutants such as ozone and nitrous acid to create new toxic compounds that contains carcinogens not seen in cigarette ingredients or tobacco smoke. This toxic mix becomes more toxic with time and can linger in the environment for decades. It can be harmful to smokers, non smokers and innocent children. Studies have shown that third hand smoke can cause different cancers to the culprits, trigger asthmatic attacks and allergic reactions. Recent work has shown that exposure to third hand smoke may result in changes that can lead to type II diabetes even when the person is not obese. Worse still is that children in environments where tobacco smoking takes place are at significant risk for suffering from multiple short-term and longer health problems, many of which may manifest fully in later life (Surgeon General's Report, 2006).

Research has documented the association between smoking indoors and persistently high levels of tobacco toxins long after the period of active smoking. Carcinogens like benzopyrene and acrolein toxicates in the body into compounds that permanently attach to nuclear DNA which may either kill the cell or cause a genetic mutation leading to cancer cells. Most of the radioactive compounds have long half-life thus they have a great of time to

undergo radioactive decay before being cleared from the environment by natural processes. In addition, the carcinogenic polycyclic aromatic hydrocarbons found in the tobacco smoke are hydrophobic thus it becomes very difficult to excrete them from the body. Therefore, radioactive substances from tobacco smoke can linger longer in the environment where they are slowly inhaled during normal breathing by both smokers and non-smokers. Biologically, normal breathing is deeper and longer than when smoking. In addition, volatilization causes smoke particles to become smaller than the actual particles found in the tobacco leaves. Therefore the particles inhaled by second and third hand smokers during normal breathing are more easily embedded deep into the lungs due to their size.

Exhaled smoke is more harmful than inhaled smoke. The former exists at lower temperatures than the latter which allows the chemical compounds to undergo changes which can cause them to be more dangerous. In addition, as smoke ages, it undergoes changes which cause transformation on Nitrogen (II) Oxide into the more toxic Nitrogen (IV) Oxide. Further, some chemicals in the tobacco leave may form new carcinogenic chemicals during combustion which may not necessarily be inhaled by the smoker. For example, nitrosamines are formed when nicotine react with other chemicals in the uncured tobacco leave.

Tobacco smoke contains substantial amount of several heavy metals such as cadmium, lead, chromium, and nickel which are known to be harmful to human body. Small amounts of cadmium taken over many years may cause kidney damage and fragile bones since it is mainly stored in bones, liver and kidney. Cadmium may also cause stomach irritation, vomiting, and diarrhea. Lead is a highly toxic metal that is capable of causing serious effects on the brain, nervous system and the red blood cells. An increase in lead levels in the blood is associated with a decrease in the intelligence quotient levels and potential behavioral problems. Studies have also shown that lead in tobacco smoke can cause impaired fetal growth and brain development.

Statement of the problem

Exposure to tobacco smoke is dangerous.. Although smoking laws apply in public and work places, there are no such indoor laws to protect children and non-smokers from close relatives and friends who are smokers. In addition, non-smokers tend to keep away from second hand smoke and resume their usual activities once the smoke has dissipated. Effects of tobacco toxins have been identified in environments long beyond the period of active smoking. These toxins are believed to be formed when exhaled tobacco smoke react with common indoor pollutants. The toxins take the form of particulate matter that clings unto various exposed surfaces in the house where it build up over time and resist normal cleaning. They also form volatile toxic compounds that continually emit harmful gases long after the visible smoke dissipate. Experts have referred to these toxics as third hand smoke. The study sought to establish the awareness of third hand smoke presence and its dangers among students in Applied Sciences Department in KIST.

Purpose of the study: The purpose of the study was to determine the level of awareness of effects of third-hand tobacco smoke on tobacco users and others by students in learning institutions.

Objective of the study:

The objective of this study was to find out whether students know what is third hand smoke and to establish whether students know the effects of third hand smoke on smokers and non-smokers

Significance of the study

This study is expected to provide new information since third hand smoke is a relatively newly postulated concept and public awareness of it is low.

RESEARCH METHODS

The study adopted descriptive survey design. The target population was students in the Applied Sciences Department in KIST. This is one of the five departments in the institution with over 300 students. The department was chosen because the researcher is a member of the department thus there was easier accessibility of respondents and support. The study adopted simple random sampling techniques where each object in the population had equal chance of being chosen (Tromp & Kombo, 2006) and each choice was independent of any other choice. Specifically the researcher used ordinal number technique to select units of the population deemed appropriate to provide the desired information. The units were selected on the basis of the researcher's judgment on their typicality (Orodho, 2009). The technique was ideal for this study since it enable selecting students from the various courses and from different year of study. Data was collected using author own formulated questionnaire and analyzed using SPSS

RESULTS

The general objective of study was to establish the level of awareness of the effects of third hand smoke among the students in the Applied Sciences and Mathematics Department at Kiambu Institute of Science and Technology (KIST). The study aimed at answering two research questions: Do students know what is third hand smoke? Do students know the effects of third hand smoke on smokers and non-smokers? Statistical analysis was carried using SPSS. The study targeted 100 (50 males and 50 females) respondents who were randomly identified among the 250 students in the department. Researcher own designed questionnaire was administered to all the respondents (n=100, 100%). The response rate was 95% (Table 3.1)

Table 3.1 Response rate

Respondents		Response	Non response	Totals
Males	Frequency	47	3	50
	%	94	6	100
Females	Frequency	48	2	50
	%	96	4	100

Awareness of third hand smoke

The participants were asked to respond to statements on a two point Likert scale which were aimed at reflecting the level of awareness of what third hand smoke is. The responses were varied, with majority (n=61, 64.21%) of the students indicating they do not know what third hand smoke is (Fig 3.1) and a further majority (n=52, 54.7%) indicating that they have never heard of the expression 'Third hand smoke' (Table 3.2).

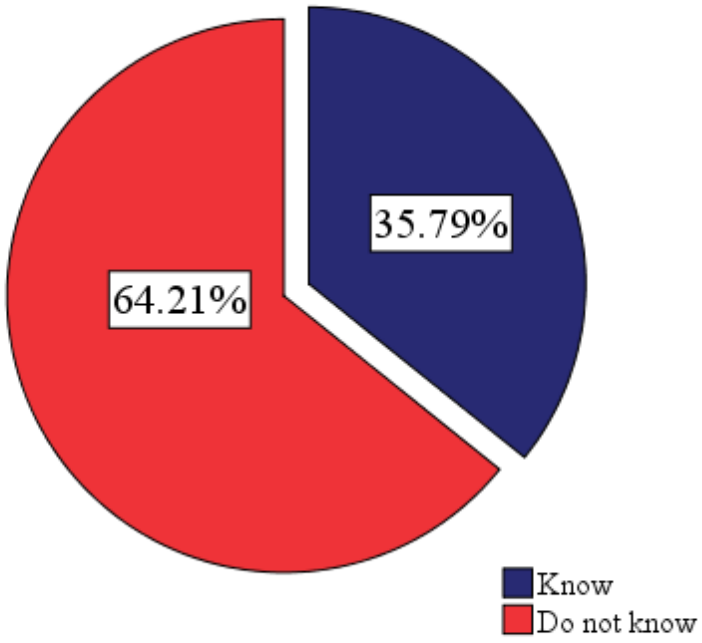

Figure 3.1 Knowledge of what third hand smoke is

Table 3.2 Ever heard of the expression 'Third hand smoke'

Statement	Frequency	Percent
Ever heard of the expression 'Third hand smoke'	43	45.3
Has never heard of the expression 'Third hand smoke'	52	54.7
Total	95	100.0

Awareness of effects of third hand smoke

The study sought to establish whether the students know the effects of third hand smoke and the harm it may cause to both the smoker and the non smokers in the surrounding environment. Respondents were asked to indicate whether they stay with friends and/or relatives who smoke. The results obtained (Figure 3.2) indicated that majority (n=86, 90.53%) were spending most of their time with non smokers.

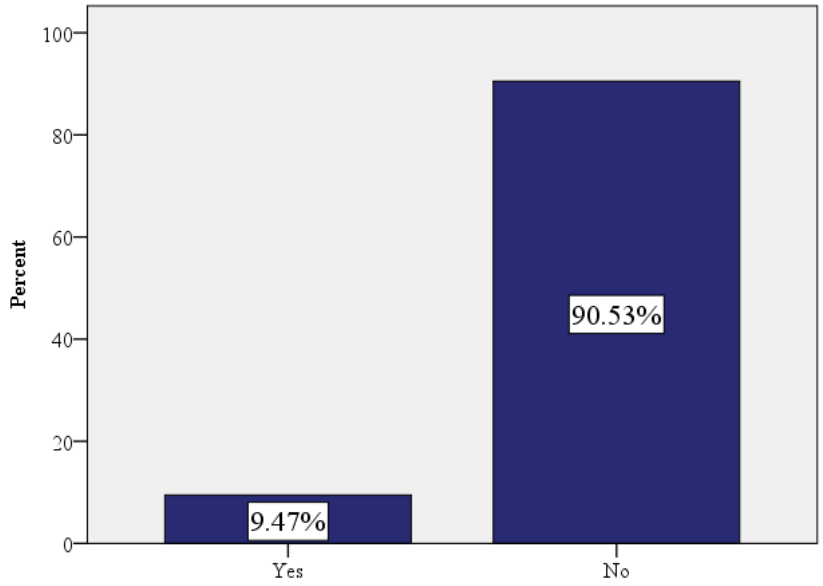

Figure 3.2 Stay with friends and relatives who smoke

Descriptive analysis for awareness of effects of tobacco smoke indicated that majority (n=%) of the respondents knew that staying in the same house with a smoker can affect their health and a further majority (n=%) had knowledge some health implications tobacco smoke may cause to both the smoker and the non smoker (Table 3.3). The study further revealed that majority (n=%) of the students in the Applied Sciences and Mathematics Department at KIST knew that smoke exhaled by the smoker (Figure 3.3) can harm others in the room. However, (n=%) of the respondents did not know the difference between second hand smoke and third hand smoke (Figure 3.4).

The study sought to determine whether the students knew that the smoke exhaled by a smoker in a closed room may harm future occupants. The respondents were asked to indicate whether they the statement "Living in a room that a smoker lived some years in the past can affect the health of a person" was true or false. Obtained data indicated that majority (n=%) of the respondents disagreed that settled tobacco smoke can cause any harm (Table 3.4). Majority (n=%) of the respondents further indicated they do not agree that contacts with the body and clothes of a smoker who is not currently smoking can be dangerous to their health (Table 3.4).

The researcher excerpted an opinion item in the questionnaire for purpose of establishing whether the students exactly understand what third hand smoke is. The respondents were asked to indicate whether the students in the Applied Sciences Department know what third hand smoke is. Although majority (n=%) indicated that students do not know what third hand smoke is there were more (n=%) who indicated that the students know what third hand smoke is(Figure3.5). However, when they were asked to list the precautions these students who know what third hand smoke is take to protect themselves from it effects, the precautions they gave were statements like "Stay away from the active smoker" and "Avoid peer influence from the smokers".

CONCLUSIONS

Despite the adverse effects of tobacco smoke and other products on the smoker and others, majority of the students in the Applied Sciences Department in KIST are not informed of the associated dangers. Concerned offices should make appropriate measures to ensure the

students are kept abreast with trends of new knowledge as is dispensed. There is need for the institution to ensure the environment is free of third hand smoke.

RECOMMENDATIONS

Rather than criminalizing smoking, the smokers should be educated to understand the need to take measures to protect themselves and nonsmokers from third level contaminants. The smokers should also be encouraged to take smoking outdoor as they work on cessation. One of the easiest remedies is moving smoking outdoors. The institution can put up the technology knowledge in place and come up with a smoking jacket which can be used by smokers and remain outdoors when not in use. Hand washing after smoking campaigns should be emphasized and smokers encourage practicing frequent bathing of the whole body.

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CROSS SECTIONAL SURVEY OF CARE SEEKING FOR ACUTE RESPIRATORY ILLNESS IN CHILDREN UNDER 5 YEARS

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Abstract

Acute respiratory infection (ARI) is a leading cause of childhood morbidity and mortality in developing countries. In Kenya, diagnosis and treatment of ARI remains predominantly health facility based. This presumes that caretakers can recognize ARI symptoms, and promptly and make a decision to take the child to an appropriate health facility for treatment. Unfortunately, these presumptions have not been assessed. We conducted a study to assess correlates to delayed hospital facility consultation for children presenting with ARI symptoms in a rural area in Kenya.

An analytic cross sectional survey was done in Githunguri Sub - County of Kiambu County. Households with children under 5 who had recently suffered an episode of ARI were enrolled. Consent was sought. Structured questionnaires were administered to the mothers; to obtain information on socio-demographics, knowledge, perceptions and health seeking practices.

From 438 households sampled, but 323(3.2%) households with children under 5 years in their households were included. Out of these, 240(74.3%) had children who had an episode of ARI in the preceding 2 weeks. Mean age of the children was 29.2 months, and male to female ratio was 1:1. Mean mothers age was 29.4 years. Most mothers were married (71.2%), 54.8% had secondary education, and 66.6% were of Christian-protestants faith. Majority, (90.0%) were in informal employment, 27.1% had poor knowledge of pneumonia. Most, (77.1%) households resided within 2kms from a nearest health facility. Delayed health facility consultation was observed in 149, (62.1%). The main factors associated with delayed hospital consultation were poor knowledge of symptoms (p= 0.007), and health facility factors; including high costs of care (p= 0.011), and long waiting time before service provision in previous visit (p = 0.023). On logistic regression, the main factors that independently determined delayed hospital consultation were poor symptom recognition (p=0.014) and turn-around time at health facility in the previous visit (0.001).

The prevalence of ARI in Githunguri Sub - County among children under 5 years was high at 74.3%, and most (62.1%) delayed health facility consultation. Poor knowledge symptoms of pneumonia and long waiting time during the previous facility visit were the main determinants of delayed facility consultations.

Key words: Acute respiratory illness, Children, Health facility consultation

BACKGROUND

Worldwide, acute respiratory infections (ARI) are a leading cause of morbidity and mortality. Globally, 5.9 million children under 5 died in 2015, which translates to 16,000 deaths every day (WHO, 2015). South East Asia reported the highest burden, followed by Africa at 0.36 and 0.3 episodes per child-year, compared to 0.06 in Europe, (Rudan *et al*, 2008). Most (60%) pneumonia deaths occur in sub Saharan-Africa and South East Asia (Black *et al*, 2010). In Kenya, according to the economic Survey of 2013, pneumonia related deaths have barely dropped despite 66% coverage of pneumococcal vaccine initiative (IHME, 2014). The Kenya demographic health survey (KDHS) 2014, estimated the National ARI prevalence at

65.3% and pneumonia contributed to 17% of under 5 mortality rate. Disproportionately higher rates occur in rural settings, mostly attributed to poverty, poor housing, and malnutrition (Bigogo *et al*., 2013). Integrated community case management (iCCM) strategy launched by WHO and UNICEF identified 3 key steps of pneumonia survival namely timely symptom recognition, prompt and appropriate care seeking, and timely provision of antibiotics, but uptake has been low in developing countries. ARI diagnosis and treatment of ARI remains predominantly health facility based in Kenya. The current model presumes that caretakers shall recognize ARI symptoms promptly and make a decision to take the child to an appropriate health facility for treatment. Only 1 in every 5 caretakers in developing countries can recognize the 2 symptoms of pneumonia, namely fast breathing, and difficulty in breathing (Young *et al,* 2012). By 2014, appropriate care seeking for ARI in children was at 47%, compared to global rate of 58% (GHO, 2015). Indeed, survival of community acquired ARI is dependent on complex interaction of numerous mediators; among these are caretaker knowledge, virulence of bacterial pathogens, child vulnerability and prompt action by caretaker. Unfortunately, some of the presumptions have not been assessed locally. We conducted a study to assess correlates to delayed hospital facility consultation for children presenting with ARI symptoms in rural Kenya.

MATERIALS AND METHODS

Design, setting and study population

We conducted a community based analytic cross sectional survey in Githunguri Sub - County, of Kiambu County, Kenya. Multistage sampling was done. The Sub - County was stratified into 3 divisions, and then each division stratified in to community units, each comprising of at least 500 households. A list of all the households was generated by the community health workers per unit. Simple random sampling was used to sample households with U5s. Proportionate sampling was done per community unit, based on the total population of the households with U5s generated. Subject enrollment started from November 2014 to December 2014. ARI was defined as an illness characterized with symptoms of cough, accompanied by fast and/or difficulty in breathing. Caretakers were asked for occurrence of ARI in their children. Those with pre-existing chronic conditions were excluded. For those households reporting ARI episodes, a structured questionnaire was administered to the caretaker. This sought information on the socio-demographics, economic, knowledge, perceptions, and health seeking practices during the child's illness. Knowledge sought covered pneumonia causation, risk factors, symptoms and prevention. A set of questions were asked and total scores obtained. Knowledge was categorized based on appropriate responses given, where good (>50%), fair (40-30%) and poor (<30%) correct responses were given. Qualitative data was obtained by 2 focus group discussions with community health workers and mothers, and 3 key informant interviews comprising of the Sub -County health officials.

Study definitions

Prompt health facility consultation was when a sick child was taken to an appropriate health facility within 24 hours of symptom recognition. An appropriate health facility was attendance to a registered health center, clinic, or hospital.

Data management and analysis

A sample-size calculation based on Fisher *et al.*, (1998) formula, required a minimum of 323 children. Consecutive eligible households with U5s were enrolled, until desired sample size

was achieved. Oversight and safety monitoring was done by the KU-ERC. Data collected was coded, entered and analyzed using Statistical software; SPSS version 21. Data on children whose guardians declined study participation and those with pre-existing chronic conditions were censored and excluded from the analysis.

Baseline contacts and source characteristics are presented as frequencies, percentages, means and ratios. Comparisons were made of the dependant variables observed in those with and without delayed health facility consultation. Cross tabulations were done and associations established by chi squares. Inferential statistics (p-value, confidence intervals) were used to establish factors associated with delayed hospital consultation. Statistical significance level was fixed at $p < 0.05$. For advanced statistics, factors showing significant associations on bivariate analysis were entered into a multiple logistic regression model, to establish those with an independent relationship with prompt hospital consultation. Qualitative data was assessed by content analysis of key thematic areas.

RESULTS

Subjects' enrollment and participants

A total of 438 households were sampled, and 402 had children U5 in their households, but 353 were eligible and consented, and were interviewed. Thirty had chronic conditions and were excluded. Hence, 323 households with children U5s in their households were included. Out of these 240(74.3%) had children with ARI symptoms within preceding 2 weeks prior to study period. The flow chart of subjects' enrollment and participants are presented in Figure 1.

Figure 1 Subjects enrollment and participants

The characteristics of the eligible households that met the inclusion criteria are presented in Table 1. Eighty (24.8%) had their children aged between 13 to 24 months, but mean age was 29.2 months. Male: female ratio was 1:1. All household heads were biological mothers of these children. Most 160 (49.5%) were aged between 20 to 29 years, with a mean age of 29.4 years. Majority, (230, 71.2%) were married. Up to 177 (54.8%) had achieved secondary level of education. Most, 215 (66.6%) were of Christian-protestant faith. Regarding their source of income, 291, (90%) engaged in informal employment as casual laborers, crop farming and animal husbandry, while only (32, 10%) had salaried employment.

On timing of health visit, 149 (62.1%) delayed visiting a health facility. Among those that delayed visiting a health facility, 80(53.7%) took 1 day, 47 (31.5%) took 2 days and 22(14.8%) took at least 3days. Regarding the facility sought, 235/240 (97.9%) was appropriate.

Factors influencing delayed hospital visit

On bivariate analysis, socio-demographic factors assessed were not associated with delayed hospital visits; these include child's age (p= 0.276), child's gender (p= 0.036), mother's age (p= 0.614), marital status (p= 0.747), occupation (p= 0.283) and level of education (p= 0.476). A few 19(7.9%) belonged to non- conventional religious, some of which barred their members from seeking health facility care. However, religion was not associated with delayed consultation (p= 0.926). On household factors, the key household decision maker was the fathers in 89 (37%) cases, and the fathers met the health costs in 160(66.7%) cases. The immediate health intervention was to give warm fluids and keep warm in 14 (5.8%), but preferred source of care was a health facility in 235(97.9%). However, only the key decision maker (p=0.016) among the household factors was found to be associated with delayed hospital consultation; the rest; Hospital bill payee (p= 0.925), preferred health intervention (p= 0.382) and caretaker perceptions (p= 0.420) were not. (Table 2)

Table 2 Socio-demographic and household factors as determinants of health facility consultation

Variables		**Timing**		**Total**		**Chi-square test**
		Delayed	Prompt			
		%	%	N	%	
Child's age (in months)	0-12	63.4	36.6	41	17.1	χ^2 = 5.115 df = 4 P = 0.276
	13-24	71.7	28.3	60	25.0	
	25-36	59.0	41.0	61	25.4	
	37-48	63.2	36.8	38	15.8	
	49-59	50.0	50.0	40	16.7	
Child' gender	Male	55.5	44.5	119	49.6	**χ^2 = 4.396 df = 1 P = 0.036***
	Female	68.6	31.4	121	50.4	
Caretaker's age (in years)	<19	66.7	33.3	6	2.5	χ^2 = 1.805 df = 3 P = 0.614
	20-29	59.2	40.8	120	50.0	
	30-39	62.4	37.6	85	35.4	
	>40	72.4	27.6	29	12.1	
Marital status	Single	58.6	41.4	58	24.2	χ^2 = 1.226 df = 3 P = 0.747
	Married	63.5	36.5	170	70.8	
	Divorced/separated	50.0	50.0	8	3.3	
	Widowed	75.0	25.0	4	1.7	
Religion	Protestant	62.5	37.5	152	63.3	χ^2 = 0.154 df = 2 P = 0.926
	Roman Catholic	62.3	37.7	69	28.8	
	Others	57.9	42.1	19	7.9	
Source of income	Non salaried	63.7	36.3	215	89.6	χ^2 =1.115 df = 1 P = 0.283
	Salaried	48.0	52.0	25	10.4	
Education	No formal	66.7	33.3	24	10.0	χ^2 = 2.496

level	Primary	66.2	33.8	68	28.3	df = 3 P = 0.476
	Secondary	57.9	42.1	133	55.4	
	College/University	73.3	26.7	15	6.3	
Key decision maker	Mother	56.3	43.7	151	62.9	**χ^2 =5.803, df = 1 P = 0.016***
	Father	71.9	28.1	89	37.1	
Hospital bill payee	Father	61.9	38.1	160	66.7	χ^2 = .0.009, df = 1 p = 0.925
	Mother	62.5	37.5	80	33.3	
Preferred health intervention	Health facility	61.7	38.3	235	97.9	χ^2 = 0.764, df = 1 P = 0 .382
	Traditional medicines	80.0	20.0	5	2.1	
Household practice	Taken to health facility	60.6	39.4	226	94.2	χ^2 = 3.729 df = 2 p = 0.155
	Other (Give hot drinks/cover the child)	85.7	14.3	14	5.8	
Caretaker Perceptions	Serious disease	62.8	37.2	223	92.9	χ^2 = 0.650, df = 1 p = .0.420
	Not serious	52.9	47.1	17	7.1	

From the FGDs, most caretakers considered pneumonia as a serious childhood illness. They knew that the commonest symptoms of pneumonia were a cough and difficulty in breathing. Most associated it with exposure to cold and therefore they mostly intervened by keeping warm or warm drinks. On bivariate analysis of knowledge level and timing of hospital consultation, the knowledge of symptoms of pneumonia was significantly associated prompt facility visit (p= 0.007). Knowledge of causation of pneumonia (p= 0.056), risk factors to pneumonia (p= 0.869), prevention strategies for pneumonia (p= 0.130) were all not significant (Table 3)

Table 3 Knowledge of pneumonia as determinants of health facility consultation

Knowledge of pneumonia		Timing		Total		Chi-square test
		Delayed	Prompt			
		%	%	N	%	
Causation	Poor	59.8	40.2	209	87.1	$\chi2$ = 3.557, df = 1 p = 0.059
	Good	77.4	22.6	31	12.9	
Risk factors	Poor	62.0	38.0	237	98.8	$\chi2$ = 0.027, df = 1 p = 0.869
	Good	66.7	33.3	3	1.3	
Signs	Poor	67.0	33.0	179	74.6	**$\chi2$ = 7.348, df = 1 p = 0.007***
	Good	47.5	52.5	61	25.4	
Prevention	Poor	63.9	36.1	208	86.7	$\chi2$ = 2.290, df = 1 P = 0.130
	Good	50.0	50.0	32	13.3	
Overall total score	Poor	64.6	35.4	65	27.1	$\chi2$ = 0.509, df = 2 P = 0.775
	Fair	61.8	38.2	157	65.4	

	Good	55.6	44.4	18	7.5	

During KIIs, enquiry into the overall turn-around time at the facility was about 2 hrs. Large work-loads and staff shortages were the main reasons. Drug shortages at the facilities were a common scenario in these facilities, and patients were given prescriptions to buy the medicines elsewhere. On bivariate analysis of health facility factors, those statistically significantly associated with delayed facility visit were previous high expenditure at health facility (p=0.001), and long waiting time before being served during the previous visit (p= 0.023). Distance to nearest health facility (p= 0.064) and past experiences at the facility (p= 0.161) were both not found to be significant (Table 4).

Table 4 Health facility factors as determinants of health facility consultation

Health facility factors		Timing		Total		Chi-square test
		Delayed	Prompt			
		%	%	N	%	
Distance to nearest health facility (Km)	≤2	58.9	41.1	185	77.0	$\chi 2$= 3.434 df = 1 P = 0.064
	> 2	72.7	27..3	55	22.9	
Previous costs at health facility (in US $)	≤2	45.7	54.3	46	19.1	$\chi 2$= 6.527 df = 1 p = 0.011*
	> 2	66.0	34.0	194	80.8	
Waiting time before being assisted previous visit (hours)	≤ 1	52.8	41.8	184	76.7	$\chi 2$= 5.177 df = 1 P = 0.023*
	>1	75.0	25.0	56	23.3	
Past experience at health facility	No medications	89.9	93.4	219	91.3	$\chi 2$= 3.651 df = 2 P = 0.161
	Few staff	6.0	1.1	10	4.2	
	Long queues or delay	4.0	5.5	11	4.5	

Variables that were significantly associated with delayed health facility consultation on bivariate analysis were included in multivariate analysis model, to identify which one was the independently significant. The strongest independent determinant of "health facility consultation for ARI" was symptom recognition (p= 0.014) and long waiting time (>1hour) before service provision, (OR = 0.25; C.I (0.12- 0.56); p = 0.001). Details of independent predictors of delayed health facility visit for ARI are presented in Table 5.

Table 5 Independent determinants of health facility consultation

Independent variable	(n = 240)	Timing of HF consultation	P value	OR	95%C.I. for OR

			Delayed	Prompt			lower	Upper
Child's sex	Male	119	66	53	0.038*	1.81	1.03	3.17
	Female	121	83	38				
Key decision maker	Mother	151	85	66	0.036*	0.53	0.29	0.96
	Father	89	64	25				
Knowledge of symptoms	Poor	179	120	59	0.014*	2.36	1.19	4.67
	Good	61	29	32				
Previous costs at health facility (US$)	≤ 2	46	21	25	0.036*	0.43	0.20	0.95
	> 2	194	128	66				
Previous time taken before service (hours)	< 1	184	107	77	0.001*	0.25	0.12	0.56
	> 1	56	42	14				

DISCUSSION

Prevalence of ARI in this area was 74.3%, slightly higher than the national prevalence of 65.9% (KDHS, 2014), maternal occupation was predominantly as laborers in agricultural farms, to where they carried children along. Rural preponderance was also reported in a Ugandan study which reported rural and urban rates of ARI at 50% and 37% respectively (Bbaale, 2011).. Another study in Ethopia found ARI prevalence at 91% among rural dwellers (Astale & Chenault, 2015). On the contrary, an Indian study reported higher urban than rural rates at 63.7% and 53.7% respectively (Kumar *et al.*, 2015).

At least 62.1% of ARI cases had delayed hospital consultations. Use of home remedies and over- the-counter medications was the main reason for these delays. Similar findings were reported in studies done in Uganda and Ethiopia (Källander *et al*., 2008),(Demissie et al., (2014) as well as studies in Pakistan and Albania ((Memon *et al.*, , 2013), (Doracaj *et al.*, , 2015). Gender disparities still play a role in health seeking behaviours. Our findings revealed that caretakers were 1.8 times more likely to delay consulting a health facility if their child was a female than male. Similar findings were reported in studies done in Pakistan, India and Africa (Memon *et al*., (2013), Malhotra &Upadhyay, (2013) and Noordam *et al*., (2015). Surprisingly, age of child was not found to influence health facility consultation in this study. On the contrary, studies carried out in Sub–Saharan Africa, Pakistan and Indonesia all found age of the child to be associated with prompt care seeking for ARI/presumed pneumonia, (Noordam et al., (2015), Memon et al., (2013)and Kresno *et al*., (2010)). Level of education of mother did not influence care seeking for childhood illness according to KDHS, (2014). Likewise, level of education was not found significant in this study. On the contrary, Keter et al., (2015) study done in Nandi County, Kenya found low education level to be associated with care seeking delays. Likewise other studies carried out in Pakistan, Yemen and Ethiopia did find level of education as significant determinants (Memon *et al*., (2013), Rehman et al., (2014), Webair& Bin-Gouth, (2013) and Mebratie *et al*., (2014). Religious affiliations have been found to influence health facility consultations. In this study, a few religious cults barred

their children from seeking health facility care. Mebratie *et al*., (2014) reported prompt care seeking in Christian based than Muslim headed households. Despite the fact that mothers were the key decision makers on health care seeking, they depended on the child's father for financial provision, which led to delays in care seeking. Similar findings were reported in studies done at Yemen and Niger where mothers were the key decision makers on care seeking, but relied on the child's father for financial provision. This caused further delays in seeking appropriate care for ARI (Webair& Bin-Gouth, 2013 and Bedford, 2012).

Even though mothers perceived ARI symptoms to be life threatening, they had to wait for the child father to provide the finances needed for transportation and care at the health facility. Contrary, findings were reported in studies done at Yemen and Nandi County, Kenya, where care givers perceptions on a childhood illness was associated with care seeking (Webair& Bin-Gouth, 2013) and Keter et al., 2015). Overall, only (18, 7.5%) had good knowledge of pneumonia and caretakers with poor knowledge had 2.4 risk of delaying consultations. This concurs with findings from an earlier study done in rural Nandi, Kenya ((Simiyu, Wafula, & Nduati, 2003) that showed that mothers sought prompt care if they were able to recognize difficulty in breathing and fast breathing in child, than a mere cough. Similar findings were also reported in a study done in Ethiopia (Demissie et al., 2014). Majority (87.1%) had poor knowledge of pneumonia causation, and (59.2%) reported that it was due to cold temperature and therefore keeping the child warm could help relief the symptoms. Similar findings were reported in a study done in Nigeria that cold caused pneumonia and reducing its exposure and wearing warm clothes would prevent it (Ekure et al., 2013).

Health facility factors strongly influenced facility consultation. Long waiting time before service provision at the health facility strongly determined timing of next consultation ($p = 0.001$). This was supported by KIIs reports that large workloads and few health personnel as main causes of delayed services. Similar findings were reported in a study carried out at Homa bay County, Kenya, where long queues or delays at the health facility were found to contribute to delays in seeking care at the hospitals (Bedford & Sharkey, 2014). Other studies done in South Africa, Australia and Central America also reported the similar findings, ((Sharkey *et al.*, , 2011), (Van der Hoeven, Kruger, & Greeff, 2012), (Najnin, Bennett, & Luby, 2011) and (Sakisaka, Jimba, & Hanada, 2010).

Health care costs are barriers to health seeking. Although the policy position that treatment of children under 5years is free in all government health facilities, caretakes often have to purchase drugs elsewhere as often stock run out. Caretakers therefore, opt to buy over the counter medications before seeking care at these facilities, hence delays in consultation. Other studies done in Kenya reported similar findings (Taffa &Chepngeno, (2005)and (Irimu, Nduati, Wafula, & Lenja, 2008). This has also been described in other studies from South Africa, Southeast Asia and Philistines. (Van der Hoeven et al., 2012), (Alvesson *et al*., , 2012), (Kim, Capeding, & Kilgore, 2014).

Most, 185, (77.1%) households resided within 2kms radius away from the nearest health facility and distance to facility was not a barrier to prompt consultation. To the contrary, studies in Kenya by Irimu et al., (2008), and Bedford & Sharkey, (2014) found poor access and long distances to be associated with delays in seeking appropriate care. The same was reported in Southeast Asia, Australia and Philippine, (Alvesson *et al*., 2012), Najnin et al., (2011) and Kosai *et al*., (2015) who found that mothers who traveled long distance to the facility delayed or failed to seek health facility care for their child.

Large number of non-consenting households in this study may have influenced findings. In addition, this study was carried out over a limited period of time and therefore did not look at seasonal variations to ARI prevalence and determinants to health facility consultations.

CONCLUSIONS

The prevalence of ARI in Githunguri Sub-County among children under 5s was high at 74.3%, and most 149, (62.1%) had delayed health facility consultation. Overall, 27% respondents had poor knowledge of pneumonia, and poor symptoms recognition was associated with delayed health facility consultation (p= 0.014). The health facility factors associated delayed facility consultations were with high cost of care (p= 0.011), and long waiting time (P= 0.023). We recommend increased sensitization on symptom recognition among caretakers, and intensified efforts to reduce turn-around time during health facility consultations in order to minimize delays in health facility consultation.

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THE EFFECT OF INFANT FEEDING METHODS ON HIV TRANSMISSION FROM INFECTED MOTHERS

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Abstract
The assertion that most children die of HIV/AIDS before celebrating their eighth birthday is the motivation for studies unveiling the correlation between HIV transmission and the mode of feeding among infants. By 2014, it was estimated that worldwide, 2.6 million children below15 years were living with HIV while more than 90% were infected through mother to child transmission (MTCT) during pregnancy, delivery and breast feeding. In Kenya, there were about 12940 children while 1480 of these were from Kirinyaga County. The Kenya government has put intervention measures to reduce these infections through access to highly active anti-retroviral therapy (HAART) and elective caesarean section. These are intended to decrease the MTCT rate to below 2% and reduce new pediatric HIV infections by 90% by 2017. The study conducted laboratory research in order to establish the main outcome among women and infants accessing a local programme for PMTCT of HIV. The research followed, for 18 months, records of 303 HIV positive mothers who had given birth to live infants along variables of anti-retroviral drugs and mode of infant feeding in the first six months. CD4-count and viral load tests were performed on all women after delivery to evaluate the indication to ART treatment and monitor the mother's immunity. HIV testing on the infant was performed 6 weeks after birth through PCR. Antibody tests were done at the 9^{th} and 18^{th} months using rapid test with either Unigold or Determine strips. In cases where the antibody tests were positiv e and the first PCR negative, confirmatory PCR tests were performed. Data was analyzed using logistic regression models involving student t-test chi-square tests with 95% confidence interval as the set confidence limit in univariant analyses. The result indicates that replacement feeding is ten times safer than breastfeeding and should therefore be embraced.

Key Words: HIV transmission, immunological status, infants, mode of feeding, CD4-count.

INTRODUCTION

Most children in many developing countries die before their eighth birthday due to ailments that include malaria, measles, pneumonia, common cold and HIV. Of the diseases, HIV is of great importance. Over two thirds of these deaths are in sub-Saharan Africa. It is estimated that worldwide, 2.6 million children younger than 15years were living with HIV in 2014 with Kenya having about 12940, while 1480 were from Kirinyaga County. More than 90% had been infected via mother to child transmission during pregnancy, delivery and breast feeding (NACC-UNAIDS 2014). Developed countries have achieved remarkable progress in reducing HIV infections to below 2% by scaling up access to highly active anti-retroviral therapy (HAART), elective caesarean section and formula feeding as replacement to breast feeding. However, in developing countries, more than 90% of new pediatric HIV infections occurs each year. Most of these countries have expanded access to comprehensive and more efficacious PMTCT interventions by use of ARV. For example, by December 2009, 22 countries, Kenya included had reported antiretroviral coverage rates of more than 50%.

The benefits of breastfeeding relating to nutrition, prevention of common childhood illness, child spacing, reduction in infant and child morbidity and mortality are well described in various studies (WHO, 2000; Coutsoudis *et al.*, 2005; Kekuta *et al.*, 2005). However in recent years, there has been conclusive evidence that breastfeeding confers a significant risk of HIV transmission from an infected mother to child (De Cock *et al*., 2000; Coutsoudis *et al*., 2005). Globally it's estimated that 20,000-35,000 infants contract HIV via prolonged breastfeeding up to 2 years (De cock *et al*., 2000). Option B of WHO recommends that all HIV positive pregnant women receive HAART starting at different stages of their pregnancy. Mothers who do not meet the WHO criteria for affordable feasible accessible safe and sustainable (AFASS) formula feeding continue ARVs throughout the entire breast feeding period (NASCOP KENYA, 2011). This study investigated the effect of exclusive replacement feeding option on the HIV status of the new born babies especially for mothers whose immunity was low and had very high viral load.

Objective

The objective of the study was to investigate whether exclusive replacement feeding could be a better option especially for mothers whose immunity is low and have very high viral load.

METHODS

The study was carried out at the PMTCT clinic in Kerugoya county referal hospital in Kirinyaga County, which acts as the referral hospital for patients from Kianyaga and Kimbimbi sub-district hospitals as well as the 12 health centres and 63 dispensaries supported by the Ministry of health. There are a total of 259 health facilities in the county whose population is about 572889. Kerugoya is at 0^0 30' 0" N and 0^0 36' 01" S latitude and a longitude of between 37^0 19' 6" to 37^0 17' 17" E. It is located about 100km from Nairobi city and has a temperature of between 12^0C to 30^0C (appendix iii). Majority of the residents are farmers with business people concentrated in the towns and shopping centres. Kerugoya town is the administrative headquarter with a population of about 150000 people which is about 25% of the general county population. HIV prevalence is about 4.4% with women having twice the rate compared to men, with 3% men and 6% women. The general infant mortality rate is 39.2 per 10000 births. Children under five years of age have the highest mortality rate taking 59.2 per 1000 deaths. Maternal mortality rate is about 530 deaths per 100,000live births (NACCK, 2008).

The study involved all the HIV-infected pregnant women who accessed the perinatal and HIV-PMTCT services at Kerugoya district hospital between August 2011 and September 2014 and delivered live newborns. About 303 HIV positive mothers were followed from the time they visited the PMTCT clinic, at delivery until their infants got to 18 months of age. Information regarding the method of infant feeding, which was; EBF, ERF or mixed feeding in some case was got from the mothers. Research permit was obtained from the ministry of education science and technology, the ethical committee of Kerugoya district hospital, the district medical officer of health (MOH) and clearance from Kenyatta University ethical review committee.

HIV status in children was carried out using the polymerase chain reaction test (PCR) for all the children at the age of six weeks after birth, then rapid HIV whole blood test was done at an interval of three months until the infant was eighteen months of age, whereby if the test was found to be positive a final PCR test was carried out for confirmation.

Data Analysis

Data was analysed using logistic regression models and was compared by student's t-distribution and the chi-square test. Significant levels were set at 0.05 and a 95% CI for HIV transmission or death.

RESULTS

Mode of feeding

The table below presents the feeding practices of the enrolled mothers. The proportions of the mothers who had practiced exclusive breastfeeding and exclusive replacement feeding were, respectively, 77.9% and 22.1%. Additionally, 29 mothers (9.6%) reported switching from breastfeeding to replacement feeding during the study period, most of whom did it within a period of six months from birth or less (58.6%).Seven mothers (2.3%) practiced mixed feeding.

Table 1. Description of the feeding approaches used by the enrolled mothers

Characteristic	No.	%
Initial feeding(n=303)		
Exclusive breastfeeding	236	77.9
Exclusive Replacement Feeding	67	22.1
Switched from breastfeeding (RF) to Replacement Feeding (RF) (n=303)		
Y	29	9.6
No	274	90.4
Age of switching from BF to RF (n=29)		
≥6 months	17	58.6
< 6 months	12	41.4
Mixed feeding(n=303)		
Yes	7	2.3
No	296	97.7

HIV/Serological status of the study children

Results from the HIV DNA polymerase chain reaction tests at 6 weeks after birth indicated a mother to child transmission rate of 3.3% (95% Confidence interval (CI) 1.8%- 6.0%). At the completion of the study, fourteen children tested positive for HIV by PCR method, thus, a transmission rate of 4.6% (95% CI 2.8% - 7.6%). A total of 34 children tested positive on conducting the first antibody-based tests with only 14 children testing positive in the second antibody-based tests.This was also confirmed by the second PCR test.

Table 2. Results from HIV tests undertaken during the study period

HIV test Results	Tot	No.	%	95% Confidence

	al	positive		interval (CI)
PCR test at 6 weeks	303	10	3.3	1.8- 6.0
1st Antibody test	303	34	11.2	8.1 - 15.3
2nd Antibody test	303	14	4.6	2.8- 7.6
PCR test at 18 months	303	14	4.6	2.8 - 7.6

The initial mode of feeding the child was found to be a significant determinant of mother-to-child transmission of HIV (χ^2=4.167, df=1, p= 0.045). Indeed, exclusive breastfeeding reduced the risk of HIV transmission by about 10% when compared to exclusive replacement feeding (odds ratio (OR) 0.941(95% CI 0.911-0.971). Switching from breastfeeding to replacement feeding was not significantly associated with mother-to-child transmission of HIV (χ^2=0.100, df=1, p= 0.998). However, transmission rate was higher, though not significant, in those who switched from breastfeeding to replacement feeding when the child was younger than six months (8.3% in children who were switched to replacement feeding before 6 months of age versus zero incidence of transmission in the opposing group, χ^2=1.294, df=1, p=0.414).

Mixed mode of feeding was shown to increase the likelihood of mother-to-child transmission (OR 19.432 (95%CI 3.870-97.560), χ^2=23.772, df=1, p = 0.002).

Table 3. Assessment of factors associated with mother-to-child transmission

Attribute	Total	PCR Test Results		OR (95% CI)	X^2, df, P-value
		Positive (n=14)	Negative (n=289)		
Sex of Children					
Male	159	7(4.4)	152(95.6)	0.901 (0.308-2.635)	X^2=0.036,df=1, p=0.849
Female	144	7(4.9)	137(95.1)		
Initial mode of feeding					
Exclusive breastfeeding	236	14(5.9)	222(94.1)	0.941(0.911-0.971)	X^2=4.167,df=1, p= 0.045
Exclusive Replacement Feeding	67	0(0.0)	67(100.0)		
Switched from BF to RF					
Yes	29	1(3.4)	28(96.6)	0.717(0.090 - 5.688)	X^2=0.100,df=1, p= 0.998
No	274	13(4.7)	261(95.3)		
Age of switching from BF to RF					
≥ 6 months	17	0(0.0)	17(100.0)	1.091(0.920-1.294)	X^2=1.294, df=1, p=0.414
< 6 months	12	10(8.3)	11(91.7)		
Mixed mode of feeding					
Yes	7	3(42.9)	4(57.1)	19.432(3.870-97.560)	X^2=23.772,df=1, p= 0.002
No	296	11(3.7)	285(96.3)		

The sex of the child was not associated with the risk of transmission of HIV from mother to child (chi square statistic(x^2)=0..036,degrees of freedom(df)=1,p=0.849). Similarly,age of the mother was not a significant predictor of the risk of mother to child transmission of HIV(x^2=0.048, df=11, p=0.763).

DISCUSSION

Exclusive breast feeding was found to increase the risk of HIV transmission by 10% when compared to exclusive replacement feeding this is comparable to findings by Coutsoudis *et al.,(*2009*)* most children born to HIV positive mothers and raised on formula do not get infected but die of undernourishment, diarrhea and pneumonia since formula milk isn't always a sterile product and is easily contaminated and hence the study recommended breast feeding due to a higher nutritional value and provides innate immunity.

Mixed mode of feeding was shown to increase mother to child transmission. It had a four fold increment in children who were less than 6 months old, this is inline with findings by; WHO (2003), UNICEF (2011) where the studies found that the gastrointestinal walls of infants below six months of age were not fully developed hence they get inflamed easily, allowing passage of the virus. The study recommended breast feeding with ARV drugs if replacement feeding is not AFASS (affordable, feasible, available, safe and sustainable).

CONCLUSIONS

Mother to child transmission was prevalent in situations where; women practiced E.B.F (59%), and mixed feeding (4.2%). Mother to child transmission did not occur in infants who were exclusively replacement fed.

This study recommends as follows; Expectant women should be monitored closely for ARV adherence and adverse drug reactions during antenatal care and breast feeding period. Exclusive replacement feeding should be encouraged and made AFASS (Affordable, Feasible,Available,Safe and Sustainable) to HIV positive mothers thus, ensuring sterility of the product and maintaining nutritional value. Although WHO has a two year exclusive breast feeding recommendation, this study has found that exclusive breast feeding had higher transmission prevalence than exclusive replacement feeding, hence more studies need to be carried out concerning the mode of feeding and mother to child transmission.

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RISK ASSESSMENT TECHNIQUES ON MEDICAL DEVICES – A LITERATURE REVIEW.

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Abstract

The importance of patient safety or protecting patients from harm as a result of interaction with medical devices in healthcare systems is a topic that is gaining a lot of prominence and equally attracting litigation. Use of medical devices may pose risk to patients, users and the environment, thus the need to embrace risk management practiceson medical facilities. Risk management practice employs systematic application of management policies, procedures and practices to the tasks of analysing, evaluating, controlling and monitoring risk. The medical device manufacturers and regulating bodies have developed standards and regulations to manage and mitigate against risks that may cause unavailability of medical devices, or harm to patients undergoing diagnostic or treatment processes. Ideally, the risk management practice encompass the life cycle of the device; from procurement of the equipment, installation, operation, maintenance and disposal of the equipment at the end of its useful life. Public hospitals in Kenya are not exceptions with critical medical devices often unavailable for long periods of time with considerable suffering to patients in need of diagnostic and treatment services. In thispaper,we review methods and tools for mapping and assessing risks associated with clinical processes which are linked to medical devices. The review aims at identifying tools/methodsbest suitedfor Kenya's problem context, and moreover, the review establishes the gap between the prescribed international standards, and actual practices in Kenya as far as medical devices are concerned.

Keywords: Healthcare risk management; medical device risks; Risk assessment; risk hazards; risk gap analysis

INTRODUCTION

With increased procurement of sophisticated medical devices, so is the increased probability of failure and harm to a patient, user or a device. It vital to note that any malpractice related to failure of the device may lead to loss of life and litigation so patient safety is emphasised. It is important healthcare organisations incorporate risks management practices and policies in their facility management. By extension, medical device manufacturers should implement a full risk assessment process of a medical device and ensure that a solid risk management is also implemented (Dumbrique, 2010). This way, the potential risk of a product can be readily addressed throughout the life cycle of the equipment including post-market phase. Studies carried out emphasise the need to have compliance standards and regulations as far as medical devices are concerned, and thus offer patients conforming services consistently. Risk-based thinking enables an organization to determine the factors that could cause its processes and its quality management system to deviate from the planned results, to put in place preventive controls to minimize negative effects and to make maximum use of opportunities as they arise (ISO-9001, 2015). These controls form the basis of decision making in the organisation at all levels and ensure total quality management forproduct realization.

The source of risks in medical devices may range from technical, operational, logistical to maintenance reasons. Prolongeddowntime of medical equipment leads lossof opportunities on both the revenue and delayed healthcare service (Mfontanazza, 2012).

Risks management

The concept of risk management follows a cycle shown in Figure 10, the processstarts with establishing the organisation context by defining internal and external parameters and factors that influence its objectives (ISO-31000, 2009). Risk assessment is carried out by identifying, analysing and evaluating risks based on established standards or organizatonal policies. Risk identification process determines risks that could potentially prevent a program, enterprise, or investment from achieving its objectives. It includes documenting and communicating the concern (Mitre.org, 2017). Risk analysis is done by estimating identified risks and examine the sequence of events that can produce hazardous situation or harm(ISO-14971, 2007), by estimating probabilities of occurrence, determining the severity of consequence; or a measure of seriousness of harm(FMEA-FMECA.com, 2006) and detectability of the hazard and/or critical points to be monitored, corrected or controlled.Information or data for estimating risks can be obtained from published standards, scientific technical data; field data from similar medical devices already in use including published reported incidents, usability tests employing typical users, clinical evidence, results of appropriate investigations, expert opinion, and external quality assessment schemes(ISO-14971, 2007). Evaluation is the last, step in risk assessment, where the estimated risk is compared against a given criteria to determine the acceptability of that risk (ISO/IEC-31010, 2009). The risks that do not conform to requirements are supposed to be reduced through treatment control measures and the cycle repeated until the risks is reduced to as low as reasonably possible (ALARP). Risk evaluation assists and organisations decide the risk treatment and control criteria. To achieve the risk management process there are several technique employed their usability is as discussed in the following sections.

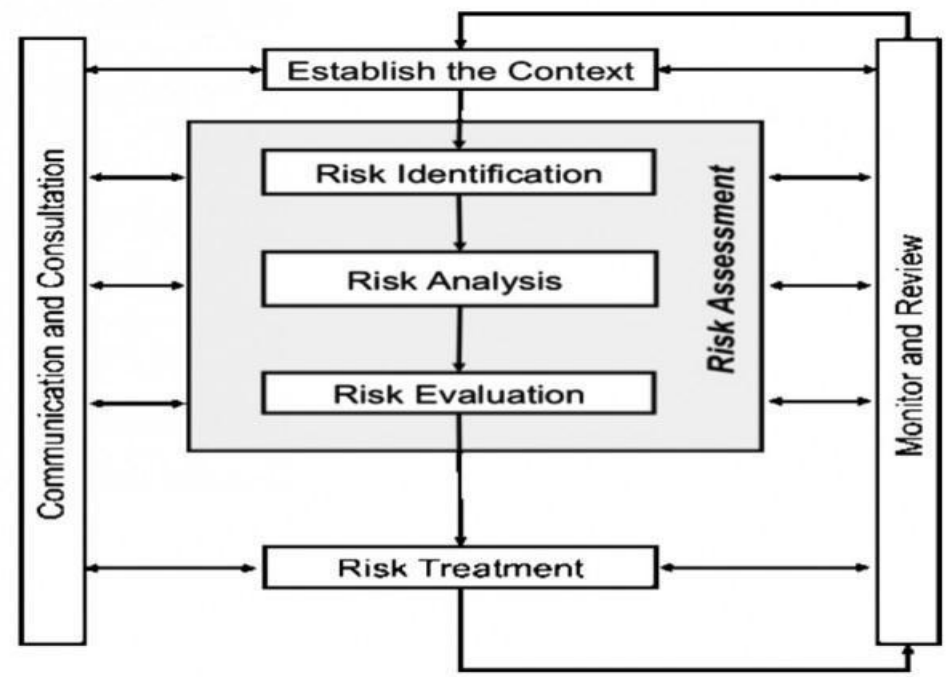

Figure 10: Risk Management process (ISO)

RISK ASSESSMENT TECHNIQUES

To establish the gaps of risk management practices of medical devices, it is important to establish the methods and techniques to achieve the goals. According to (Cohrssen, J. J., &

Covello, V. T., 1989), most of these techniques follow a similar pattern of: Identification of hazards; risk estimation;communicating the significance of a risk; establishing recommendations and planning actions; measuring the effects of the new implemented actions; repeating the process. The risk assessment techniques prescribed by several studies serves a specific purpose depending on the situation at hand, whose application depends on complexity of the problem and the data required. **Error! Reference source not found.** summarises the most common techniques and categorised according to broad application criteria. For healthcare risk assessment, only some of these techniques are applicable. The sections below will discuss briefly the techniques applicable in healthcare, a mention of some studies conducted using the techniques and results achieved.

Table 4: Risk assessment techniques

Risk Assessment Techniques	
Broad Category	**Assessment Technique**
Look up methods	Checklist
	Preliminary Hazard Analysis (PHA)
Supporting Methods	Structured interview and brainstorming
	Delphi Technique
	Structured What If Technique SWIFT
	Human Reliability Analysis
Scenario Analysis	Root Cause Analysis (RCA)
	Fault Tree Analysis (FTA)
	Event Tree Analysis (ETA)
	Cause and Consequence Analysis
	Cause and Effect analysis
	Toxicological Risk Analysis
	Business Impact Analysis
	Scenario Analysis
Functional Analysis	Failure Mode and Effect Analysis (FMEA)
	Failure Mode Effect and Criticality Analysis (FMEA)
	Reliability Centred Maintenance
	Sneak Circuit Analysis
	Hazard and Operability Study (HAZOP)
	Hazard Analysis and Critical Control Points (HACCP)
Control Assessment	Layers of Protection Analysis
	Bow tie analysis
Statistical Methods	Markov Analysis
	Monte-Carlo Analysis
	Bayesian Analysis

Checklist analysis

Checklist is a basic tool for identifying initiating events and for dividing the plant into subsystems that are likely sources of an accident or initiating event (Kumamoto, Hiromitsu

and Henley, Ernest J, 1996). In a checklist analysis, a process is analyzed using an advanced created checklist that contains a list of hazards, risks or control failures that have been developed usually from experience, either as a result of a previous risk assessment or as a result of past failures (ISO/IEC-31010, 2009). The advantages of this technique are that less experienced analyst can carry out analysis once a checklist has been prepared by an experienced risk analyst. It is relatively fast and important hazards cannot be forgotten. The downside however, the technique requires a great deal of experience in order to setup a good checklist and the results are qualitative.It follows three steps of: developing checklist, performing analysis and documenting results and recommended actions.

The application of this technique is healthcare very common, such as use of checklist in surgical operation. According to (Panesar *et al*, 2011), (Slim, K., & Martin, G. , 2009) and (Bock M, *et al*, 2016), reported thatadoption of checklist analysis prevented patient safety incidents. Checklists have also been used in order to optimize the working condition for the nursing staff, discharge patients, or estimation risks involved with new equipment (Engkvistl *et al*., 1995;Dierickx P., & Van Dingenen K., 2009).The suitability of the checklist analysis for risk analysis applies in the identification of hazards and ensure that activities in a process are not neglected.

Preliminary Hazard Analysis (PHA)

PHA is a simple, inductive method of analysis whose objective is to identify the hazards and hazardous situations and events that can cause harm for a given activity, facility or system (ISO/IEC-31010, 2009). The technique can be used early in the development process to identify the hazards, hazardous situations, and events that can cause harm when there is little information on design details or operating procedures (ISO-14971, 2007). It often forms a basis of future studies on the device. The application process is broken into four steps: Establishment of PHA requirements, Identification of potential hazard, Measurement of frequency of occurrence and its severity, and Risk ranking (Dumbrique, 2010)

In healthcare systems, the method is completed with the identification of the probabilities that the accident happens, the qualitative evaluation of the extent of possible injury or damage to health that could result, and the identification of possible remedial measures. The results obtained can be presented in different ways such as tables and trees. The strengths of the technique is ability to identify hazards early enough to be corrected at minimum cost, it can help to develop operating guidelines useful throughout the life of the process/device (Verplaetsen, 2009) and can be used when there is limited information. The downside is that it provides only preliminary information; it is not comprehensive, neither does it provide detailed information on risks and how they can best be prevented.PHA is only suitable for risk identification and may not be sufficiently applicable for risk analysis and risk evaluation. Equally the technique cannot provide quantitative output.

Root Cause Analysis (RCA)

RCA) refers to a class of problem solving methods which are aimed at identifying the focal root causes of recurrent equipment failures in technical assets (Peter Chemweno *et al*., 2016).The principle of RCA is based on the belief that problems are best solved by correcting or eliminating root causes, rather than taking actions directly on the defective event (Duc Dang Vu, Tom Trappeniers, 2010). Variation in performance can (and often does) produce unexpected and undesired adverse outcomes, including the occurrence or risk of a sentinel event(unanticipated occurrence involving death or major permanent loss of function unrelated to the natural course of the patient's illness or underlying condition) (Joint Commission Resources, 2015). RCA uses structured analysis techniques to determine the root cause of failure. The approach of RCA is used by other techniques in their risk assessment. The main objective of RCA is accident investigations and occupational health and safety. It can also be

used in failure analysis of engineering systems related to maintenance, reliability and quality control.

Some of the strengths of RCA are: involvement of experts working in a team environment, structured analysis, consideration of all likely hypotheses,documentation of results and the need to produce final recommendations.

Fault Tree Analysis (FTA)

FTA is a top down approach of problem solving (O'Connor, 2002). It starts by identifying the potential hazard (top event) and breaks it down to failure modes that may have caused the hazard. Causal factors are deductively identified, organized in a logical manner and represented pictorially in a tree diagram which depicts causal factors and their logical relationship to the top event. This approach uses logic gates like "and" and "or" gates to relate potential failures to possible causes. Where probabilities can be assigned to base events the probability of the top event may be calculated. It provides a systematic approach to problem solving as it visually details the causes and effects of activities or human related factors that may have caused a high level of risk if overlooked (Kamm, 2005).The tree like representation of root cause analysis gives the reviewer a clear picture, at a glance, of each of the possible scenarios that is taken into consideration. For large complex systems where failure modes may be enormous, software programs are now available to aid organizations in doing (O'Connor, 2002). This approach is useful in safety engineering, early in the development stages, for the identification and prioritization of hazards and hazardous situations as well as for analysing adverse events (Dumbrique, 2010).

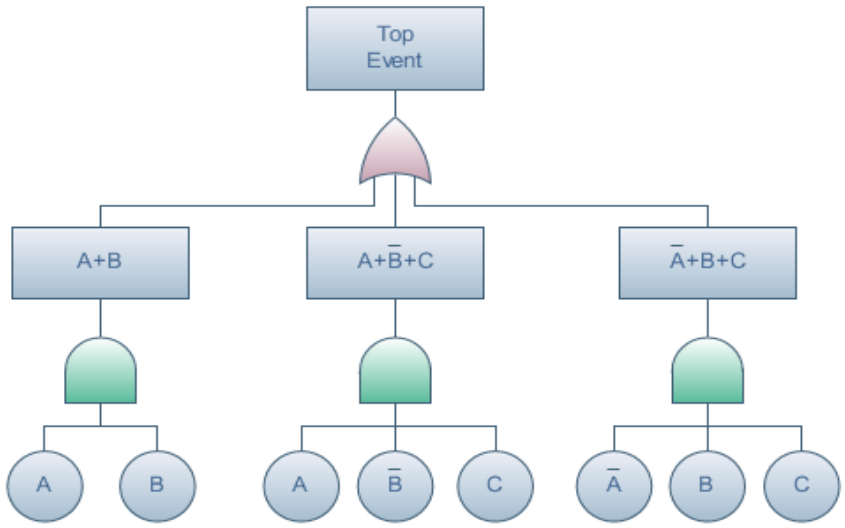

Figure 11: Example of a FTA (Edrawsoft, www.edrawsoft.com)

This benefit of FTA is being systematic and flexible allowing variety of factors, link of the top event to the causal factors, easy understanding due to pictorial representation and ability to identify failure pathways in a complex system. The downside of FTA include: uncertainties of the base events failure probabilities, sometimes the causal events are not bound together thus difficult to ascertain if all important pathways are included, FTA is a static model- time interdependencies are not addressed and FTA can only deal with binary states (failed/not failed) thus ignores domino effects or conditional failures or degree of human error.

The application of FTA in healthcare was conducted as a tool for understanding the interaction of errors or faults within a system that causes wrong site surgery (WSS). WSS occurs as a result of a cascade of errors, many of which occur outside of the operating room

(Abecassis, Z. A., McElroy, L. M., Patel, R. M., Khorzad, R., Carroll, C., & Mehrotra, S., 2015). Other studies conducted using FTA include: detection of causes of radiation misadministration to patients at a large cancer treatment centre (Ekaetteet al., 2007), In summary FTA is applicable in risk identification, analysing risk probability, risk level and evaluation of risk but it is not suitable in determining the consequences of the risk identified.

Failure Mode and Effects Analysis (FMEA)

Failure modes and effects analysis (FMEA) is used to identify ways in which components, systems or processes can fail to fulfil their design intent. FMEA identifies: all potential failure modes of the various parts of a system (a failure mode is what is observed to fail or to perform incorrectly); the effects these failures; the mechanisms of failure; how to avoid and/or mitigate the failure effects. A component level assessment gives designers ideas on what they can improve in the design to enhance the product's reliability and make it less susceptible to harmful failures (Dumbrique, 2010). FMEA incorporates an investigation of the individual component fault modes, their probability of occurrence, detectability and also the degree of severity of the consequences, where the results of this analysis reveals the risk priority number (RPN), a product of three risk metrics: occurrence (O), severity (S) and detectability (D) (Chemweno *et al*, 2016)that determine acceptability of the risk. Figure 12shows the basic application approach that can be modified depending data being analysed.

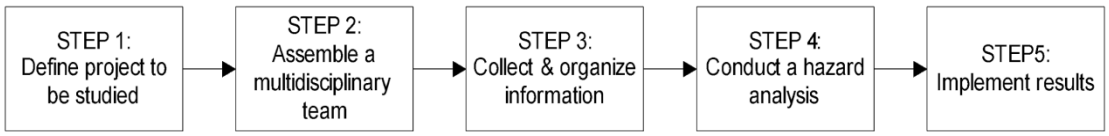

Figure 12: FMEA Approach (Duc Dang Vu, Tom Trappeniers, 2010)

The Strengths of FMEA is comprehensiveness, the systematic establishment of relationships between failure causes and effects, and its ability to point out individual failure modes for corrective action in design.The limitation of the technique is slow to implement (Duc Dang Vu, Tom Trappeniers, 2010), labour intensive and trivial cases considered. Also the result is argued to be statistically invalid, static, and RPN is seldom updated with the emergence of new sources of risks (Peter Chemweno et al, 2016). FMEA has been applied in healthcare systems, based on numerous studies done such as (Bonfant et al, 2010), (Fallon E. F., Chadwick L., & van der Putten W., 2009) and (Van Der Hoeff, 2003), where they were able to identify failure modes and also hailed the technique for its structure.It is a tool whose use in healthcare syetem require modification to HFMEA discussed in sub-sections below.

Healthcare Failure Mode and Effects Analysis (H-FMEA)

HFMEA is a modified form of FMEA developed by National centre for patient safety of the US; department of Veterans Affairs (NCPS, 2001). It is a systematic approach to identify and prevent problems in products and processes before they occur (Dyro, 2004) that improves steps in a process thereby reasonably ensuring a safe and clinically desirable outcome (NCPS, 2001). HFMEA streamlines the hazard analysis steps found in the traditional FMEA into an algorithm presented in a decision tree. It also replaces the calculation of the risk priority numbers with a hazard score that is read directly from a hazard matrix. It is a preferred technique because it is well structured and healthcare specific. Several studies indicates that HFMEA is a promising technique, but its disadvantage is time consuming, however it results in thorough risk analysis and understanding of the process. The multidisciplinary team approach ensures that no failure modes are neglected or forgotten.Figure 13 depicts the steps followed while conducting HFMEA, sometimes with variations depending on the situation.

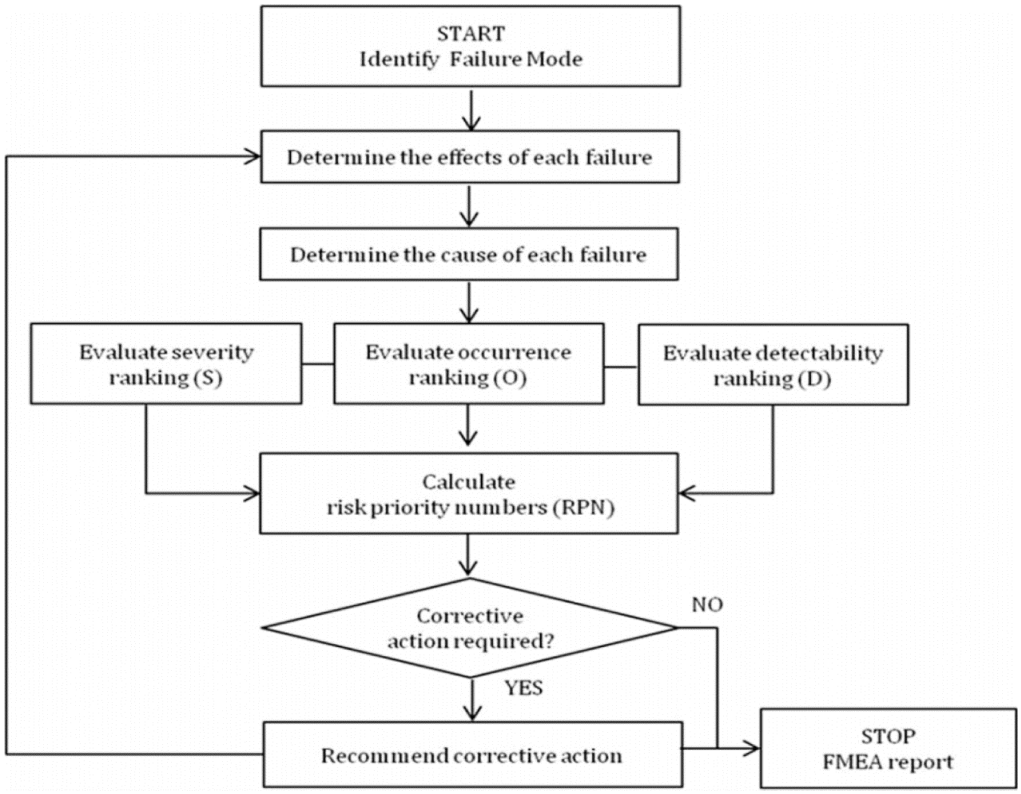

Figure 13: HFMEA process (Source: Jeong-Eun Rah, Ryan P. Manger, Adam D. Yock, GweYa Kim, 2016)

Application of HFMEA in the healthcare

Most of the articles written of HFMEA in healthcare validate the suitability of the technique as an alternative for healthcare risk analysis, although most of the articles have deduced that a lot of improvements is required in the tool. Most of these articles handle about a first time implementation of HFMEA.The information from several studies such as (Linkin, 2005), concludes that HFMEA's results do not give statistical inference, but raised correctable errors during analysis. Other studies reported that the technique is time consuming but applicable in Dutch healthcare system (Habraken, Van der Schaaf, Leistikow, &Reijnders-Thijssen, 2009), though lack of guidance with regard to the identification of failure mode causes and effective actions might have influenced the quality of the outcomes of an HFMEA analysis. The University Medical Centre of Utrecht performed an HFMEA on the process of prescription and administration of vincristine (a chemo medicine) (Van Tilburg C. M., Leistikow I., Rademaker C., Bierings M., & Van Dijk A., 2005) and deduced that (HFMEA) is a valid proactive method to evaluate circumscribed health care processes. It is also a useful tool for the prospective risk analysis method (Jeong-Eun Rah, Ryan P. Manger, Adam D. Yock, GweYa Kim, 2016). It can be concluded that HFMEA is the ideal technique to handle risk assessment of health care devices for it is systematic, structured and gives results. It has been noted that the technique require in-depth understanding, time and personnel resources to be able to execute any risk analysis

Hazard and Operability Study (HAZOP)

HAZOP is a systematic technique for identifying hazards and operability problems. It is structured for examination of a planned or existing product, process, procedure or system. It can be used to identify human related risks, equipment, environment and/or organizational objectives (ISO/IEC-31010, 2009). It is based on assumption that accidents are caused by deviations from the design or operating intentions (ISO-14971, 2007). The HAZOP technique was initially developed to analyse chemical process systems, but has been extended to other types of systems and complex operations. The technique follows a multidisciplinary approach

where a team reviews process drawings and procedures and uses a predetermined protocol to methodically evaluate the significance of deviations from the normal design intention (Duc Dang Vu, Tom Trappeniers, 2010). The HAZOP technique is qualitative, and aims to stimulate the imagination of participants to identify potential hazards and operability problem.The HAZOP analysis focuses on specific points of the process called process sections. Its application in healthcareinvolves provision of full description of medical device and its intended use, reviewing the intended use and determining how design deviations can occur on each intended use. Stepwise, the HAZOP team examines each process section for potentially hazardous deviations,

Strengths of HAZOP analysis includes systematic and thorough examination of a system process or procedures, allows explicit consideration of the causes and consequences of human error and creates a written record of the process. The limitations are: time-consuming and therefore expensive, requires a high level of documentation or system/process and procedure specification,focus on finding detailed solutions rather than on challenging fundamental assumptions, the analysis process is constrained by the design and design intent, and the scope and objectives given to the team and the process relies heavily on the expertise of the designers who may find it difficult to be sufficiently objective to seek problems in their designs. In healthcare sector technique can only be used in the identification of potential hazards in chemical and biological processes and their causes.

Hazard Analysis and Critical Control Point (HACCP)

This is a systematic, proactive, and preventive system for assuring product quality, reliability and safety of processes by measuring and monitoring specific characteristics which are required to be within defined limits (ISO/IEC-31010, 2009). This technique was primarily developed and used in food and pharmaceutical industry that focuses on the prevention of physical, chemical, and biological hazards rather than finished product inspection. This method is very well adapted for the risk analysis of mass production processes in food and pharmaceutical sector (Duc Dang Vu, Tom Trappeniers, 2010). When applied to medical devices, HACCP is used for the control and monitoring of initiating causes of product hazards originating in processes, particularly manufacturing processes and other possible hazards that take place in the different life cycles of a medical device.

Strengths of HACCP is that it is structured process with documented evidence for quality control as well as identifying and reducing risks, focus on practicalities of preventing and controlling process hazards without relying on the final product and ability to identify hazards introduced through human actions and how they can be controlled at the point of introduction. The downside of this technique is the requirement to combine the process with other tools in order to specify critical control points (Hyman, William A., 2003).

The application of HACCP in healthcare is related to pharmaceutical processes and food production. For instance (Griffith, 2006), carried out a study to examine some of the management solutions developed in the food industry, and discusses their application to healthcare delivery. It is mostly used in in medical device design and manufacturing. Conclusively the technique is appropriate during manufacture of medical devices as a form of hazard identification and their consequences and used as an evaluation tool but, has deficiency in analysis probability of occurrence of the hazard and the severity of the same.

Applicability of risk assessment techniques

Table 5below summarizes the applicability of the reviewed risks assessment techniques. Most of the techniques cannot be applied across the process of risk management. Sometimes it requires a combination of techniques to attain optimum results. It is important to note that it is only FMEA that can be used across the all requirements of risk assessment.

Table 5: Application of risk assessment techniques

Tools and techniques	Risk assessment process				
	Risk Identification	Risk analysis			Risk evaluation
		Consequence/ Severity	Probability of occurrence	Level of risk	
Check-lists	SA	NA	NA	NA	NA
Primary hazard analysis (PHA)	SA	NA	NA	NA	NA
Hazard and operability studies (HAZOP)	SA	SA	A	A	A
Hazard Analysis and Critical Control Points (HACCP)	SA	SA	NA	NA	SA
Root cause analysis	NA	SA	SA	SA	SA
Failure mode effect analysis (FMEA)	SA	SA	SA	SA	SA
Fault tree analysis (FTA)	A	NA	SA	A	A
	SA – Strongly applicable A – Applicable NA – Not Applicable				

Risk Evaluation of Medical Devices

From the above discussed techniques, it can be noted that only three techniques can evaluate identified risks. Risk evaluation is a process that is used to compare risk analysis results with risk criteria in order to determine whether or not a specified level of risk is acceptable or tolerable. This is where comparison of the assessed risk to given risk criteria using a quantitative or qualitative scale to determine the significance of the risk is done. The risk acceptability will assist in decision making and ensure that priority is taken on those hazards that will pause greater risk to patients, systems and device users.

CONCLUSION

In Kenyan health sector, there are only two available studies remotely related to risk management. One is a performance audit conducted by the auditor general of Kenya (Auditor General, November 2012) in Kenyatta national hospital concerning medical equipment that were constantly unavailable due to breakdown and another by (David Mutia, John Kihiu, Stephen Maranga, 2012) on maintenance management of medical equipment in hospitals.

From the foregoing discussion, it can be concluded that the risk management practice is very necessary towards ensuring that patients and medical practitioners are safe while using devices. The practice will also ensure that the devices meet the needs of Kenyan patients and are always available and utilized without wastage. The techniques discussed required minimal resources that are available, subject to capacity building on the different methodologies. If it is applied in Kenyan public hospitals it will assist in developing either a risk management framework or policy that ensures safety. It will also assist healthcare organisations prioritize mitigation measure on hazards that pose unacceptable higher risks and reduce those that can be reduced.

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DRIP IRRIGATION: A MEANS OF IMPROVING SMALL FARMER LIVELIHOODS IN MICHAKA VILLAGE, MERU COUNTY

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Abstract

Rainfall in Kenya has become unreliable in frequency and inadequate in quantity leading to poor crop production levels in almost all regions of the country.Kenya can be considered to be one of the developing countries that have not made significant progress in mitigating climate change thus rendering the country highly vulnerable to the effect of drought. This has led to hunger and loss of livelihood as many small scalefarmers rely on the sale of produce as their only source of income. Drip irrigation may be the key to enabling such farmers to achieve adequate levels of vegetable production and a level of income to properly maintain their families. This study characterizedthe impact of drip irrigation on the livelihoods of small scale women farmers in Michaka village, Meru County. A Canadian NGO 'Farmers Helping Farmers' supplied a water storagetank and drip irrigation lines to half of the 40 members of a self help group. Microsoft Excel computer package and descriptive design was used to analyse water usage, production levels of selected vegetables, income and family welfare. The study determined that income of the farmers was increased from the sale of surplus vegetables. This resulted from an enhanced level of crop production which was undertaken throughout the year while utilizing less water. Welfare of the families studied was thus enhanced. The study concludes that drip irrigation has a great impact on the livelihoods of farmers and recommends that the same model be replicated by other farmersalthough training is likely to beessential for the success of drip irrigation. The government should also subsidize drip irrigation kits so that many small scale farmers can betterafford them.

Key words*:* Drip irrigation, Smallholder farmers, Income, Food production

INTRODUCTION

Despite the constant and varied changes that have occurred in the agricultural sector in Kenya, agriculture remains the backbone of the economy contributing 30% of the gross domestic product (GDP).This sector accounts for80% of employment nationwide (Ndung'a et al, 2016). Kenya primarily relies on rain fed agriculture (Moresmau and Hanne, 2004) which mostly is erratic, unreliable and inadequate thus making the country vulnerable to food shortages as well as making the anticipation of the performance of the systems of agriculture very complex (Nicol, *et al.,* 2015)

This study was conducted in Michaka village, Meru County, a village which relies on rain-fed agriculture for their livelihood. Meru County has two rainy seasons, that is the long rains which occur in March to May and short rains in October to December (Oxford, 2014). However in the rains have been unreliable and erratic thus affecting the smallholder farmers.

In Meru, the agricultural scene is primarily 98.6% comprise of small scale farms with two acres of land (Ministry of Agriculture, 2013). A report by Oxford (2014) on Meru County indicated that there are few up to date irrigation systems in the county. However larger farms located in Kisima and Timau areas of the county have adopted trickle irrigation as well as greenhouse croppingexpertise. The county government has set an ambitious goal to have

100,000 acres irrigated by 2017. This ambitious plan was basedon the report by County Integrated Development Report 2013-17 which stated that there is potential for irrigation of 200,000 acres within the county and noted that only 5,266 acres of land was currently irrigated. In their research (Postel, *et al*., 2001), indicated that there is great potential to reducing poverty through improving and encouraging irrigation by smallholder farmers.

Water is extremely important more than land for farm production development particularly in the Arid and Semi-Arid Lands (Iddrisu, 2011). FAO (2015) indicated that in the dry seasons the volume of water in rivers went from average to low. This means the availability of water is scarce when most needed.Irrigation consequently is viewed as the procedure of ensuring water reaches the root area of plants for improved crop growth.Drip irrigation is generally documented as one of the most proficient techniques of irrigating fields (Keller and Bliesner, 1990).

Dasbary and Or (1999) describe drip irrigation as a system of conserving water by delivering water drops to plants from tiny holes in pipes laying on the soil surface. The system ensures the plants are frequently supplied with water. Irrigation technologies which include drips and sprinklers were first introduced in Israel the 1960s and later spread to other parts of the world (Shah and Keller, 2002). Shah and Keller (2002) however noted that recently efforts have been made to promote these technologies which are well suited for smallholder farmers, their management is easy and the start-up capital required is low.

Sijali (2001) noted that drip irrigation systems have many benefits such as higher crop yields, conservation of water and minimized fertilizer and chemical use. It can also lead to increased income amongst poor smallholder farmers (IDE, 2004). Chitsiko and Mudima, (2002) in their study in Zimbabwe noted that production from drip irrigation increased by 300% compared to production that relied on rainfall. Kuscu *et al* (2009) found that water applied through drip technology had a positive impact on the vegetable production and increased profit. However the smallholders may not be in a position to meet the expense of the technology.

Postel *et al* (2001), described a variety of drip irrigation structures now accessible for smallholder farmers; these systems are affordable, easily divisible, good rate of returns as well as use water economically. Initially seen as expertise for big, for profit growers who producehigh value crops, drip systems are currently seenas an enormous guarantee for improving productivity of land, effectiveness in water usage as well as revenue for the underprivileged smallholder farmers. Despite the expansion of the farms under irrigation to almost fifty times through the last twenty years, this is just a representation of a percentage of the total area under irrigation worldwide. In Kenya drip irrigation was first introduced in the late 1990s (Kulecho *et a.,l* 2005). Kulkarni (2000) noted that the entire area in Kenya under drip irrigationwas less than onehundred hectares; however, in countries such asIndia over 260,000 hectares were under drip irrigation in a span of 10 years. The difference in adoption of drip irrigation according to Kay (2001) is lack of demand for the technology from the farmers, he estimated that only 1,200 hectares were put under drip irrigation in African countries.

The major barrier to its adoption has been stated to be thevery high initial cost. A methodical and autonomous study on the utilization and effect of drip irrigation in Africa is deficient. Drip irrigation is extensively viewed as an accomplishment notwithstanding the deficiency of information on its continuous or non-continuous use in the smallholder's farms. This study therefore sought to characterize the effect of drip irrigation in the livelihoods of smallholder farmers in Michaka village.

Research objectives

This study was guided by the following objectives:

- To identify the influence of drip irrigation on water usage of smallscale farmers.
- To examine the influence of drip irrigation on vegetable production of smallscale farmers.
- To evaluate the influence of income from drip irrigation on smallscale farmers.
- To establish the influence of drip irrigation on family welfare of smallscale farmers.

METHODS

Study Design

Mugenda and Mugenda (2003) noted that the purpose of descriptive research is to determine and report the way things are and to help in establishing the current status of the population under study.This study used descriptive research survey designs to achieve the stated objectives.

Target population

The target population in this study comprised those members of the Upendo Women Group in Naari, Meru County who had received drip irrigation kits. Twenty (20) members have gardens measuring 10 m by 30 m installed with drip irrigation kits which included drip line and a 1500 litre water tank, this study therefore targeted the twenty members with drip irrigated gardens.

Sample and sampling procedure

This study adopted a census, which according to Burns & Bush (2014) is anaccounting of the complete population. Twenty (20) is a small number but the study secured information from all members of the population. The instrument used was the questionnaire which wasadministered by the researcher to the women on their farms.

Data analysis

Data was coded to facilitate analysis. It was analyzed with theaid of excel computer packages. Data wascategorized and arranged to determine how independent and dependent variables related.

RESULTS AND DISCUSSION

Socio-economic characteristics

The average farm size of the women respondents was 0.89 acres with a median size of 1.6 acres. The smallest farm was of ¼ acre, 3 respondents, and the largest 3 acres, as reported by 1 member of the Upendo group. This is representative of small farms throughout this village.

Table 1: Farm size

Land Size (Acres)	Frequency	Percentage
¼	3	15
½	6	30
¾	1	5
1	6	30
1 ½	2	10
2	1	5

3	1	5
Total	20	100

Family size

Figure 1: Number of member in each farm family

Figure 1 indicates family size tends to be large with the most frequent family reported having up to 8 members. This describes the extreme need for productive vegetable gardens if these families are to have proper diets for both children and adults as generally a family of 8 consists of two adults and 6 children. On occasion, however, families of three generations live in the Upendo area. **Water usage**

Majority of the respondents filled their 1500 litre water tank twice a week, this translates to 3000 litres of water every week for the garden. Having a water tank enables the members to store water and they are also able to regulate the amount as well as the time the water drips to the crops.

Figure 2 Number of times water tank is filled with water

All respondents had access to piped water, the number of days or availability times was however different (Table 4). This was the criteria used by Farmer Helping Farmers in providing the drip kits.Postel et al (2001) urged that a huge number of underprivileged family farm unitswho do not have access to sufficient water, would use drip irrigation resourcefully

and effectively if they had access to the needed equipment. This would imply that the majority had water available to undertake an efficient watering system as the water storage tank provided would enable several days supply to be stored and available for use as needed.

Table 4: Availability of on farm piped water

Number of times	Frequency	Percentage
Everyday	3	15
Three times a Week	9	45
Twice a Week	5	25
Once a Week	2	10
More than a week	1	5

On how they used the water before they had the drip irrigation 55% indicated that they used the available water mostly for domestic uses such as cooking washing clothes and also for their animals. Almost half of the respondents (45%) had previously tried to use overhead sprinklers to irrigate their gardens. However, these farmers were forced to irrigate mostly at night when more water was available because there being less drawn down on the water lines. However 25% of those who had tried overhead sprinkler irrigation abandoned this method. This is because of fatigue of having to wake up at night to move the sprinkler to another spot and also due to illnesses that arose due to coming into contact with cold water moreso at night. This supports Palada et al (2011) who noted thattrickle irrigation methods can guarantee smallholder farmers greater profit from available water resources.

Figure 3: Vegetables under drip irrigation Figure 4: Overhead irrigated cabbages

Figure 2 and figure 3 shows the different types of irrigation: Figure 2 illustrates rows of carrots and cabbages under drip irrigation while Figure 3 show cabbages under overhead sprinkler irrigation. Cabbages in Figure 2 are healthier appearing compared to Figure 3 because water from the drips goes directly to the plant roots. This agrees with Fintrac (2016) who concluded that drip irrigation facilitate farmers boost harvests, save water, as well as lessen amount of time spent working in the farm.

Production

Production of vegetables in drip gardens was undertaken throughout the year. All respondents using drips had planted crops three times in the course of one calendar year. This compares to the traditional planting of gardens twice yearly; during or after each of the two rainy seasons. This is in agreement with Drija and Salagean (2012) who concluded that, trickle irrigation has improved production although it entails a first high investment compared to flood irrigation.

Income

On average the respondents sold Kes.6526/- worth of vegetables from the first harvest, Kes. 6140/- from the second harvest and Kes. 3590/- from the third harvest of the three crops produced annually under irrigation. The lower value for the third harvest can be explained as half of the respondents indicated they were still harvesting and selling the third harvest at the final data collection time.This is in agreement with Winrock (2000) who noted that drip irrigation kits give promises of increase in income at the farmer level. This income increase can be explained in part from the sale of three harvests verses only two harvests on farms with no drip irrigation as such farms normally establish vegetable gardens only following the two yearly rainy seasons.

Table 2. Point of sale of vegetables harvested from irrigated gardens.

Avenue	Frequency	Percentage
Neighbours	19	95
Open Air Market	1	5
Brokers	16	80

Three main channels of marketing or selling produce were used (Table 2).Some respondents used more than one channel to sell produce. The most popular avenue, and with the least difficulty of sales was to neighbours, a method used by 95% of the farmers. Some 80% of respondents sold to brokers or middlemen, whereas only 5% delivered and sold their produce to the local open air market.

Family welfare

The study sought to find out whether the nutritional welfare of the family was enhanced or not through the establishment of the drip irrigation systems. The entire population of respondents (100%) indicated their family were consuming more vegetables when compared to before they established drip irrigated gardens. Of the respondents, 90% indicated they had more vegetables every day in their diets. Only 10% could not approximate any change in consumption of vegetables by the family.

Table 3. Uses of Income from vegetable gardens.

Uses	Frequency	Percentage
Household Items	20	100
School Fees	11	55
Farm Animals	8	40
Labour	1	5
Paid Debt	3	15
Inputs for Gardens	13	65

Buy Utensils	4	20
Hospital Bills	2	10

Table 3 indicates all of the respondents used a portion of the income from the sale of the vegetables to purchase household items such as salt, sugar, rice, cooking oil and soap among others. However the other uses of the proceeds were varied with 55% using it to pay school fees, 5% paid for labour for the garden, 10% paid hospital bills, 40% bought poultry or other farm animals such as sheep and goats, 15% paid debts, 65% bought inputs for their gardens while 20% bought household utensils. This indicates a healthier and more nutritious diet for members of these families. The purchase of inputs for the gardens (fertilizers and chemicals) and additional farm animals would be expected to improve futurefamily nutrition as well as provide for enhancements to the future farm income potential.

CONCLUSION

Drip irrigated gardens are, and continue to be, vital in the livelihood of the beneficiaries from the Upendo Womens Group, Michaka village. The water is scarce but with the drip irrigation system and a small water storage tank the respondents were able to grow productive crops. The system ensures the use of water was economical as the drops trickled to the roots of the crop thus little water was wasted as with overhead systems. Water scarcity is increasing by the day creating competition between different uses as well as users. Thus it is imperative that the water resources of the community be effectively managed and drip irrigation is one such way. More vegetables were available for the families on a daily basis compared to when they did not have drip irrigation and the sale of surplus vegetables facilitated the purchase other food items they did not have such as rice, flour and sugar further enhancing the family nutritional status.

The daily sales to neighbours provided a steady income. This ensured the respondents had cash for their daily requirements. Not only were able to take care of their daily needs but also fulfil other needs such paying school fees, buying additional farm animals as well as inputs to ensure successful gardens in the future.

This study only looked into the influence of drip irrigation, thus other studies need to be undertaken to examine the actual profitability of garden and on any hindrances which may restrict adoption of drip irrigation.

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EFFECT OF REGULATED DEFICIT IRRIGATION AND SUPERABSORBENT POLYMER ON MAIZE PRODUCTIVITY

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Abstract

Growing crops in an arid area or during a dry season should not automatically lead to absence of harvest because agriculture has many options for the mitigation of rainfall inadequacy irrigation being one of such options. However, irrigation requires some adjustments when water is limited. This study investigated the performance of maize in dry areas under regulated deficit irrigation (RDI) in combination with a superabsorbent polymer. Field experiments for the study were carried out at Marimanti in Tharaka Nithi county and Isiolo in Isiolo county. Deficit irrigation except during the exponential growth stage (DIE) and deficit irrigation except during the reproductive (DIR) stage were compared to full irrigation throughout (FI) and deficit irrigation throughout (DI) the season from the 31st day after sawing. A superabsorbent polymer (SAP) was compared to a control without SAP. The experimental design was RCBD replicated three times. Growth parameters were plant diameter and plant height to flag leaf while yield indicators were stand count, productive plants per plot, ear size, above ground biomass, grain yield, and harvest index. The data was summarized in MS ACCESS and SPSS version 24 was used for F-test at 5% level of significance and for post-hoc tests where necessary. FI gave the highest diameter (2.206 cm); the highest plants (148.02 cm for height to the flag leaf) and highest grain yields (3019 kg/ha) but DIR gave the highest harvest index (0.4665) while DIE had the highest water productivity ($0.5082 kg/m^3$). SAP did not affect growth or yield significantly, but its interaction with RDI had a significant effect on various yield indicators and on water productivity. The study concluded that RDI increases water productivity when combined with SAP and DIE was recommended as a viable practice when water for irrigation is limited.

Keywords: Kenya, limited water for irrigation, maize, regulated deficit irrigation, superabsorbent polymer

INTRODUCTION

Due to a growing demand for agricultural products used as food for humanity, feeds for domestic animals and raw material for industries, agriculture is under constant pressure to increase the total world production (Acquaah, 2007). As the world population increases, population pressure results in a decrease in arable land forcing crop production to be directed towards dry areas where water is a limited commodity and yet irrigation is inevitable (Ahmad, Khan & Naeem, 2014). Furthermore, due to competition among water – use sectors, the percentage of water allocated to agriculture for irrigation is expected to continue shrinking (Ghane et al., 2011). In Kenya, Liniger (1988) argues that whereas most of the soils in marginal rainfall areas have high potential for agriculture, low soil water constitutes a major limiting factor for crop production. Unfortunately, little research has been done locally to understand how deficit irrigation can be used as a strategy for water conservation in the semi – arid areas of Kenya.

When rainfalls cannot sustain crop production, irrigation is used to meet crop water demand with satisfactory results. However, irrigation in view of meeting the full water requirements

becomes a challenge when water is in limited supply. That is why deficit irrigation which aims at increasing productivity per unit of water adopts technologies that do not target full evaporative requirements. Unlu et al(2011) recommended 50% deficit irrigation as giving significantly higher water use efficiency (WUE) and harvest index (HI) compared to treatments where 100% of the water required was applied to reach field capacity. On the other hand, regulated deficit irrigation (RDI) improves water use efficiency of crops by producing almost the same yields with less water (Du, Kang, Sun, Zhang, & Zhang, 2010). Moreover, RDI may also offer additional advantages such as: (i) reduction of the number of irrigations if the irrigation frequency is reduced; (ii) reduction in energy to lift water if pumping is involved; and (iii) reduction of the total cost of production if water used on the field is paid for (Igbadun, 2012). Klocke, Currie, Tomsicek, & Koehn (2011) and Ayana (2011) found RDI to improve crop water productivity in maize. Regulated deficit irrigation was recommended by Cosgrove and Rijsberman (2000) to supplement rainfall in order to increase the productivity of water when a limited supply is made available to crops at critical periods.

Moreover, soil water loss through deep percolation can be prevented using chemical methods such as superabsorbent polymers (SAP) which are hydrophilic materials that can absorb and retain huge amounts of water thus improving water productivity when water is in limited supply (Dabhi, Bhatt, & Pandit, 2014). SAPs have been found to increase both the shoot dry matter (SDM) and the root dry matter (RDM) under deficit irrigation with water use efficiency increasing by 50% (Islam *et al*., 2011). With increased water retention capacity in the soil, superabsorbent polymer can delay water stress of plants by acting as buffer against damage of plants between irrigation events (Ghehsareh, Khosh, & Abedi, 2010). Though Kipkorir, Raesa, and Massaweb (2002) recommended the use of deficit irrigation for maize production in the Kenyan drylands under rain–fed conditions with irrigation as a supplementary input, information remains scanty. Furthermore, as Du *et al*. (2010) caution, the timing of RDI and the degree of soil water deficit in different climates, varieties and planting conditions need to be investigated before it can be concluded whether it is practical in those specific conditions.

This study generated information on the performance of regulated deficit irrigation under local dryland conditions and it is our hope that its findings will be useful to those in charge of guiding farmers on how to practice crop production with limited water supply.

MATERIALS AND METHODS

Site Description

Location

Two field experiments were conducted at Marimanti Rural Training Center located on a latitude of 0°9′ S, a longitude of 37°54′ E and an altitude of about 845 m above sea level (absl), and at Isiolo Maili Saba on a farm located on a latitude of 0°16′ N, a longitude of 37°33′ E, and an altitude of about 1120 m absl.

Climatology

Both Marimanti and Isiolo receive an average annual rainfall of about 850 mm, which is bimodal in distribution, average temperature of 16 to 35°C. The experiments at Isiolo and Marimanti were carried out under rain – fed conditions with irrigation as a supplemental measure during the short rainy season of October, 2016 to February, 2017. The total amounts of rainfall recorded at Marimanti and Isiolo during the experiment were 212.7 and 209.4 mm, respectively.

Soils

The soil type of the Marimanti site was sandy loam, while the Isiolo site had clay loam type of soil. Soil analysis for both sites was done and the suggested corrective measures were used to determine the inorganic fertilizers to use as basal fertilizer applied at planting and as top-dressing fertilizer applied in two splits at 21 and at 45 days after sowing (DAS).

Treatments and Treatment Combination

Four regulated deficit irrigation treatments were used: (i) full irrigation during the first 30 days after sowing followed by deficit irrigation throughout the season with only 50% of the required amount (DI); (ii) full irrigation until after the end of the exponential growth stage and then 50% deficit irrigation (DIE); (iii) full irrigation during the first 30 days after sowing followed by 50% deficit irrigation during growth stage and full irrigation from tasseling to grain filling (DIR); and (iv) Full Irrigation throughout the season (FI). The chemical water conservation practice used was Superabsorbent polymer (SAP) compared to a control without SAP.

Experimental Procedure

Each experimental site consisted of three blocks divided into eight plots each, while the plots were sub-divided into four sub-plots each. Primary and secondary cultivation were done manually and different treatments were assigned to the split plots. Two seeds were planted per hill, and thinning was later done leaving one plant per hill to obtain a uniform plant population. Penman-Monteith method was used for the calculation of the reference evapo-transpiration from long term averages of climatic data from CLIMWAT. Fertilization and weed control were done as per agronomic requirements.

Data Analysis

The data collected were summarized in MS ACCESS then analyzed using SPSS (version 24). Analysis of Variance (ANOVA) was conducted to determine if there were significant differences between the treatment means at $\alpha=0.05$ followed by post hoc tests where necessary.

RESULTS AND DISCUSSION

Effect of Regulated Deficit Irrigation

Effect of regulated deficit irrigation on growth

Plant diameter and plant height were measured from the 30 days after sowing and the data obtained was subjected to the F-test to check for significant differences and thereafter a post-hoc analysis was done to compare the treatments means, the summary in Table 1 was obtained.

Table 1: Comparison of the effect of deficit irrigation treatments on growth components

Irr. Treat.	Plant diameter (cm)					Plant height (cm)				
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
DI	1.568a	1.650a	1.744a	1.829a	1.859a	34.50a	74.54a	107.44a	124.04a	126.20a
DIR	1.551a	1.652a	1.771a	1.863a	1.883a	34.60a	73.49a	104.94a	123.40a	125.86a
DIE	1.585a	1.762b	1.938b	2.009b	2.027b	34.88a	78.58b	116.24b	135.15b	138.53b
FI	1.581a	1.827c	2.080c	2.170c	2.206c	34.47a	80.45b	120.55c	142.80c	148.02c

Means in the same column with the same letter are not significantly different ($p > 0.05$)

It can be found from the results in Table 1 that irrigation treatments had a significant effect with plots under FI producing significantly bigger and taller plants while plants in plots under DI and those under DIR producing the thinnest and the shortest plants. On the other hand, plants under DIE did not show any significant difference from the ones under full irrigation at until 60 days after sowing but they were significantly smaller and shorted than the ones under full irrigation at 90 days after sowing though significantly bigger and taller than plants in other plots under deficit irrigation.

Effect of regulated deficit irrigation on yields

The effect of deficit irrigation treatments on yields was analyzed using yield indicators which were observed at harvest and a summary of the results after ANOVA and Post-hoc analysis is given in Table 2.

Table 2: Post-hoc analysis results for the effect of RDI on yield indicators

Irrig. Treat.	Stand count	Number of Productive plants	Ear diameter (cm)	Ear height (cm)	Above ground biomass (g)	Grain yield per plant (g)	Total grain yield (kg/ha)	Harvest index
DI	35.67a	33.44a	4.112a	13.03a	131.71a	39.69a	1323.7a	0.3111a
DIE	35.29a	33.90ab	4.021 a	14.44b	154.02b	66.94b	2278.6b	0.4415 bc
DIR	35.21a	33.96ab	4.003 a	14.88 b	151.18b	69.93b	2372.3b	0.4665c
FI	35.25a	34.54b	3.923 a	17.14 c	202.95c	87.29c	3019.5c	0.4342b

Means in the same column with the same letter are not significantly different ($p > 0.05$).

The results in Table 2 show that FI recorded significantly higher values for ear height, above ground biomass and grain yield while regulated deficit irrigation treatments (DIE and DIR) performed the same as full irrigation or even better for stand count, number of productive plants, ear diameter and harvest index. These results are consistent with recommendations made by Kamana, Kirdab, and Sesverenc (2010) who recommended deficit irrigation practices to prevent drastic crop yield reductions in regions of high recurrent water scarcity.

Effect of regulated deficit irrigation on water productivity

The effect of regulated deficit irrigation on water productivity was evaluated in the two open field experiments. The results obtained are represented in Table 3.

Table 3: Effect of irrigation treatments on water productivity

Irrigation treatments	Irrigation water productivity
DI	0.3693a
FI	0.4828b
DIR	0.4987b
DIE	0.5082b

Means in the same column with the same letter are not significantly different ($p > 0.05$).

The results in Table 3 show that DIE had the highest water productivity and it was followed by DIR. DI had the lowest water productivity. These results are in agreement with the findings of Sani, Oluwasemire, & Mohammed (2008) who state that crops irrigated with full

irrigation tend to use more water; and they tend to grow luxuriantly due to the abundance of soil moisture.

3.2 Effect of Superabsorbent Polymer (SAP)

3.2.1 Effect of SAP on growth

The effect of SAP on plant growth was evaluated in the two field experimental sites using plant diameter and plant height as growth indicators and the results showed that all the differences were not significant ($p > 0.05$). This rather disappointing performance of SAP is suspected to have been caused by the fact that the dosage of 15 kg per hectare recommended by the manufacturer for row application which is quite low compared to international standards. Our results show that as previously proposed by other researchers, higher doses of SAP would be more beneficial. For example, Nikoorazm et al. (2009) recommended the use of between 20 to 60 grams of SAP per plant to increase fresh and dry weight compared to a control without polymer.

However, the fact that our results did not show the expected effect does not allow us to conclude that SAP has no effect on growth; it will make us investigate further on the recommended rate which was used in the experiment as it seems to be too low to produce measurable effects on growth.

Effect of SAP on yields

The effect of SAP on yields was once again analyzed using yield indicators observed at harvest and a summary of the results is given in Table 4.

Table 4: Group means comparison for the effect of SAP on yields

SAP treatment	Stand count	# of product. plants	Ear diameter (cm)	Ear height (cm)	Above ground biomass (g)	Grain yield per plant (g)	Total grain yield (kg/ha)	Harvest index
without SAP	35.32a	33.78a	4.005a	14.912a	156.40a	63.12a	2137.9a	0.4046a
With SAP	35.39a	34.14a	4.025a	14.834a	163.53a	68.80a	2359.1b	0.4220a
Sig.	0.752	0.326	0.797	0.858	0.211	0.057	0.041*	0.181

Means in the same column with the same letter are not significantly different ($p > 0.05$).

The results in Table 4 show that only total grain yield which has a p value of 0.041 had a rather marginally significant effect of SAP on yields. However, other researchers such as Yazdani, Allahdadi, and Akbari (2007) reported that the effect of different rates of polymer and irrigation intervals were significant for not only grain yield but also harvest index with the highest increase in seed yield being achieved at 225 kg ha^{-1} polymer while the lowest increase in seed yield occurred at 75 kg ha^{-1} polymer. However, Khadem, Rousta, Chorom, Khadem, and Kasraeyan (2010) found that even at a rate of 200 kg/ha, SAP without manure did not increase nutrient uptake compared to the control.

Effect of SAP on water productivity

To assess if compared to the control, SAP had a significantly different water productivity, the t-test for 2 independent factors was used and the results showed that with a mean of 0.4891 for plots with SAP and 0.4404 for plots without SAP, application had a significant effect ($p = 0.003$) on irrigation water productivity. This result is in agreement with the ones reported by Fallahi *et al* (2015) who found that by applying 60 kg of SAP per hectare, it is possible to increase water productivity by 14% compared to the control treatment.

3.4 Interaction Effect between Regulated Deficit Irrigation and SAP on Growth

The interaction effect between different irrigation treatments and superabsorbent polymers was analyzed using ANOVA and Post-hoc and the results are presented in Table 5.

Table 5: Interaction effect of irrigation treatments and SAP on growth

Combination	Plant diameter (cm)					Plant height (cm)				
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
DI+SAP	1.583 a	1.668a	1.774 a	1.862a	1.895ab	34.24a	76.03ab	110.8b	129.2b	131.81bc
DI alone	1.553 a	1.631a	1.715 a	1.795a	1.821a	34.77a	73.06a	104.05	118.9a	120.60
DIE+SAP	1.603 a	1.771b	1.936 b	2.015 b	2.040b	35.04a	78.22bc	115.7bc	134.8c	137.93cd
DIE alone	1.568 a	1.753b	1.939 b	2.002 b	2.019b	34.72a	78.93bc	116.8c	135.5cde	139.13cd
DIR+SAP	1.541 a	1.637a	1.758 a	1.835 b	1.870a	34.80a	73.20a	104.8a	123.4a	126.23ab
DIR alone	1.560a	1.666a	1.784a	1.892ab	1.920ab	34.41a	73.79a	105.1a	123.4a	125.50a
FI+SAP	1.587 a	1.845c	2.105 c	2.183 c	2.215c	34.52a	81.12c	120.9c	143.3e	148.38e
FI alone	1.574a	1.809bc	2.055c	2.158c	2.197c	34.41a	79.78c	120.2c	142.3de	147.66de

Means in the same column with the same letter are not significantly different ($p > 0.05$)

The results in Table 5 show that there is a significant interaction effect between irrigation treatments and superabsorbent polymers for plant height under deficit irrigation (DI) at 60, 75 and 90 DAS with SAP application (DI+S) producing significantly higher plants than the control (DI+N). The results in Table 6 show that thou our results for the effect of SAP did not provide enough proof that the use of SAP was effective in retaining soil water as was mentioned earlier, SAP interaction with irrigation shows that SAP had an effect.

Interaction Effect between Regulated Deficit Irrigation and Superabsorbent Polymer (SAP) on Yield Indicators

The parameters for which there are significant interactions between irrigation treatments and superabsorbent polymers were identified by use of F-test at 0.05 followed by post-hoc analysis (DMRT) where necessary and the results are given in Table 6.

Table 6: Interaction between irrigation treatments and superabsorbent polymers on yield indicators

Treatment	stand count	productive plants	ear diam. (cm)	ear height (cm)	AGB (g)	grain yield (g/plant)	grain yields (kg/ha)	harvest index
DI + alone	35.62a	33.46a	4.12521a	12.90a	125.9a	35.51a	1182.8a	0.2929a
DI + SAP	35.71a	33.42a	4.09958a	13.17ab	137.5ab	43.87b	1464.5b	0.3293b
DI_E + alone	35.33a	33.71a	4.01875a	14.71bc	151.3bc	63.93c	2164.8c	0.4272c
DI_E + SAP	35.25a	34.08a	4.02333a	14.18abc	156.7c	69.95d	2392.3e	0.4559cd
DI_R + alone	35.42a	33.75a	3.98167a	14.77bc	144.7bc	68.69d	2313.8cd	0.4777e
DI_R + SAP	35.00a	34.17a	4.02458a	14.98c	157.6c	71.16d	2430.9e	0.4553cd
FI + alone	34.92a	34.21a	3.89458a	17.28d	203.7d	84.36e	2890.2f	0.4208c
FI + SAP	35.58a	34.88a	3.95146a	17.01d	202.2d	90.23f	3148.9g	0.4476c

Means in the same column with the same letter are not significantly different ($p > 0.05$)

It can be seen from the results in Table 6 that SAP had a positive effect on grain yields for all irrigation treatments as DI+SAP recorded a mean of 1464.5 kg/ha which is significantly higher than 1182.8 kg/ha obtained under DI without SAP; DI_E+SAP produced an average of 2392.3 kg/ha which was significantly higher than 2164.8 kg produced under DI_E without SAP. It is also worth noting that although full irrigation recorded the highest total grain yields both with SAP and without SAP, the two regulated deficit irrigation treatments (DI_E and DI_R) had the highest harvest index, meaning that their conversion of nutrients into grains was better.

Figure 2 shows how above ground biomass changed with irrigation treatments in combination with SAP or without SAP.

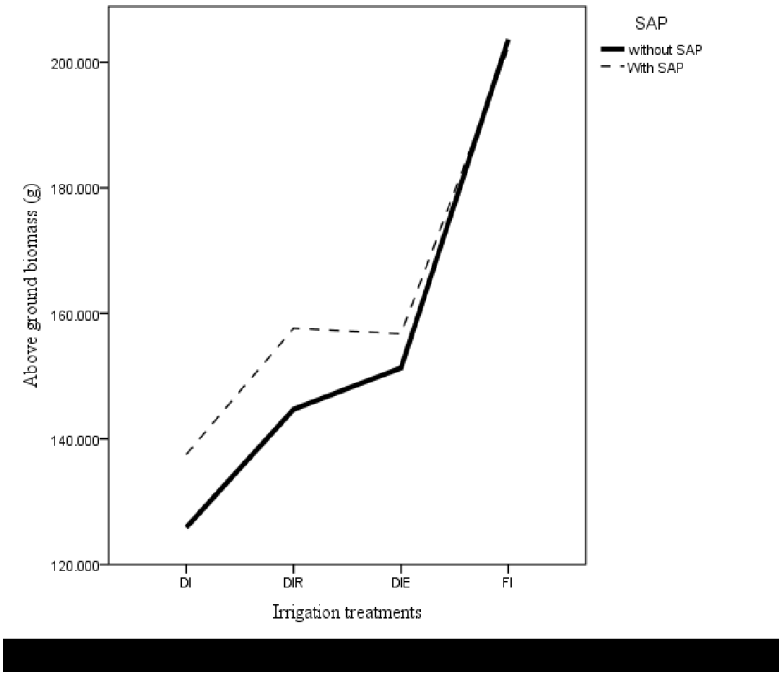

Figure 2: Effect of interaction between irrigation treatments and SAP on biomass

Interaction between Irrigation and SAP on Water Productivity

The interaction effect between regulated deficit irrigation and superabsorbent polymers on water productivity was assessed and the results are summarized in Table 7.

Table 7: Treatments comparison for the interaction effect of irrigation treatments and SAP on water productivity

Interaction irrigation-SAP	Water productivity
DI alone	0.329835a
DI + SAP	0.408769b
DIE alone	0.482987cd
DIE + SAP	0.533381d
DIR alone	0.486655cd
DIR + SAP	0.510832cd
FI alone	0.462276bc
FI + SAP	0.503363cd

Means in the same column with the same letter are not significantly different ($p > 0.05$)

As can be seen from the results in Table 7, SAP application had a significant effect on water productivity when SAP was combined with DI.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The study has proved beyond any doubt that:

(i) Irrigation treatments affected significantly maize growth, maize grain yields, and irrigation water productivity with full irrigation giving the highest results except water productivity which was higher under regulated deficit irrigation.

(ii) The effect of superabsorbent polymer on maize growth and maize grain yield was not significant at the recommended rate of 10 Kg per ha for raw crops.

(iii) Interaction effects between irrigation treatments and superabsorbent polymer affected significantly maize growth, grain yields and irrigation water productivity under reduced water application.

Recommendations

Based on the findings of the study, the following recommendations are made for consideration in order to make better use of the limited water supply available for agriculture in arid and semi-arid areas:

(i) Regulated deficit irrigation is a viable practice under limited water supply with just enough water available for deficit irrigation. DIE (deficit irrigation from the beginning of the reproductive stage) performed better than DIR (deficit irrigation from 30 days after sowing followed by 100% during the reproductive stage and 50% deficit irrigation afterward) in terms of growth and grain yields.

(ii) It is beneficial to combine regulated deficit irrigation with SAP application as the interaction effect between the two treatments affects positively growth, yields and water productivity.

(iii) Further research is needed on the effect of different rates of superabsorbent polymers on the growth, yields and water productivity under different regulated deficit irrigation treatments.

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DETERMINING THE RESOURCE SUPPLY THRESHOLDS THAT WOULD TRIGGER LIVESTOCK MOVEMENT BETWEEN COMMUNITY CONSERVANCIES

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Abstract

Grazing conflicts in Northern Kenya is causing critical scenario that is drawing the attention of many stakeholders, communities and Governments alike. These conflicts are as a result of many conspiring factors in the North of Kenya. However, most of the grazing conflicts occur on the already established community conservancies, before they filter out to the private ranches and conservancies. This mixed method of study sought to find out the thresholds of grazing resources available throughout the year in the Community conservancies, and how these contribute to livestock movements in and out of the conservancies in search of grazing resources. No study has come up with a model to predict these grazing conflicts, therefore this article is a presentation of the findings of one of the real or perceived causes of the grazing conflicts in Northern Kenya, and forms a contribution to the overall study carried out that seeks to contribute to the development of a model that can be used to predict the grazing conflicts. The study used an integrated Mixed Method approach of experimental and social survey designs to assess how competition for limited resource triggers intra and inter-conservancy conflicts. In this study a total of eight experimental plots measuring 50mx50m were set up, two in each of the three community-owned conservancies, and two in a private conservancy to assess forage availability during dry and wet seasons. The privately owned conservancy acted as the control. Carrying capacities were assessed during the dry and wet seasons using clip-dry-and-weigh method. 5 samples of Clippings were obtained using 0.5mx0.5m wire quadrant randomly distributed in each plot. Visual estimates were used to assess ground cover percentages while grass height and weight measurements were taken to assess biomass characteristics. We found that the months of June to October are the hardest periods of grazing in the study area. There are general decline in vegetation vigour, and through Participatory GIS (PGIS) the respondents attested that this has been the cause of movements to unknown areas in search of browsable forage. It was found out that there is a close correlation between grazing conflicts and water and forage availability

Key Words: Grazing conflicts, real &perceived, mixed method approach

INTRODUCTION

In northern Kenya, traditional pastoralism and social-ecological systems are undergoing profound transformation. Diminishing resource base, changing social values and governance systems and new resource management institutions challenge the capacity of the community for effective common pool resource management. Individual values and environmental perceptions play a substantial role regarding the resource use and management (Kaye & King, 2014). Pastoralism is a critical livelihood in Kenya, accounting for over 80% economic livelihoods of the communities of the northern Kenya. Forage is the second critical resource for livestock and wildlife after water. Instability of forage productivity is the major factor constraining the Kenyan pastoralists, especially form the more arid rangelands of the north (Jatzold, 1995). Highly variable rains cause wide fluctuations of productivity from short lived seasonal highs that cannot be optimally utilized to lows during the frequent droughts that are

insufficient to support resident livestock. During drought when it is almost impossible to sell livestock, large numbers of animals may die, destroying the pastoralists' economic base leading to poverty (Jatzold, 1995).

In Ewaso Ngiro catchment, over 90% of the catchment is covered by shrubland and grasslands, which are where forage is produced (Ericksen *et al*., 2011). The production of forage varies geographically with rainfall and hence forage availability and productivity varies temporally and spatially. The rangelands in the study areas (see plate 1), occurring over a wide range of altitudes, receive widely varying amounts of rainfall and are characterized by different soils, vegetation types and geomorphological features (Herlocker *et al*., 1993). Controlled livestock grazing has been used to manage rangelands by reducing grass biomass and changing plant composition to provide quality, healthy grass for long-term conservation benefits. On community conservancies, grazing is guided by mutually agreed upon grazing plan governed by grazing committees. Privately owned conservancies have a greater control of grazing. On Lewa, two management options, namely controlled cattle grazing and mowing have been used to improve the quality of the Conservancy's rangeland by reducing unproductive grass. The impact of this grazing regime is analysed on a seasonal basis. In addition, Lewa has established 28 permanent monitoring points to evaluate the condition of the rangeland. Information from these sites, including grass biomass and species diversity sites is gathered annually in the month of June.

The Problem Statement

In pastoral communities, availability of pasture and water for livestock has been critical as their main livelihood. Various traditional methods of managing the available grazing areas have been used by the different communities living in northern Kenya. Formation of Community Conservancies has enabled community pasture management through season-based grazing plans. Success has been noted in majority of the conservancies, and communities have reaped benefits of peaceful coexistence, resilient pasture resources, and stable environmental externalities. However, intercommunity conflicts and invasion of private ranches and conservancies in search of pasture has persisted, and have in many occasions led to losses of human lives and livestock in the region. The real or perceived drivers of the grazing conflicts have not been well researched or their likely occurrences properly predicted using resources-based scientific or theoretical models. There is no documented research on the relationships between the grazing conflicts and seasonality of resource availability per conservancy, nor the contribution of temporal and spatial characteristics of the resource to effects that lead to migrations and grazing conflicts in parts of northern Kenya. This study will establish the relationship between the available grazing resources and community grazing regimes in order to come up with a model to predict inter and intra-conservancy grazing conflicts. It will bridge the gaps existing between the dynamics of resource availability and the current community grazing systems, and ultimately produce adoptable knowledge for sustainable mitigation of grazing conflicts in parts of northern Kenya.

MATERIALS AND METHODS

Study area description

This study was undertaken in four community conservancies distributed within two counties of northern Kenya namely Laikipia and Isiolo. These are Ngarendare, Ilngwesi, Nasuulu and Lewa Wildlife conservancy. The two counties have almost similar geophysical and climatic characteristics and are adjacent to each other, with Laikipia bordering Isiolo to the Northwest. The main soil types are Acrisols, Luvisols, Ferralsols, Alfisols, Ultisols, Oxisols, and Lithisols (Lerberg, 1988). These soils are all generally of low fertility, and many are highly erodible. The dominant vegetation in the two counties is dry bush with occasional shrubland and open grasslands (Lerberg, 1988). Both counties are semi-arid and receive about 450 - 800mm of rainfall per year. The rainfall pattern is bimodal and starts from March until May in the first season and from October to December in the second season. Average temperatures range from 25^0C to 29^0C (Republic of Kenya, 2009). These climatic conditions result in very low crop yields at times, and are mostly dominated by nomadic pastoralism.

Study design

This study adopted a mixed method approach that combines or associates both qualitative and quantitative forms. It involves philosophical assumptions, the use of qualitative and quantitative approaches, and the mixing of both approaches in a study. Thus it is more than simply collecting and analyzing both kinds of data; it also involves the use of both approaches in tandem so that the overall strength of a study is greater than either qualitative or quantitative research (Creswell & Plano- Clark, 2007). Specific methods for data collection included the field experiments, quadrants and transect walks, administration of questionnaires, interview schedules, Focus Group Discussions (FGDs), desk research. Four conservancies were purposely picked at random out of the 15 within Laikipia and Isiolo counties.

Forge surveys

Two sites were located in each of the conservancies grazing field, and a plot of 50mx50m set on each site. The sites were selected based as much as possible on representation of the variation characteristics of entire grazing field like slope direction, forage species, vegetation growth forms and accessibility (NCRS,1997). Each plot contained 50 sub-plots (quadrants). To estimate available forage biomas, five quadrants were picked at random on each plot and clip, dry and weigh method used to estimate the biomas levels in both wet and dry seasons. 0.5mx0.5m square wire was placed on the subplot and all above ground grass cut using secateurs. The samples were put in Kirk papers and weighed, then oven-dried for 24 hours at 60^0c and weighed at 14 % moisture content. To ascertain available forage biomass, regression equation: **Y = a + bx** (LeHourerou & Hoste, 1977), was used Where**:** Y = dry matter production (kg/ha/year or season), x = annual or season precipitation (mm) a = regression constant (-180 for herbs and – 400 for shrubs), b = regression constant (6.3 for herbs and 10 for shrubs)**.** Data on forage biomass was collected twice i.e. dry season data (February -March) and wet season data at the end of the growing season (May -June). Two transect walks were conducted between the plots to describe vegetation variability, tree and shrub density and diversity. Data on vegetation and soil characteristics was recorded on Range Condition Data Sheets.

Social surveys

The survey approach focused on the resource persons, grazing committees, key informants and experts within each community conservancy and in the entire study area. Respondents were Conservancy committee members picked from each conservancy (see Table 2), and the questionnaires administered. 4 focused group discussions of between 8-12 people were conducted. Key informants and experts were interviewed to clarify controversial issues in the course of the research. The survey data was analyzed using SPSS package to yield the views and opinions sought out in the study objectives. Results were presented in graphs, tables, and accumulation curves.

RESULTS

In this objective, the researcher sort to find out what resource levels in the conservancies lead to the various ways of grazing conflicts. The results were ascertained through evaluation of the available forage, analysis of distances to water and corroborated through questionnaire responses and focused Group Discussions.

Distances to water points

Water availability

The information from the data analysed was that most of community members indicated that they cover long return distances to and from watering points. On average, it was found that most community conservancies do over 10 Km searching for water for their stock during the dry seasons, while there was a noted difference in Ngare Ndare and Lewa where the number of Kilometers to the watering point was shorter in the range of less than 5 Kilometers return. Similarly, Ilngwesi and Nasuulu had fewer options of the types of watering points with Ngare Ndare having more options to chose which is springs and rivers. Numbers of water points were more for the Ngarendare and Lewa (control group) with a total of 15 water points while they were very few for Ilngwesi and Nasuulu case. The results showed that there was a strong correlation between availability of water and conflicts, such that the more the distances to available water resources, the more the number of grazing conflicts per conservancy and vise versa. The figure below shows the analysis of the distances to water per conservancy and the correlation with grazing conflicts:

Figure 1. The correlation between the vailable water resources and grazing conflicts

Forage availability

Forage availability was evaluated by both available forage analysis, grass height measurements, observation of grass colour and growth vigour. Basal gaps were analysed through visual observations and estimations of percentages of ground cover and bare ground. Transect walks were done between the plots to ascertain the vegetation characteristics, soil and available browsable trees and shrubs. In the dry season data, generally all the community conservancies exhibited depressed forage and herbal cover, with bigger percentages of bare ground on Nasuulu, Ilngwesi and Ngarendare in that order. It was derived that Ilngwesi and Nasuulu have the lowest available forage biomass compared to other conservancies. Ngarendare forest has the highest amount of shrub density hence provides more shrub forage than the other conservancies.

Figure 2. Available grass and shrubs in the study area

From the figure above, it can be derived that Nsuulu and Ilngwesi had the lowest number of brousable grass and shrubs. Ngarendare exhibited the highest count of the trees and shrubs, while Lewa exhibited almost equal distribution of the grass and trees and shrubs. It was noted that after the rains in April, all the community conservancies and the control showed improved forage, soil and basal cover characteristics. The control showed lowest bareground percentges in both the dry and wet season data collection periods. There was overall improvement in the observable vegetation greenness and vigour immediately after the wet season, with more brousable foliage species coming up after the short rains on both the communities and the control. In the community managed conservancies, this improvement was however shortlived due to immediate defoliation by the incoming livestock. This observaton was coroborated by Sammy Tema, a community liason officer at Ilngwesi, who told the reasearchr that immediately after thee rains, the livestock that had moved out during the dry season came back and broused on the emerging new herbage. The figure 3 below shows the available forage for the Lewa and the Ngarendare Forest in the wet season:

Figure 3. Wet and dry season forage differences for Ngarendare and Lewa Conervancy.

From the table 3 bove, Lewa Widlife Conservancy showed the highest grass forage per ha than other conservancies in the dry season. This can be attributed to the fact that bieng a private conservation area it is more protected and grazing is well planned and managedleading to a better management of the available forage biomass. Overall the grass heights at Lewa were the highest, followed by Ngarendare. The table below shows the grass wieghts on Ngarendare and Lewa conservancies, both at cutting and after oven drying during the dry season:

Table 1: Dry Season forage variability

Site		Point 1	Point 2	Point 3	Point 4	Point 5	Total	Average
Lewa 1	Raw	68.488	92.045	74.26	89.999	145.392		
	Dry	77	96	76	98	157	504	100.8
	dff	8.512	3.955	1.74	8.001	11.608	33.816	6.7632
Lewa2	Raw	33.719	95.351	106.485	77.666	107.791		
	Dry	36	103	117	82	113	451	90.2
	dff	2.281	7.649	10.515	4.334	5.209	29.988	5.9976
Ngare 1	Dry	23.11	43.008	21.046	22.734	23.544	133.442	26.6884
	Raw	25	51	25	27	26		
	dff	1.89	7.992	3.954	4.266	2.456	20.558	4.1116
Ngare2	Raw	0	24.911	24.393	30.468	39.036		
	Dry	0	**32**	**28**	**37**	**30**	127	25.4
	dff	0	7.089	3.607	6.532	-9.036	8.192	1.6384
Ngare3	Raw	14.651	19.742	48.61	20.688	34.09		
	Dry	17	26	62	25	44	174	34.8
	dff	2.349	6.258	13.39	4.312	9.91	36.219	7.2438

This shows that the forage productivity of the conservancy varies in the dry season with other factors. However, the grass species available on Ngarendare and Lewa, arae doinated by *Penisetum mezianum*, and *P. stramenium*, the type that is not very palatable to livestock since it is tough, It can only be useful to livestock during the short period after the growing season,

prompting the livestock to move to other areas with better palatable pasture, or depend on other brouserbles like short trees and shrubs as witnessed at Nasuulu and Ilngwesi, effectively supporting the conclusion that dwarf shrubs are important forage in the arid areas (Schwartz et al. 1989). They concentrate on small drainage lines and water runoff tunnels and collection points and have longer growing periods than grass.

At Nasuulu and Ilngwesi the ground cover was over 80% bare exhibiting widely spaced thorny herbs and perennial grass with huge basal gaps, scattered shrubs and short trees. Browsers depended on species like Grewia, *Rhus natalensis*, *Boscia angustifolia*, devils thorn and Balanites eagiptica. The figure 4 below describes the availability of forage in the dry season on Lewa and Ngarendare forest

A combined presentation of both dry and wet season forage is described in the figure 5 below:

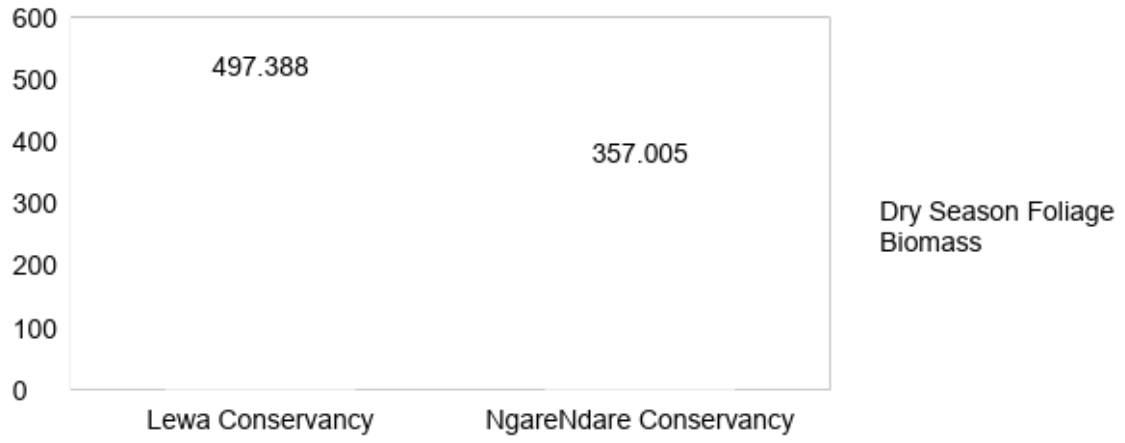

Figure 4: Available forage on Lewa and Ngarendare in the dry season

DISCUSSIONS

This mixed approach method aimed to combine both the community views on the grazing potential of their land with the real time assessment of the availability of forage both in the wet and dry seasons. Rainfall variability and landuse in the study area are currently undergoing more profound changes than in the 1990s as can be seen in both the rainfall data. The rapid response to the scanty short rains of May-June seen in Nasuulu and Ilngwesi, shows that the forage recovery can achieve full ground cover if the ground is given substantial recovery period. However, the rest period was insignificant as livestock returned immediately during the short rains. This scenario gave no chance for grass to re-grow to browsable stages. The resilience of the community conservancies is most dependent on precipitation. Grazing Planning, which is already in place according to the social survey, are showing no effective control of grazing, or are neglected or ignored in times of drought. If not, after the rains it should have been seen working where blocks are well designated for resting and regeneration or for grazing. Despite the general greener appearance of the vegetation after the short rains, the river and gullies were dry, indicating that the short rains were never sufficient to feed the upstream communities and leave sufficient stream flow for the downstream communities. This infers that the downstream communities have to move up in search of the limited resource, as indicated by abandoned cattle bomas at Ilngwesi. The

huge percentages of bare ground witnessed at Nasuulu and Ilngwesi also suggests that there is little infiltration and huge evaporation hence affecting forage recovery potential.

Due to continuous defoliation and browsing exhibited in the community conservancies, giving the grass and other herbal vegetation no adequate time to recover compared to the control. The huge basal gaps witnessed on the community conservancies in the dry season data period reduced significantly in the wet season grazing regime. This implies that applying the grazing plans effectively could significantly improve soil stability, reduce degradation, lead to high productivity of the rangelands leading to less movements of the livestock hence leading to less grazing conflicts in the study area

CONCULUSIONS

Basing on the responses it is clear that the months of June to October are the hardest periods of grazing in the study area. There are general decline in vegetation vigour, and through Participatory GIS (PGIS) the respondents attested that this has been the cause of movements to unknown areas in search of browsable forage. There are minimal forage for both small and large stock at Nasuulu, Ilngwesi due to large livestock numbers as well as little forage cover, triggering movements in search of pasture to far areas of upper altitudes like Ngarendare, Lewa and the mountain areas. Therefore this situation leads to conflicts and more environmental externalities. On the water situation, the community can benefit from sand dams and the county governments of Laikipia and Isiolo are the potential supporters to ease access to water and reduce grazing conflicts. Lewa has already installed a number of dams, an initiative that can be replicated to community conservancies. More boreholes need to be surveyed and installed at Nasuulu and Ilngwesi.

RECOMMENDATIONS

This study did not include the analysis of forage supplied by shrubs and trees. It is recommended that other suppliers of livestock forage rather than grass be analysed in the study area. It is imperative that destocking is considered as mitigation factor to restore degradation and reduce stock movements. Further research to establish the real figures of stock losses due to grazing conflicts in the study area is recommended. This will enable future studies on relationship between grazing conflicts and real economic losses to be ascertained. It is also important recommendation to ascertain the real distances of movements of livestock to correlate this with grazing conflicts along the movement routes, and enable prediction and decision making in different regions affected by grazing conflicts

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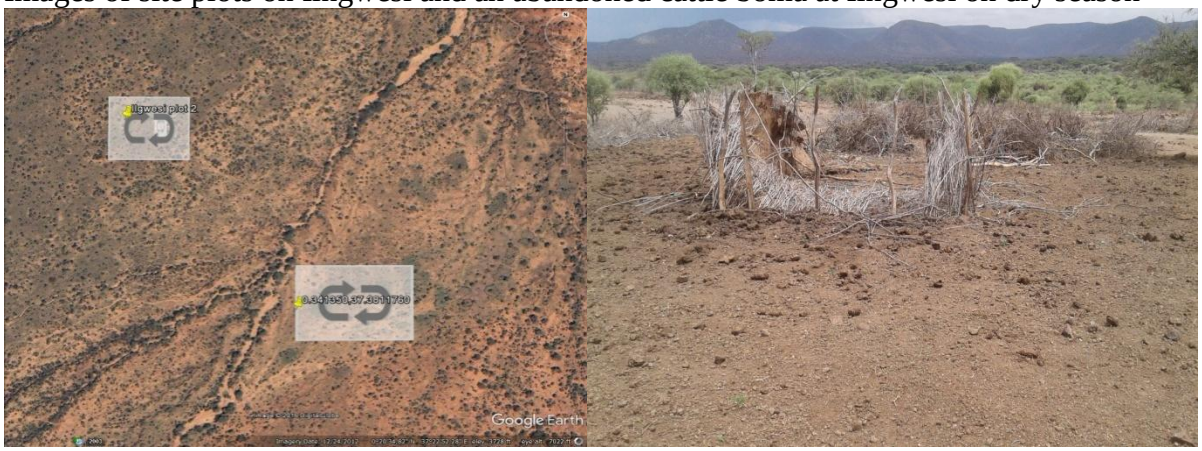
APPEDIX

Images of site plots on Ilngwesi and an abandoned cattle boma at Ilngwesi on dry season



EFFECT OF MOBILE COMMUNICATION SERVICES ON PERFORMANCE OF DEPOSIT-TAKING SACCOS IN KENYA

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Abstract

The ubiquitous nature of mobile technologies and devices, present new challenges and opportunities for Deposit-Taking Savings and Credit Cooperative Societies (SACCOs) as they integrate them into their processes with the hope of improving their performance. To enhance their performance, Deposit-Taking SACCOs have adopted and are using mobile communication services including mobile messaging, mobile call services, mobile email, mobile chatting and mobile conferencing services. However, the effect of these mobile communication services on performance of Deposit-Taking SACCOs has not been well studied. Even though some studies have indicated the positive potential of mobile communication services, other studies indicate that they have no effect on organizational performance. Given these contradictions, this study sought to investigate the effect of mobile communication services on performance of Deposit-Taking SACCOs in Kenya. The study adopted positivism philosophy as it aimed at testing hypotheses derived from a predetermined conceptual framework. Descriptive and explanatory research designs were adopted using quantitative and qualitative approach to data collection, analysis and reporting. The study used a sample of 86 Deposit-Taking SACCOs drawn from a target population of 110 Deposit-Taking SACCOs that were licensed by SACCO Societies Regulatory Authority as at 31st December 2011. A structuredquestionnaire administered to two managers (from information technology and finance departments) in each SACCO was used to collect primary data. Multiple linear regression model was applied on the quantitative data to generate coefficients and their corresponding t-statistics and p-values. Inferential analysis revealed the exististence of statistically significant positive effect of mobile communication services on performance of Deposit-Taking SACCOs in Kenya. The study therefore recommends investments and increased utilization of mobile communication services within Deposit-Taking SACCOs in Kenya.

Keywords: mobile messaging, mobile call services, mobile email, mobile chatting and mobile conferencing services

INTRODUCTION

Rapid evolution in mobile computing has driven new directions in the growth of economy particularly the financial sector. The rapid advances in mobile technologies and the increased coverage of mobile networks present new opportunities for integrating mobile technology services into existing financial services delivery models as well as driving innovations leading to new financial solutions' delivery channels. Infrastructure barriers (especially in

remote areas) associated with desktop computers and non-portable traditional technologies are addressable by utilization of mobile devices since they provide mobile technology services from any location and at any time conveniently to their users (Liang *et al*., 2007; Dineshwar& Steven, 2013).

Mobile technology services are classified in different ways. Rao*et al*. (2007) classify them into messaging services (that allow use of short message services for communication), mobile content and information services (that provide mobile devices' users with information in various modes), and transaction-based services (that enable transactions such as money transfer, mobile bill payments, and mobile account opening). Mobile technology services have also been classified based on targeted users that is business-to-business, business-to-consumer and business-to-employee services (Rangone&Renga, 2006). In place of mobile technology services, other more specific terms have been quoted in existing literature. These terms include mobile business applications (Scornavacca& Barnes, 2006), mobile office services (Vuolle, 2010), and sales force automation applications (Evans, 2002) among others.

Mobile communication services refer to use of mobile devices to facilitate exchange of business information through mobile calls, mobile messaging, mobile email, mobile chatting services and mobile conferencing services. Mobile communication services allow communication from anywhere to any person, which is crucial in overcoming geographical barriers by allowing parties involved to save on transport costs. It is also essential for timely delivery of information and knowledge by an organization's employees, managers and other stakeholders. Information is regarded by economists as a critical element in the efficient functioning of markets and therefore important towards enhancing performance of firms (Jensen, 2007).

Deposit-Taking SACCOs in Kenya

The financial sector comprises players from the banking industry, microfinance institutions, capital markets, insurance companies, savings and credit cooperative societies (SACCOs), mutual funds and development finance institutions each playing a role in provision of diverse financial solutions. A SACCO system is a type of credit unions owned by members sharing a common interest in order to mobilize savings to facilitate credit and other financial services to themselves (World Council of Credit Unions, 2013). Credit unions evolved from the cooperative activities of early 19th century from the idea that people could pool their money and make loans to each other. The first of these cooperatives emerged in Germany and England before spreading to other countries (World Council of Credit Unions, 2013).

The SACCO subsector in Kenya comprises of Deposit-Taking and non-Deposit-Taking SACCOs. Deposit-Taking SACCOs are licensed, supervised and regulated by SACCO Societies Regulatory Authority (SASRA) under the SACCO Societies Act of 2008 (Mumanyi, 2014). Deposit-Taking SACCOs unlike non Deposit-Taking SACCOs offer front office saving activities (FOSA) which allow them to provide simple banking services to their members/customers (such as taking deposits, payment services, automated teller machines and other quasi banking services) thus improving their working capital.

Based on their membership, Deposit-Taking SACCOs are categorized into teacher based, Government based, farmers based, private institutions based and community based SACCOs (SASRA, 2013). Majority of the members of Government based SACCOs comprise employees of Government Ministries, Departments, State Corporations, Public Universities and Colleges and County Governments. For farmer based SACCOs, majority of the members are farmers engaged in different agricultural activities (both direct and indirect activities) in various parts of the country while private institutions based SACCOs have members who are mainly employees of private organizations including non-Governmental organizations operating in Kenya. Community based SACCOs have members who are mainly residents of a

given geographical area engaged in a productive economic activity while teacher based SACCOs have membership mainly drawn from employees of public/private schools, colleges and universities (both public and private).

The Deposit-Taking SACCOs account for three quarters of the SACCO subsector's assets, deposits and membership (SASRA, 2013). Sub-Saharan Africa remains the region with the lowest deposit-taking institutions penetration in the world which stands at an average of 16.6% compared to 63.5% in developed countries and therefore the need to have Deposit-Taking SACCOs to fill this gap (Savings Plus, 2010). In line with the Kenya's Vision 2030 strategy (that requires financial organizations to increase savings and to mobilize more investments for economic growth and development of the country)Deposit-Taking SACCOs' role in the Kenyan economy remains paramount (Government of Kenya, 2013). Given that only about 19% of Kenyans have access to banking services, services provided by Deposit-Taking SACCOs are expected to be vital towards enhancing the reach and access to financial services particularly for citizens living in rural areas (Olando, Mbewa&Jagongo, 2012). By the year 2009, out of the 20 million adult people in Kenya, 22.5% were served by commercial banks and MFIs while 17.6% were served by SACCOs making SACCOs a key player in Kenya's financial sector (Matumo, Maina & Njoroge, 2013).

Statement of the problem

Kenya's Vision 2030 requires a vibrant and a stable financial system to mobilize savings, and to allocate resources more efficiently in the economy (Government of Kenya, 2013). Deposit-Taking SACCOs are expected to play a key role towards the realization of this vision especially by connecting people who have been financially excluded by major banks to financial services. Although Deposit-Taking SACCOs have embraced prudent norms in credit risk management as expected by their regulator, SASRA, SACCOs still have a problem of non-performing loans which was recorded at 4.7 percent in 2013 and 5.73 percent in 2014 (SASRA, 2014). Additionally, SASRA (2013, 2014) noted that many SACCOs had not yet managed to comply with capital adequacy ratios.

Deposit-Taking SACCOs also face high demands for loans which might be incompatible with the available funds given that they cannot seek credit from the Central Bank of Kenya like other commercial banks (Mugambi *et al.*, 2015). Therefore it implies that when faced with cash problems such as in time of business difficulties or in case of excessive demands for loans, they have nowhere to turn to. Deposit-Taking SACCOs are therefore prone to liquidity shortage which has the potential to greatly bring down any financial institution as noted by Mugambi *et al.* (2015). Additionally, they continue to face stiff competition from other deposit taking institutions particularly commercial banks (Matumo*et al.*, 2013; SASRA, 2013).

Although various scholars have asserted that mobile technology services particularly mobile communication services have the potential to cause business performance outcomes including organizational efficiency, increased number of customers, service quality in business, competitive advantage, cost savings, increased productivity, increased knowledge sharing, employee satisfaction, increased profitability, increased amount of data processing and operational performance (Kagan *et al.*, 2005; Zhang & Mao, 2008; Abadi, Kabiry & Forghani, 2013; Aboelmaged & Gebba, 2013; Maina & Gekara, 2014; Stoica, Mehdian & Sargu, 2015), these benefits are yet to be confirmed in studies covering Deposit-Taking SACCOs. Additionally, some scholars assert that despite mobile technology services having significant benefits for citizens using them, organizations that employ them are yet to realize notable gains in productivity from them (Dineshwar & Steven, 2013; Orotin, Quisenbery & Ted, 2013). Further, despite the potential of mobile technology services, SASRA (2011)

raised concerns in regard to increased incidences of fraud among Deposit-Taking SACCOs raising deep questions on the role of ICT towards the performance of this sector.

Lack of understanding the implication of these mobile technology services might lead to Deposit-Taking SACCOs investing in unproductive technology and or refusing to adopt technologies that might cultivate competitive advantage for them (Gunasekaran, Ngai & McGaghey, 2006). Therefore, given the contradicting evidences in literature on the effects of mobile technology services on organizational performance, the researcher found it necessary to conduct a study to investigate the effect of mobile communication services on performance of organizations. This study was contextualized within Deposit-Taking SACCOs in Kenya given their performance challenges and a dearth in literature regarding their performance.

Research Hypotheses

The study collected and analyzed data to test the following hypotheses:

H_{01}: There is no statistically significant effect of mobile messaging services on performance of Deposit-Taking SACCOs in Kenya
H_{02}: There is no statistically significant effect of mobile call services on performance of Deposit-Taking SACCOs in Kenya
H_{03}: There is no statistically significant effect of mobile email services on performance of Deposit-Taking SACCOs in Kenya
H_{04}: There is no statistically significant effect of mobile chatting services on performance of Deposit-Taking SACCOs in Kenya
H_{05}: There is no statistically significant effect of mobile conferencing services on performance of Deposit-Taking SACCOs in Kenya

Literature Review

Several studies have been conducted to establish the effect of mobile communication services on organizational performance. Kiganane, Bwisa & Kihoro (2012) found that mobile call service had the greatest effect on improving firms' performance. Other services such as mobile messaging, mobile email, mobile chatting and mobile conferencing also constitute mobile communication but were left out in the study. Another study combining all these mobile communication services on organizational performance is therefore important and was the focus of this study.

In another study by Maina, Bwisa & Kihoro (2012), mobile phone services were found to have significantly increased sales volume, profit, worker productivity, and customer satisfaction ratings. The study was based on the use of longitudinal data from manufacturing firms and considered six mobile technology services that were listed as mobile calls, mobile internet services, mobile banking, mobile messaging, M-Pesa and mobile bills payment where mobile calls, mobile messaging and M-Pesa were the only significant variables in determination of firms' performance. As the study by Maina *et al.* (2012) was exploratory in nature, further studies are required to confirm their findings especially in other sectors of the economy using other research designs such as explanatory design. This study sought to address this gap by covering additional mobile technology services such as mobile advertising, mobile deposits, mobile statements, and mobile chatting among other mobile technology services and in a different sector, that is, SACCO sector.

Wahla &Awan (2014) noted that use of mobile phones for communication improved working efficiency of employees in Pakistan industries as they could easily contact their colleagues for purposes of sharing thoughts and knowledge. Although the respondents in the study admitted using mobile phones for personal issues such as calling their family members and sending messages to their loved ones, they nonetheless argued that their productivity was

greatly enhanced through mobile communication services especially to their colleagues on work related issues. Some respondents even indicated that they could not manage to work without their mobile phones as they needed to make enquiries related to their tasks from time to time to both their managers in other offices and their colleagues. This study was conducted to establish how mobile communication services affect not just individual performance but the overall organizational performance which was not addressed by Wahla & Awan (2014) in their study.

Salia, Nuamah & Steel (2011) found in their study that market efficiencies improved and price variations reduced as a result of better availability of up-to date information. Their study aimed at investigating the effect of mobile communication on market efficiency and livelihoods in Ghana. In their study, they argued that mobile communication services enabled fishermen towards improving their incomes and expanding markets for their produce. Additionally, the study noted that mobile communication improved the livelihoods of the fishermen as it facilitated the staying in touch with their families. Mobile communication services are now embraced by SACCOs to communicate with their members on various organizational products and services. According to International Telecommunication Union (2013) mobile communication services, which are currently the most widely used form of mobile technology services, include SMS, MMS, e-mails, and mobile chatting. This study was important in validating the benefits of mobile communication services within the context of an organization.

In their study, Smits & Mogos (2013) found that social media enhanced business capabilities of an advertising company. The study also found that improved business capabilities led to improved business performance for the company. They noted that social media tools are an ecosystem of various tools that allow communication through chatting and advertising by organizations. Another study by Njeri (2012) found that commercial banks have embraced social media interaction where Facebook is the dominant platform with the highest number of users and the most commonly used for interaction between firms and customers. Njeri (2012) noted that social media interactions offers a platform for marketing and sales of products, development of new product brands, and access to real-time customer feedback to enhance banks' understanding of the needs of their customers. It would be interesting to also study how social media services such as advertising and communication via chatting and conferencing services affect the performance of Deposit-Taking SACCOs.

Kimani (2005) noted the crucial role played by social media marketing on performance of organizations in Kenya. In her study, she argued that through marketing via social media, organizations can benefit in terms of improving their brand awareness, real-time communication and repeat exposure. She also argued that social media can greatly enhance the competitive advantage of an organization by facilitating real-time responses to customers' concerns, by monitoring brand information and by enabling generation of demographic profiles of its customers. This study included conferencing and chatting services provided by social media to establish how they affect the performance of SACCOs in Kenya.

Conceptual Framework

Based on the review of the literature, the study proposed that the performance of Deposit-Taking SACCOs is affected by mobile communication services as captured in the conceptual framework shown belo

Figure 3: Conceptual Framework

METHODOLOGY

This study was guided by positivism paradigm. It was an ideal philosophy for this study as scientific processes were followed in formulation of the hypotheses and deductions of the observations in order to determine whether to reject or not to reject the formulated hypotheses as recommended by Mack (2010). According to Sekaran & Bougie (2009) there is no single perfect research design, hence the researcher used both descriptive survey and explanatory research designs to achieve optimal results.

In order to obtain data necessary to draw inferences, the target population included those Deposit-Taking SACCOs that had existed for at least three years since their being licensed. Therefore, the target population was the 110 Deposit-Taking SACCOs that were licensed as at 31st December 2011 in Kenya. To select an optimum sample of 86 Deposit-Taking SACCOs from where data was collected, simple random sampling method was used. Simple random sampling ensured that each Deposit-Taking SACCO had an equal chance of being selected as suggested by Mugenda & Mugenda (2003). Random sampling was also found suitable by Acharya *et al*. (2008) who conducted a study to establish website usability impacts on performance of banks.

From each Deposit-Taking SACCO, two managers (from information technology and finance departments) were purposively sampled as the respondents of the study. Mugenda & Mugenda (2003) contend that a researcher can purposefully select respondents he/she considers to have the required information or with capability to provide credible responses. The respondents selected were believed to be conversant with the utilization of mobile communication services within the SACCO and their effect on SACCO's performance. They

were, therefore in a position to provide credible responses necessary to make valid conclusions regarding the study objectives.

A self-administered structured questionnaire was used for primary data collection. The questionnaire was divided into various sections as informed by the objectives and the conceptual framework. Gall, Borg & Gall (1996) recommends a questionnaire as a convenient and the most suitable instrument for data collection in survey as well as statistical research in social and technical research. Administered questionnaires have usually high response rate because they are delivered and collected by the researcher or the assistant (Saunders *et al.*, 2007). In addition, data collected using questionnaires is easier to analyze (Cooper & Schindler, 2014). Since the positivism philosophy adopted in this study calls for quantitative data for easy generalizations (Babbie, 2010), a structured questionnaire was considered appropriate for data collection.

Empirical Model

Multiple linear regression analysis was conducted to establish the effect of independent variables (mobile messagingservices, mobile call services, mobile email services, mobile chatting services and mobile conferencing services) on the dependent variable as recommended by Jackson (2009). SPSS software application was used to generate composite indices based on arithmetic means for each independent variable and the dependent variable (comprising both financial and non-financial measures) to use in the multiple linear regression model. According to Faraway (2002) and Brooks (2014) multiple linear regression analysis is chosen when the dependent model is continuous and when independent variables are more than one. It was therefore relevant in testing the effect of mobile web services (independent variables) on performance of SACCOs (dependent variable) in this study as the dependent variable was continuous. This is depicted by the model shown below:

$$\mathbf{Y= \beta_o+ \beta_1X_1+ \beta_2X_2+ \beta_3X_3+\beta_4X_4+ \beta_5X_5 +\varepsilon}$$

Where,

Y= Performance of the Deposit-Taking SACCO

X_1= Mobile messaging services

X_2= Mobile call services

X_3= Mobile email services

X_4= Mobile chatting services

X_5= Mobile conferencing services

ε=error term (accounting for variables other than those specified in the model that explains changes in the dependent variable)

β_0 = constant term

β_1 to β_5 = coefficients of the independent variables

The empirical model above was used to generate coefficients and t-statistics for each independent variable and their corresponding p-values. To determine whether each independent variable had a significant effect on performance of SACCOs, its corresponding coefficient was tested to check whether it was statistically different from zero by checking its p-value. If p-value of a given coefficient was less than the chosen significance level (0.05) the null hypothesis was rejected and a conclusion drawn that the corresponding variable significantly affected the performance of SACCOs.

RESULTS AND DISCUSSION

Response Rate

The study aimed at obtaining responses from a sample of 86 Deposit-Taking SACCOs in Kenya and therefore 86 questionnaires were issued one for each of the 86 randomly selected Deposit-Taking SACCOs. After checking the completeness and non-response cases of questionnaires, 68 questionnaires were correctly filled representing a response rate of 79.1 percent. Unreturned questionnaires were 10 representing 11.6 percent while the disqualified questionnaires due to incompleteness and inconsistencies were 8 representing 9.3 percent of the total number of issued questionnaires. Table 1 below represents the summary of the response rate.

Table 1: Questionnaire Response Rate

Responses	**Values**	**Percentage**
Administered questionnaires	86	100 percent
Unreturned Questionnaires	10	11.6 percent
Disqualified questionnaires	8	9.3 percent
Returned and correctly filled questionnaires	68	79.1 percent

According to Babbie (2004), Mugenda&Mugenda (2003) and Saunders *et al.* (2007), a response rate of 50 percent is adequate, a response rate of 60 percent is good, and a response rate of 70 percent is very good. The response rate of 79.1 percent observed in this study was therefore very good and as such sufficient for further analysis and for drawing conclusions based on the stipulated research objectives. Furthermore, the study's response rate was acceptable as it compared well with similar studies conducted in Kenya such as Kidombo (2007) who achieved a response rate of 64.0 percent, Magutu (2013) who had a response rate of 75 percent and Waithaka*et al* .(2013) who had a response rate of 69 percent.

Regression Results

The regression model used the composite indexes for both the dependent variables (SACCO performance) as well as the independent variables (mobile messaging, mobile call, mobile email, mobile chatting and mobile conferencing services). Arithmetic mean was used to generate the composite indexes of all the variables. To indicate the amount of variation in the performance of SACCOs explained by the independent variables, the coefficient of determination (R^2) was used. Tables 2, 3 and 4 summarize the regression analysis results.

Table 2: Summary Results of Regression Model

Model	R	R Square	Adjusted R Square
1	.656[a]	.430	.384
a. Predictors: (Constant), Mobile Conferencing, Mobile Messaging, Mobile Call, Mobile Chat, Mobile Email			

As shown in the Table 2, R^2 was 0.430 indicating that the five independent (mobile messaging, mobile call, mobile email, mobile chatting and mobile conferencing services) explained 43.0% percent of variations in performance of SACCOs, implying that 57.0 percent of variations was explained by other variables outside the model.

Table 3: Anova Results for Model Significance

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	11.494	5	2.299	9.345	.000[b]

	Residual	15.251	62	.246		
	Total	26.745	67			
a. Dependent Variable: Sacco Performance						
b. Predictors: (Constant), Mobile Conferencing, Mobile Messaging, Mobile Call, Mobile Chat, Mobile Email						

To check the statistical significance of the overall regression model, Anova test was used as shown in Table 3. From Table 3, the overall model was statistically significant ($F_{(5,62)}$=9.345, p=0.000) implying that the study's independent variables (mobile messaging services, mobile call services, mobile email services,mobile chatting and mobile conferencing services) explained the variations in the dependent variable (performance of Deposit-Taking SACCOs) and therefore the model was adequate for further hypotheses testing.

Table 4: Regression Coefficients

Variable	B	Std. Error	t	Sig.
(Constant)	2.169	.279	7.786	.000
Mobile Messaging Services	.126	.083	1.528	.048
Mobile Call Services	.123	.068	1.808	.044
Mobile Email Services	.028	.081	.341	.734
Mobile Chatting Services	.165	.072	2.297	.025
Mobile Conferencing Services	.044	.064	.685	.496

For hypotheses testing, Table 4 derived from running multiple linear regressions of independent variables on the dependent variable was used. From the regression analysis, it was found that mobile messaging services, mobile call services and mobile chatting services had a positive statistically significant effect on performance of Deposit-Taking SACCOs. However, mobile email services and mobile conferencing services were found to have no statistically significant effect on performance of Deposit-Taking SACCOs. The table below summarizes the outcome of hypotheses testing based on the regression model shown above.

Table 6: Summary of Hypotheses Testing

Hypothesis	Results	Remarks on Hypothesis
H_{01}: There is no statistically significant effect of mobile messaging services on performance of Deposit-Taking SACCOs in Kenya	β=0.126 t-value=1.528 p-value=0.048	Reject H_{01}
H_{02}: There is no statistically significant effect of mobile call services on performance of Deposit-Taking SACCOs in Kenya	β=0.123 t-value=1.808 p-value=0.044	Reject H_{02}
H_{03}: There is no statistically significant effect of mobile email services on performance of Deposit-Taking SACCOs in Kenya	β=0.028 t-value=0.341 p-value=0.734	Do Not Reject H_{03}
H_{04}: There is no statistically significant effect of mobile chatting services on performance of Deposit-Taking SACCOs in Kenya	β=0.165 t-value=2.297 p-value=0.025	Reject H_{04}
H_{05}: There is no statistically significant effect of mobile conferencing services on performance of Deposit-Taking SACCOs in Kenya	β=0.044 t-value=0.685 p-value=0.496	Do Not Reject H_{05}

From this study, it can be concluded that use of mobile devices to provide mobile communication services is paramount towards enhancing performance of Deposit-Taking SACCOs and should therefore be encouraged by the management boards of these SACCOs. Findings of this study are corroborated by the study of Maina *et al.* (2012) who indicated that mobile calls and mobile messaging services had significantly improved performance of manufacturing firms in Kenya. It also agrees with the study of Smits &Mogos (2013) who found that mobile chatting via social media enhances business capabilities and business performance. The role of communication services such as through use of social media has also been found to enhance communication flows, collaboration and business processes within organizations (Bradbury, 2010). Using social media, contacts can be established with knowledgeable professionals leading to collaborations in project execution, benchmarking in business processes and strategy reviews which enable organizations remain competitive.

The study is also consistent with that of Tirunillai &Tellis (2012) who noted the role of communication services in organizations through online services where online users' reviews and blogs provide product and brand specific information compared with other forms of marketing. It is also corroborated by Kimani (2005) who indicated the crucial role played by social media marketing on performance of organizations in Kenya. Additionally, the findings are consistent with the study by Kiganane*et al.* (2012) which indicated that mobile communication services had a positive effect on organizational performance. Another study by Salia *et al.* (2011) found that mobile communication services had improved market efficiencies and reduced price variations as a result of availing better up-to date information to citizens.

CONCLUSION

The significant role played by mobile communication services towards enhancing performance of Deposit-Taking SACCOs in Kenya has been demonstrated by the findings. The study concluded that the utilization of mobile communication services particularly mobile messaging, mobile call and mobile chatting services by Deposit-Taking SACCOs enhances their performance. Use of mobile communication services such as mobile messaging and mobile call services for official communication within SACCOs should therefore be encouraged by SACCOs' management. The information technology managers in consultation with SACCOs' chief executive officers should also allow and encourage the new methods of mobile communication particularly mobile chatting via social media applications to enhance SACCOs performance as their utilization remains low within SACCOs. Additionally, academicians should collaborate with telecommunication industry players to further develop capabilities of mobile technology devices in order to support the emerging new methods of mobile communication services in order to encourage their utilization within organizations.

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POST IMPLEMENTATION ANALYSIS OF ERPS IN KENYAN UNIVERSITIES

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Abstract

Enterprise Resource Planning Systems have increased usage among Kenyan Universities and in order to achieve the full benefits that ERPS systems have to offer, Universities need to also achieve the Post implementation success. This results from continuous review of ERP systems and there after addressing the emerging ERP implementation challenges and barriers. ERP implementation by universities is a strategic investment aimed at improving and adding value to the university's information system infrastructure which needs to be safeguarded. The problems related with ERP implementations are most dominant during the post-implementation phase.

To establish the ERPs implementation experience in Kenyan Universities the study is based on the evaluation of ERP post implementation phase of selected public and private universities in Kenya. The study seeks to investigate the status of EPRs implementation success, analyze the factors that affect post implementation success of ERP systems and evaluate what university management should put in place so as to achieve post implementation success.

The study applied an empirical methodology using both quantitative and qualitative research approach. Questionnaires, targeted interviews and data from ERP project implementations were used. From the findings of the study, technological and institutional factors indirectly or directly impact post implementation success. The findings will be used to empower university management on ways to evaluate ERP post implementation success of their university based on the ERP experiences of the universities in the study and adopt the findings to make improvements for future ERP projects.

Recommendations are made on possible ways to overcome existing ERP post implementation challenges and also to improve on ERP post implementation success.

Keywords: Enterprise Resource Planning Systems, University, Challenges, Post implementation success.

INTRODUCTION

In a constantly ever changing global academic and business environments, Enterprise Resource Planning Systems (ERPs) have become a key tools to improve the efficiency of operations in the universities. To increase their competitiveness universities, have replaced and/or integrated their existing information systems with ERPs. ERPs are software tools that enable integration and sharing of information and business processes within an organization units and functions. ERPs had its origins in manufacturing companies, however today various industries have adopted their implementation to improve the organization processes(Oliver, 2002).

Some of the attractive feature of an ERP system includes a common data set, standardized data definitions, adaptability of the system and external systems intercommunication (Basir, Khoumbati, Ismaili, & Nizamani, 2014). Business process in a university context includes and not limited to student management, faculty management, human resource, finance, procurement, assets management, library services and research. The universities continue to

enjoy various benefits gained from the adoption and use of ERPs; ranging from easier and fast access of information for better planning and management of the institution; improved services to students, faculty and other administration staff; better ways of risk management and improved data management for better decision making (Robert Kvavik, 2003).Whereas universities have allocated a sizable percentage of their budget to the acquisition of an ERP system very few have successful implementation of these applications (Abugabah & Sanzogni, 2010). Challenges faced in implementing the ERP systems include complexity of the system, lack of user training, low number of technical staff, poor support from consultancy /vendors and poor support from management (Omuono, 2015).

Several studies have been conducted globally on the implementation of ERPs in organizations however, limited literature exists of the post implementation success of the ERPs in the universities (ChianSon Yu, 2005). This paper seeks to investigate the status of EPRs implementation success, analyze the factors that affect post implementation success of ERP systems and evaluate what university management should put in place so as to achieve post implementation success.

METHODS

Empirical study was conducted among Kenyan universities where the survey research method was used. Out of 48 chartered universities in Kenya (CUE, 2017), 20 chartered universities were used for the study. To collect the data from the respondent's online questionnaires were distributed to 11 public and 9 private chartered universities, where the specific respondents included in the study were three per university comprising of one ICT technical support personnel and two faculty members. Data was analyzed using the statistical tools (SPSS Version 22) and results presented in the findings.

RESULTS AND DISCUSSION

Out of the 20 universities that were given the online questionnaire 15 responded representing 75% of the response rate. The four main areas of specialization Sciences, Technology, Engineering and Social Science were represented. 75% of the respondents were male and 25% were female from both faculty and ICT department personnel across the Universities.

65% of the respondents who responded were in the age bracket of 35-54, 30% being of age between 26-34 and 5% of the age between 17-25.The findings shown that all the respondents had used information systems at their respective universities. 65% of the respondents also indicated that they had ERP systems at the universities as shown in the figure 1 below:

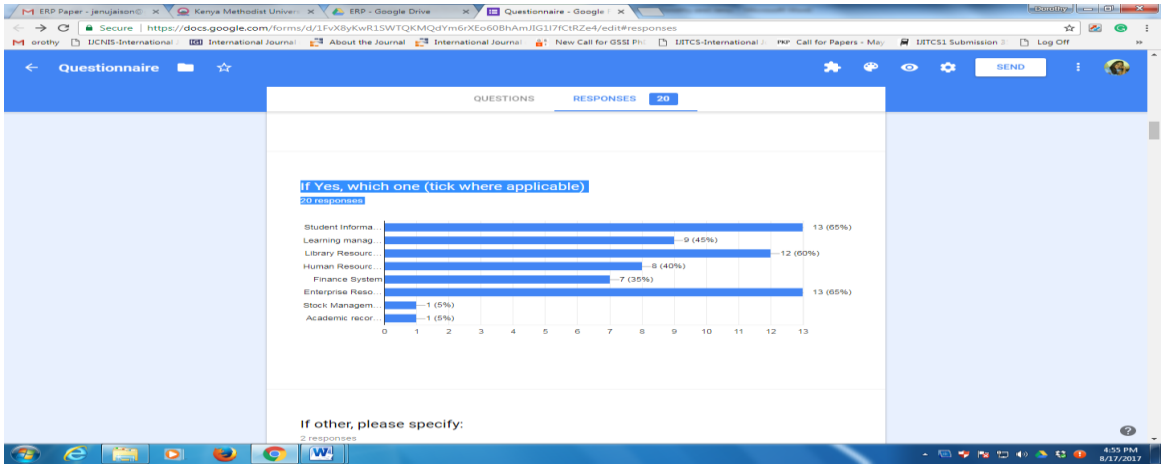

Figure 14: Information Systems Used in Universities

The Results of the study indicated that the main modules implemented in the Universities' ERP system were the student registration, Finance and Library service. Other ERP system modules implemented included Human Resource, Faculty, Procurement, Learning Management Systems, Stock Management, Hospital, Catering and Accommodation Module as shown in the figure 2 below:

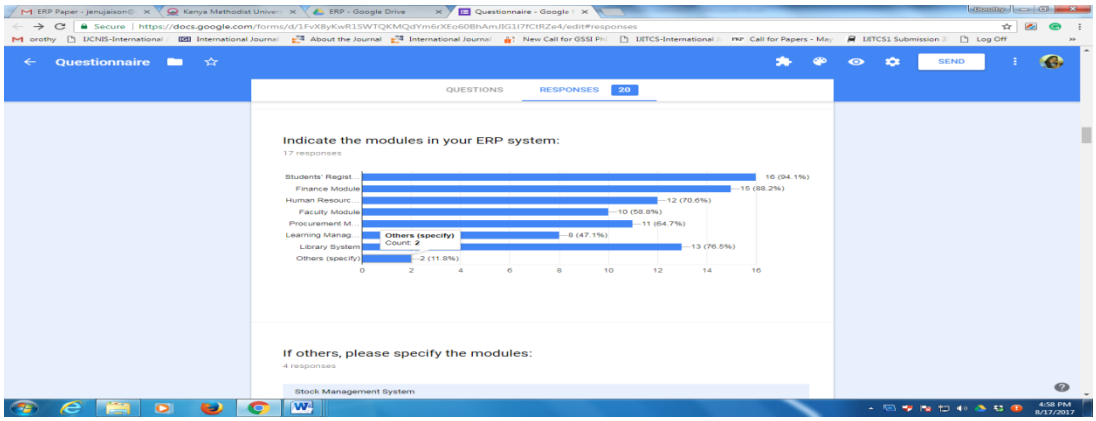

Figure 2: Modules Implemented in ERP System

However some universities had not acquired an ERP system due to high cost and use of other independent information systems.

80% of the respondents indicated that they use the ERP systems at their university. However, 20% of the respondents indicated that they do not use the ERP system due to lack of access and the university has not acquired one.

55% respondents had not attained any training on the use of ERP and the 45% who had been trained the frequency was annually. Teaching, learning and dissemination of information were the major objectives achieved by use of the ERPs. Budgeting and planning by departments in the university were not fully addressed by the use of ERPs.

The findings of the study shown that more than 75% of the respondents agreed that the ERP systems facilitated quick information retrieval, easy detection of errors and feedback.

Whereas, the ERP implementation success rate is high, over 50% of the respondents indicated that it also faced a number of challenges which included and not limited to provision of real-time help facility, inadequacy of university wide support and feedback on the functionality of the specific ERP system modules.

60% of the respondents indicated that the university management had a roll-out strategy and change management plan for the ERP system. 75% of the respondents agreed that the university ERP system was supported by consultants. On the other hand, 75% indicated that the universities had no structured communication channels for the ERP implementation process and 70% responded that the university senior management did not supportthe use of the ERP system.

60% of the respondents indicated that the overall perspective on the ERP implementation was successful as shown in the Figure 3 below:

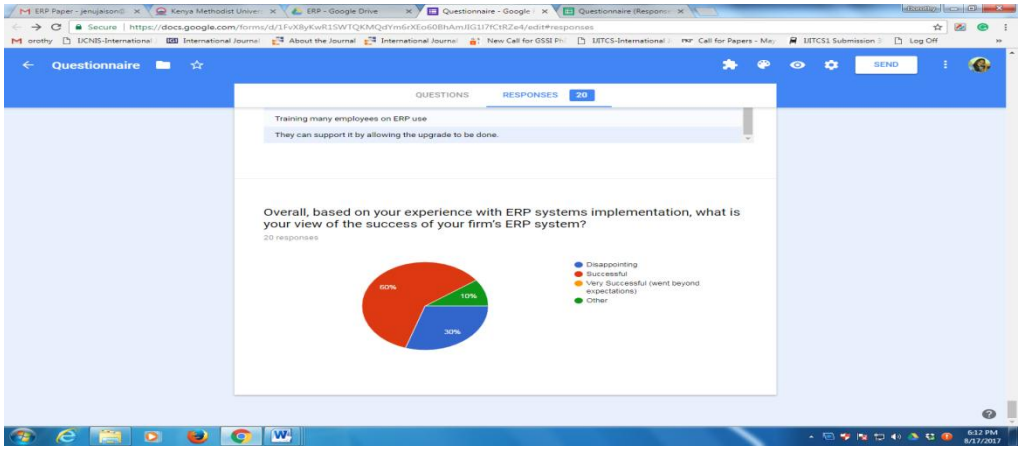

Figure 3: Overall Success of ERP Systems

The respondents had the opinion that the senior university management would better support the use of ERP systems by providing frequent trainings, support of the ERP functionalities, better communication on ERP system implementation process and improving the existing ICT infrastructure.

The study established that universities use ERP systems mostly for students registration processes, Financial management and Library services as supported by research done earlier by (Basir *et al.*, 2014). The factors that affect the success implementation of ERP system in universities were the financial constraints, lack of adequate user training and ICT infrastructure(Ali Syed Imran, 2013). The management has a major role to play to the success of the ERP implementation by ensuring their universities conduct frequent trainings on ERPs, put in place proper communication channels and improve on the existing ICT infrastructure (Lotfy & Halawi, 2015).

CONCLUSION

The results agreed with the initial problem statement that there existed challenges in the success of ERP post implementation stage. Respondents confirmed that there was need for continuous improvement from the university management at the ERP post implementation stage so as to achieve ERP post implementation success.

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A REVIEW OF WIRELESS LOCAL AREA NETWORKSVULNERABILITY

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Abstract

Related literature is reviewed in this paper on Wireless Local Area Networks (WLANs), Vulnerability of Wireless Local Area Networks, system simulation and wireless network vulnerabilities in the quest for developing a simulation model based on standards and facts. Discussion on security attacks and measures to curb them is discussed. This was of essence in developing a model that evaluates vulnerabilities in WLANs putting in consideration the current wireless networking state in perspective. Further research is proposed on the area of vulnerability of Wireless Local Area Networks.

Keywords: Vulnerability, WLANs, Wardriving, SSID, MAC

INTRODUCTION

Openness of wireless network paths and flexibility in dealing with wireless communication protocol vulnerabilities create poor security. Due to deficiencies in the security mechanisms of the first line of defense such as firewall and encryption, there are emergent interests in detecting wireless attacks, it is necessary to select representative attack test cases that are extracted mainly from a comprehensive classification of wireless attacks (Anjum, 2006).

A lot of trepidations arising in making WLAN vulnerability models have been linked to the physical security of systems, protocols and policies according to recent research. However as opposed to this it has been suggested that lack of human behavior assessment as components in these models has been the cause of key risk issues (Ken, 2007).

This is because as the paper suggests without the inclusion of a component that caters for the behavior of human beings in modeling the vulnerability models, then it is impossible to effectively apply the necessary features used in developing an effective vulnerability model.

In addition to this other research has suggested that one such area of the need to consider human behavior when creating vulnerability models is in wireless communications. This results from wireless network data being spread between devices through the air through radio waves, which are vulnerable to interception from unauthorized users.

Elucidations are consistently being searched for these vulnerabilities with the emergence of Wi-Fi Protected Access Protocols (WPA2). In order to deal with these deficiencies researchers have suggested that more consideration is given to the basic concepts of security modeling experimental design, as the types of goals to be addressed are so important and useful to the objectives of the security modeling simulation. The researchers argue that the justification for this approach is because security models are developed through an experimental design approach and that a well-designed experiment allows the analyst or researcher to examine many more factors than would otherwise be impossible (Ken, 2007).

Passive monitoring of investigate response frames and beacon is done by network discovery tools that run on 802.11 stations. Some actively probe for stations configured for peer to peer and Aps. The discovered devices are typically done by MAC address, SSID, channel, and location (when used with a GPS), and the generated data saved to a file.

AirTouch Network's Security System War Driving Kit is a commercial war-driving kit, complete with sniffing software, 802.11b adapter and antenna. NetStumbler is a freeware AP discovery tool for Win32 systems. WaveStumbler is a freeware WLAN mapper for Linux. MacStumbler is freeware AP discovery software for Mac OS X and Apple Airport adapters.

Network discovery and vulnerability assessment tools, sniff traffic to spot security policy violations by querying APs to obtain system information and identify risks (e.g., open ports). Assessment tools of known Aps build a database so that rogue devices can be highlighted when repeated at regular intervals while generating reports that document vulnerabilities.

Internet Security System's Wireless Scanner is a Windows 2000 vulnerability checker with active penetration scanning. AirMagnet's Handheld/Laptop Analyzer series are portable analyzers for Win32 laptops and Pocket PC 2002. WaveSecurity's WaveScanner is a discovery, assessment and reporting tool for Linux; uses Prism2 adapters.

Traffic monitoring and analysis tools also provide discovery and vulnerability notification. They capture and examine packet content (not just headers), so that applications' behavior can be examined. They're typically used for security and performance troubleshooting and trend analysis. Network Associate's Sniffer Wireless real-time analyzer for 802.11a/b runs on Win32 and Pocket PC 2002.

WildPacket's Scanner AiroPeek is a real-time analyzer for 802.11a and b which runs on Windows XP/2000. Ethereals' is a freeware network protocol analyzer with WLAN support on certain platforms. Network Instrument's Network Observer is a real-time analyzer for 802.11a/b, Token Ring, and FDDI for Win32.

Intrusion Detection: As in wired networks, IDSes provide 24/7 network-layer monitoring for possible intrusions. IDSes may use signature analysis, protocol inspection, rules enforcement and/or anomaly detection. Latis Networks' StillSecure Border Guard is a WLAN gateway that focuses on intrusion detection and content filtering for 802.11, stripping worms and similar viral payload at the gateway. AirDefenses' Air Defense Guard IDS appliance employs remote sensors to capture 802.11 packets and send summaries to central IDS engine (Kirongo, 2014).

State of Practice in Wireless Local Area Networks

The IEEE 802.11 and 802.11b WLAN standard defines three physical (PHY) layers and a medium access control (MAC) sub layer. The IEEE 802.11 protocol describes a WLAN that provides services commonly found in wired networks, such as constant network connections, reliable data transfer, and throughput. Detection and prevention of WLANs vulnerability are used to protect unauthorized access for WLAN data (Al-Surmi& Othman, 2012).

"A vulnerability in an application or an operating system can then be subjugated to take over a system, however it can be identified before the system is actually compromised. Here, the tester should deliberate whether this last step of manipulating the vulnerability needs to be carried out in order to verify it, or whether it is sufficient to merely point out the presence of the vulnerability. This question can only be resolved by keeping in mind the defined objective of the test and the conditions derived from this. If the penetration test is to be as realistic and informative as possible, it may be appropriate not to impose any limits on the aggressiveness of testing procedures. If, on the other hand, a potential disruption to operations is to be avoided as far as possible, vulnerabilities should not be actively exploited. In this case, the result of the penetration test would be the identification of existing vulnerabilities and no evidence of a successful penetration would be provided. Automated tools should be used to analyze vulnerabilities to ascertain system patch level." (Anjum, 2006).

The WLAN experience many capabilities of attacks. WLAN traffic is made up of management frames, data frames, and control frames. Existence of manipulations to these

frames that may affect data confidentiality, integrity, mutual authentication and availability either directly or indirectly, is considered in this dissertation as a vulnerability and a threat.

WLAN vulnerabilities

Other researchers have highlighted the following forms of threats and vulnerabilities as problematic in wireless local area networks security which are summarized below:

Eaves Dropping/Traffic Analysis:

In this set are found passive eaves droppings, war-driving, traffic analysis, active eaves dropping, sniffing, war walking, sniffing,. This is a category of many attacks which adopt the pros of unreliable encryption and is made up confidentiality of data. (Sheila, 2007).

Message modification

In this classification falls all the attacks intended for modification of data such as network injections. These attacks compromise the integrity of information and data (Khalid & Christian, 2007).

Rogue devices

It comprise Accidental associations, rouge applications, rogue AP, soft APs, unauthorized Ad hoc networks. These devices may result to compromise of the data and information confidentiality, integrity loss or uncertain validity or non-repudiation. Rogue devices are capable of Launching replay attacks and malicious association (Sheila, 2007).

Session hijacking

The attacker planning this attack waits a valid session to be initiated between a valid node and an AP. The attacker then poses as a valid AP to the node and as a valid node to the AP. The attacker then sends a disassociation message to the node and continues posing as the valid node, completely taking over the session from the legitimate node who believes the session was terminated by the AP. The attacker upon achieving this can mine for more information such as the SSID and password (Tanya &Shiuphyung, 2008).

Man-in-the Middle attacks

In this category specific malicious Access Point superimposed with clients, pretending as a genuine client and to the client subterfuges as the legitimate Access Point. When the client and AP infiltrates into this association the man-in-the-middle can then interrupt communication, read unencrypted information, can get passwords and even compromise the system further by denied legitimate user access to the some resources (Ustan& Yilmaz, 2006).

Having a successfully MAC spoofing, an invader can create a fake MAC address for the counterfeit organization frame from his device. Hence, the attacker simulates a network that receives most requests to and from AP. Here the attacker is capable of initiating the following denial of service attacks.

a) **Distributed Denial of Service Attacks**

An attacker installs MAC spoofing and flooding software in many stations to act as slaves while the attacker remains the master to trigger the stations to act. The attacker then triggers the devices either to all send beacon frames at a higher rate or authentication flooding and or deauthentication flooding. This attack has the capability of completely bringing down the network (Tanya &Shiuphyung, 2008).

b) Association request flooding

The attacker pumps a flood of association requests to the AP. Each association request frame has a faked MAC address and unique to fool the AP that they are from different STA. The processing of the frames consumes resources and responses are not acknowledged. Thus, the attack keeps the AP busy at the expense of legitimate host.

b) **Disassociation flooding**

This works the same way as the disassociation flooding (Tanya &Shiuphyung, 2008). The attacker forces AP or STA to disassociate. The disassociation frames just like deauthentication frames are notification frames and therefore can be ignored by the device. The attacker can repeatedly carry out the disassociation each time forcing the device to go through association process.

c) **Authentication Request Flooding**

The attacker fakes the MAC address and sends a flood of authentication requests simulating a busy network with many stations (Sheila, 2007). The AP has to check the frames for authentication of the station and responds with appropriate response message. Authentication processes and association response consumes computational resources and degrades the performance of the network by denying legitimate station the computational resources.

d) **Deauthentication flooding**

The attacker fakes the MAC address of a legitimate device. The attacker then sends a faked deauthentication frame to the AP. The AP deauthenticate the STA since de authentication frames are notification frames that can't be ignored. The legitimate device is therefore disassociated and will be required to reauthenticate before accessing network resources. The attacker can continuously repeat the process each time disrupting the services to the legitimate network hosts. For applications that are sensitive to throughput and delay this can seriously degrade the performance of the application and the quality of service to the users. The attacker fakes the MAC address of a legitimate device.

Increased accessibility to information resources in wireless networking improves productivity because network configuration and reconfiguration is easier, faster, and less expensive. However, wireless technology also creates new threats and poses information security threats. Communications in WLANs is through radio frequencies resulting to the risk of interception. When the message is not encrypted, or encrypted with a weak algorithm, it compromises confidentiality. Wireless networking alters the risks associated with various threats to security, the overall security objectives remain the same as with wired networks: preserving confidentiality, ensuring integrity, and maintaining availability of the information and information systems.

CONCLUSIONS

The study identified a need for a methodology for analyzing the WLANs in a wardriving setting that are vulnerable / secure. Artificial Neural Networks is represented as the suitable methodology for analysis in the dissertation.

The researchers identified that Artificial Neural Networks was used in a number of WLANs wardriving settings successfully. The use and development of Artificial Neural Networks as an analysis /assessment tool will therefore be of significant importance to the WLANs users.

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INTEGRATING INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) IN THE FARMING SYSTEM FOR LIVELIHOOD IMPROVEMENT; A CASE OF KIENI EAST CONSTITUENCY, NYERI COUNTY, KENYA

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Abstract

In many developing countries, the agriculture sector is dominant in raising incomes among the poor by as much as four times than other sectors realizing about 17% of the GDP and 40% of exports are from Agriculture according to World Bank, 2008; and this was noted to improve agricultural productivity through integration of ICT in the farming system to address SDG number two on zero to hunger. The study was conducted in 2013. Data collection methods included use of questionnaires, focus group discussions and interviews. The data was collected from 90 respondents sampled across Kieni East Constituency. The research targeted producer organizations, change teams, extension agents and key stakeholders. The overall objective of the research was to investigate the role of ICT to small holder farmers to harness the benefit of information and communication technologies to maximize returns on agriculture production system. The research examined the role of ICT mainly using market price information through short message service or web portal, open data kit, internet and use of geographical information system in enhancing growth and efficiency in agri-business transactions. The research findings indicated that there is a correlation between increase in information and communication technology and increase in returns on agricultural production system. It also indicated that use of ICT enhanced growth and efficiency in agri-business transactions by empowering the farmer and producer organizations with real time marketing information. The research demonstrated the role of ICT in the systematic dissemination of agricultural information to provide comprehensive, up-to-date and detailed knowledge and information. The research witnessed tremendous advancement in information dissemination among smallholder farmers. Use of ICT in Agricultural extension and education provided an efficient and effective way to reach out to small holder farmers.

Key Words: ICT, Agricultural extension, Agricultural information, market, mobile technology

INTRODUCTION

The use of ICT in Agriculture plays a vital role in the social and economic development of most African countries and is the main contributor to economic growth and stability, Hilda Munyua, *et al* (2008). According to Chukwunonso *et al* (2013), the main impediments to ICT adoption is the sophistication of the technology which requires human capital investment to synchronize efficiently challenges faced by small holder farmers that includes production and marketing. ICTs have a positive impact on the development of any nation especially in the food security sector (Kuhlmann, 2005). There is a strong link between integrating ICT in farming systems and achievement of sustainable development goal number two which targets to end hunger, achieve food security, improve nutrition and promote sustainable agriculture.

The farmers, especially the youth seem inclined towards going online on computers to access market and production information while the older generation respond better to audio and visual ICTs. Most of the stakeholders have also taken a keen interest in some of our technical solutions like Frontline SMS used for mobilizing farmers and use of the technology to answer

farmers' queries via phone as well as accessing agronomic information. Agriculture involves the conceptualization, design, development, evaluation and application of innovative ways to use information and technologies in rural domain with a primary focus of livelihood improvement (Manish Mahant *et al*, (2012). According to Alexander B. Sideridis (2010), poverty and hunger in developing countries can be addressed through increasing farm productivity and ICT in particular can contribute in the achievement of the goal.

The application of ICT in agriculture is an important pillar of agricultural extension (Dhaka, B. L., and K. Chayal, K.(2010). The desire to strengthen farmer's access to market has seen the emergence of a number of interventions that employ ICT tools in the provision of agricultural marketing information, Julius J. Okello (2012). Market access is one of the most important factors influencing the performance of small holder agricultural farmers (Barret, 2008; Kirsten, 2010). Ezeh Ann Nnenna (2013), stated that its imperative to provide adequate training on the use of ICTs to all stakeholders strengthening more the use of phones and internet and this needs collaboration with research institutions on information dissemination and training,(Spyros Fountas , 2014).

The ICT technologies accessed include use of using market price information through frontline short message service or web portal, open data kit, internet and use of geographical information system, (Jayathilake *et al* 2015).This enhances growth and efficiency in agri-business transactions through timely marketing and technical information to both individual farmers and producer organizations. This is a data base for disseminating market and agronomic information to farmers. Other technologies included creating awareness through the radio and various foras and use of farmers/buyers interactive platform. Others included use of a mobile platform to provide location based information to farmers on topography, rainfall, temperature, farm management practices, crops range and soil types. This was supported by Anthony G. (2013) in the journal on information technology and rural development in Africa, experiences in Kenya.

Objectives of the research

1. To find out if there is a correlation between increase in information and communication technology and increase in returns on agricultural production system.
2. To investigate whether use of ICT enhanced growth and efficiency in business transactions through dissemination of timely marketing and agronomic technical information to both farmers and producer organizations
3. To examine the role of ICT as a driver of economic agribusiness indicators in the agricultural value chain, climate change and resilience intervention and to assess the views of farmers regarding use of ICT in Agriculture.

RESEARCH METHODOLOGY

The study was carried out through a desk review of secondary sources of information covering small scale agriculture and a wide range of ICT related experiences and initiatives. The primary data was collected in Gakawa, Kiamathaga and Thegu ward in Kieni East Constituency.The research wanted to investigate if there is a correlation between increase in information and communication technology and increase in returns on agricultural production system. The paper accessed the role of ICT to enhance growth and efficiency in business transactions through dissemination of timely marketing and technical information to both farmers and producer organizations. The research was based on key indicators which included the number of farmers trained, numbers actively using the SMS service, numbers of

producer organization using ICT in their programing, marketing and income generated at various levels as a result of integrating ICT.

The researcher used regression and correlation analysis to explore the nature of the relationship that exists among dependent and independent variables. The researcher did hypotheses tests and conducted analysis of variance in accordance to the research objectives. The study followed exploratory research design. Quantitative and qualitative research methods were adopted to collect data from the study respondents. Survey research approach was implemented to collect data from the study participants. Quantitative data included open ended and closed-ended information. Data collection methods included use of questionnaires, focus group discussions and interviews. The data was collected from 90 respondents sampled across Gakawa, Kiamathaga and Thegu ward in Kieni East Constituency. The research targeted producer organizations, change teams, extension agents and key stakeholders.

Research instrument

The survey instrument comprised demographic data items, Likert-scale survey items, dichotomous questions and checklists which were designed to collect data on the issues under investigation.

Reliability of the instrument

Reliability is the degree to which an assessment tool produces stable and consistent results when administered at different time intervals to the same respondents. For an instrument to be considered reliable to making statistical inference, the Cronbach's alpha of at least 0.7 is required.

Reliability Statistics

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.722	.579	23

From Table the alpha of 0.722. The alpha obtained is above the minimum threshold of 0.7 which imply the questionnaire tool used was reliable to make inference and generalize the results.

Scope of the study

The study was conducted through case study targeting 90 participants. The farmers were identified through stratified random sampling. This included farmers that were using mobile technology.

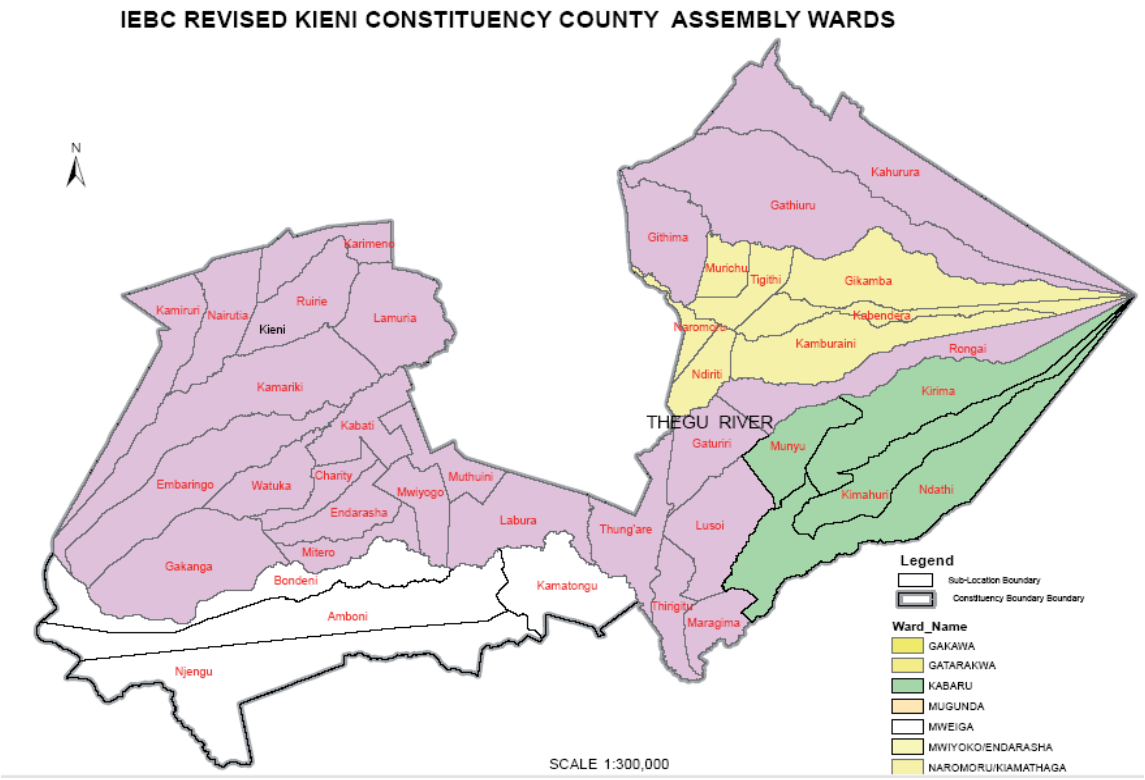

Figure 1. Map indicating the research area – Kieni East constituency

Target population and sampling method

The data was collected from 90 respondents sampled across Gakawa, Kiamathaga and Thegu ward in Kieni East Constituency who had high concentration of farmers using ICT. The sampling process yielded a sample of 90 farmers out of the 300 population size.

Table 1: Stratified random sampling technique employed to select study participants

Sub Location	**Farmers involved**	**Sample Size**
Kabaru	70	21
Kiamathaga	100	30
Narumoru	50	15
Lusoi	30	9
Gakawa	50	15
TOTAL	**300**	**90**

The research used stratified random sampling since it's a method of sampling that involves the division of a population into smaller groups known as strata. The population in this case is the five sub locations. The proportionate sample size method that was used to justify the sample size

(70/300 x90 - 21) (100/300 x 90 – 30) (50/ 300 x 90 – 15)

(30/ 300 x 90 – 9) (50/300 x 90 -15)

Total selection: 90 respondents from the population of 300 farmers. The researcher used the systematic or the nth method where every nth farmer was selected from the randomized list.

Data collection tools used

a) Questionnaires
b) Interviews
c) Focus groups discussion.
d) Observations

Research Component/ Methodology

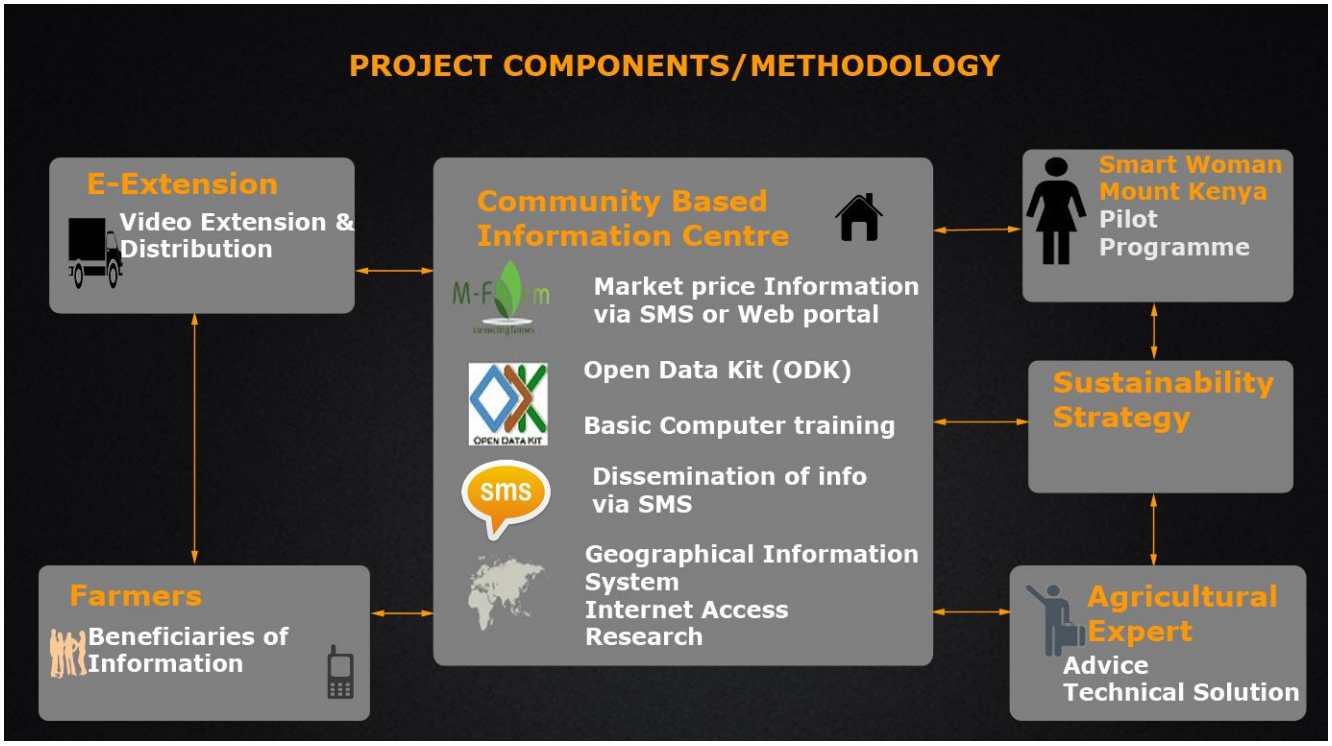

Figure 2. Research Component

Conceptual Framework

Figure 3. Research methodology

The regression model

$Y= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon$

Y= Integrating ICT in the farming system

β_0= Y intercept

β_1 to β_3 = regression coefficients

X_1 = ICT technology

X_2 = Market platforms

X_3 = E-Extension

ε = error term.

Whereby Y represent the Integrating ICT in the farming system, X_1 is ICT technology, X_2 , Market platforms and X_3 .E- Extension. B_0 is the model's constant, and $\beta_1 - \beta_3$ are the regression coefficients while ε is the error term form the model's significance. Holding other factors (Integrating ICT in the farming system) constant, a unit increase in use of ICT technology would lead to an increase in marketing hence encouraging farm productivity and improve on livelihoods.

Key outcomes: Use of ICT in agricultural productivity

	Use of ICT in agricultural productivity	
Rating	Checking market rates	Obtaining agronomic information
To a very little extent	0.0%	8.7%
To a little extent	0.0%	11.1%
To some extent	55.6%	32.1%
To a great extent	44.4%	48.1%
TOTAL	100%	100%

The table shows that almost half of the farmers use mobile phones to a great extent (48.1%) to access agronomic information to boost productivity. Over 50% use the mobile phones to some extent to check market rates using short message service or internet. All the farmers interviewed used the mobile phone to check the market rates

Satisfaction with use of mobile technology to boost production

Satisfaction level	**Level of information reliability**	**Level of application of information obtained**
Very dissatisfied	24.0%	0.4%
Somewhat dissatisfied	11.1%	3.7%
Neither satisfied or dissatisfied	0.0%	9.7%
Somewhat satisfied	28.9%	29.6%
Very satisfied	36.0%	56.6%
TOTAL	100%	100%

Over 50% of the farmers interviewed applied the information obtained through the ICT technology. However 3% did not trust the information and were dissatisfied.

CONCLUSION

The research findings indicated majority of farmers had positive attitude towards use of ICT and there was a correlation between increase in information and communication technology and increase in returns on agricultural production system. The research concluded that use of ICT calls for good infrastructure, adequate ICT skills, good and affordable connectivity and appropriate ICT policies. Use of ICT enhanced growth and efficiency in business transactions

through dissemination of timely marketing and technical information to both farmers and producer organizations. Use of ICT in Agricultural extension and education provided an efficient and effective way to reach out to small holder farmers. The research concluded that without the enabling environment and infrastructure, no much can be achieved.

There must be right policy formulation and capacity building of farmers and extension workers on ICT usage in agriculture related software and provision of market information platforms. The researcher recommended the need to strengthen Agriculture ICT curriculums in the formal and informal educational and training programs. The governments should invest more on the acquisition of advanced ICT skills targeting agriculture extension staff in the rural areas. There is need to establish community based village knowledge centers to act as clinic for farmer's needs. There is also need to design phones that can be solar powered to reduce dependency on electricity which is less available in some remote areas. The research recommended that promotion of high technology such as ICTs for communication with farmers should be targeted to youth in agriculture because they are already familiar with the communication tools and require little additional training for their use and the fact that older farmers have less understanding of the benefits of ICT adoption.

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EFFECTIVE USE OF MOBILE PHONES IN ENHANCING EDUCATION OUTCOMES IN KENYA. A HISTORICAL STUDY ON FACTS AND MISCONCEPTION OF MOBILE PHONES USES BY STUDENTS

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Abstract
Despite the current improvements in educational indicators in Kenya, like enrolment, significant challenges remain with regard to access and the delivery of quality education, particularly in rural and remote regions. Attempt to find viable solutions to these challenges, some hope has been placed in use of ICTs, computers and internet being Key. Little has been done to find the effectiveness of the use of mobile phone in enhancing education out comes. For quite some time, the international development community has emphasized the paramount role of education in bringing about sustainable socio-economic development in the world. Goal 2 and 4 of the United Nations MDGs and SDGs aimed to achieve universal primary education by 2015, and ensure inclusive and quality education for all and promote lifelong learning respectively. Research shows that more than one-third of the world's adult population most living in the developing world has no access to printed knowledge, new skills, and technologies that could improve the quality of their lives. Inequalities in access to education continue being a barrier in the developing world, and the delivery of cost-effective and quality education remains a persistent common problem. This article is a historical study,showing how effective use of Mobile phones in education will contribute to improved educational outcomes in Kenya.It examines the extent to which the use of mobile phones(Mlearning) helps to improve educational outcomes by improving access to education and bypromoting new learning and new teaching. The paper argues that Mlearning, Mteachingand Meducationare current realities in all levels of education not only in Kenya but world over. Educators should not panic on negative effects of the use of mobiles phones by students but should focus on their benefits. Educators should eliminate all misconceptions on mobile phones use in education.

Keywords: Mobile phones; mobile learning; Meducation, educational outcomes; new learning, new teaching

INTRODUCTION

The goal of the Vision 2030 is to transform the country into a globally competitive and a prosperous nation by the year 2030. The vision is founded on the social, economic and political pillars. Within the social pillar, education sector plays a critical role in facilitating the process of inculcating knowledge, attitudes and skills necessary for catapulting Kenya to a globally competitive country and acquiring new knowledge in a systematic way with a view to improving products and processes. The sector therefore has a major responsibility of facilitating the process of developing manpower necessary for transforming Kenya into a globally competitive country.

For quite some time, the international development community has emphasized the paramount role of education in bringing about sustainable socio-economic development in Africa. Goal 2 of the United Nations Millennium Development Goals (MDGs) aimed to achieve universal primary education for children everywhere, boys and girls alike, by 2015. On the other hand Goal 4 of the United Nations sustainable development goals (SDGs) aims to ensure inclusive and quality education for all and promote lifelong learning opportunities

for all. Since 2000, there has been enormous progress on the goal to provide primary education to all children worldwide.The primary school enrolment rate in developing regions reached 91%. By measures in any school, that's a good grade. Now, let's get an even better grade for all kids and achieve the goal of universal primary and secondary education, affordable vocational training, access to higher education and more (UNDP SDGs Booklet 2017). Looking at Kenya enrolment by Gender and Level of Education the trend in enrolments across the three levels of basic education is as follows; The ECDE level has witnessed tremendous growth between 2009 and 2014, registering an annual growth of 6.1%. The growth may be attributed to assured transition between ECDE and primary schools as most ECDE centers are hosted in primary schools. The absolute parity index has improved in favor of girls from2009 to 2014. The national average for the parity index has hidden cross county variations which have been presented in chapter four.

Enrolment in ECDE increased by 772,600 pupils over the period between 2009 and 2014 this giving an annual growth rate of 6.1%. The total number of pupils enrolled in Primary Education increased by more than 8% over the period, with about 767,200 additional pupils and an annual growth rate of1.6%. Secondary Education had the highest increase over the period with about 837,300 additional students that represent almost 57% increase over the period and with 9.4% annual increase.

The parity index between girls and boys at ECDE level, increased over the period from 0.95 in 2009 to

1.05in2014. Thus there were more boys than girls at the beginning of the period and this changed to having more girls than boys in 2014. In Primary Education, the parity index improved over the period but did not get to parity by 2014 and hence equality is not yet achieved. Despite a real improvement in the gender parity at Secondary Education over the period, the index is still low at 0.92. Thus there are fewer girls than boys at Secondary Education level.

Access at grade six (retention) has improved over the years from 95% in 2009 to 100.2% in 2014(EFA target). The enrolment at class eight has grown over the same period at an annual rate of 0.6%.

However, this rate of growth in the enrolment is lower than the annual growth of the population that is theoretically supposed to be in class 8 (Age 13) over the same period hence the significant drop inthe primary completion rate from 86.5% in 2009 to 79.3% in 2014.

Under the Education for All Framework, the desire of all countries that ratified the commitment is to attain universal primary education, i.e. all children of school going age to enroll in school and complete the primary cycle as designed. In Kenya there is universal access but after grade six, the system loses children along the way thereby undermining the attainment of universal primary education.

Significant challenges remained, however. For example, in Sub-Sahara Africa the enrolment ratio has reached 90%, but there still remain more than 18 million children of primary school age who are not enrolled. Similar challenges confront secondary and tertiary education. In developing countries, on average, only 54% of children of the appropriate age attend secondary school currently (UN, 2008).

Additionally, more than one-third of the world's adult population – most living in the developing world – has no access to printed knowledge, new skills, and technologies that could improve the quality of their lives (Dhanarajan, 2009). Inequalities in access to education continue to pose major barriers in the developing world, and the delivery of cost-effective and quality education remains a persistent problem.

In the attempt to find viable solutions to these problems, much hope has been placed in new information and communication technologies (ICTs). It is believed that ICTs can empower teachers and learners by facilitating communication and interaction, offering new modes of delivery, and generally transforming teaching and learning processes. Of the many different forms of ICTs, mobile phones are thought, for several reasons, to be a particularly suitable tool for advancing education in developing regions. First, mobiles phones are the most prevalent ICT in the developing world, and the penetration rate is rising rapidly. In Africa as well as Asia, mobile phones penetration has doubled within a short span of time; in 2001, average penetration was 19.7 per 100 inhabitants while in 2005 the penetration rate rose to 40.9 (Orbicom, 2007). Also relevant is the fact that mobile phone ownership is increasingly more common in the lower socio-economic segments of society (Samrajiva&Zainudeen, 2008). Second, mobile phones are an especially good 'leapfrogger' since they use the radio spectrum. There is, therefore, less need for new physical infrastructure such as roads and phone wires, and base-stations can be powered via generators in places where there is no electrical grid (Economist, 2008) in Kenya remote areas are using Sola energy to charge phones others use Diesel/petrol generators. Finally, in addition to voice communication, mobile phones allow the transfer of data, which can be particularly useful for delivering educational content over long distances. Currently whatups is common social media communication platform.

The concept of mobile learning (Mlearning) – understood for the purposes of this article as learning facilitated by mobile devices – is gaining traction in the developing world. The number of projects exploring the potential of mobile phone-facilitated Mlearning in the developing world is steadily growing, spurred in part by the use of mobile technology in the educational sector in the developed world which has expanded from short-term trials on a small scale to large-scale integration. However, there remains a lack of analysis that brings together the findings of the rising number of Mlearning programs and projects in the developing world in general and Kenya in particular.

With the increasing attention now being given to the role of mobiles in the educational sector in developing countries, there is a need at this juncture to take stock of the available evidence of the educational benefits that mobile phones provide in the Third world that is the less developed countries of Africa and Asia. Consequently, this article explores the possibilities of Mlearning/Meducation/Mteaching programs and projects in Kenya. Inequalities in access to education continue being a barrier in the developing world, and the delivery of cost-effective and quality education remains a persistent common problem.

This article is a historical study, showing how effective use of Mobile phones in education will contribute to improved educational outcomes in Kenya. It examines the extent to which the use of mobile phones (Mlearning) helps to improve educational outcomes by improving access to educationunder Meducation and by promoting new learning and new teaching under Mlearning and Mteaching respectively. The paper argues that Mlearning, Mteaching and Meducation are current realities in all levels of education not only in Kenya but world over. Educators and education stake holders should therefore not panic on negative effects of the use of mobiles phones by students but should focus on various benefits of mobile phone uses in education. It argues that mobile phones uses in education benefits surpass many times their negatives. Therefore educators/education stakeholders should be in the front line in fighting and eliminating all misconceptions and said untruths (negative myths) on mobile phones use in education and by students. In exploring how mobile phone-facilitated Mlearning/Meducation/Mteaching contributes to improved educational outcomes, this article examines specific issues like; the role of mobiles in improving access to education, the role of mobiles in promoting new learning, those new learning processes and new instructional methods currently stressed in educational theory.

The structure of the article continues as follows. After the introduction, the article engages with the literature that discusses how mobile technology can address the problems of access confronting the educational sector as well as mobile technology's role in relation to new learning. The article then examines examples of theactual use of mobile phones for education in developing countries in of Africa and Asia and of the developed world of the US and UK. The article discusses the potential of mobile phone-facilitated Mlearning as well as with indications for possible future areas of research. It concludes with conclusions and recommendations. An elaborate reference is give at the end of the paper.

How Mobiles phones improve Access to Education

In theory, Mlearning increases access for those who are mobile or cannot physically attend learning institutions – those who would not otherwise be able to follow courses in a traditional educational setting due to the constraints of work, household activities, or other competing demands on their time. Mlearning makes education more accessible in that it enables learners to pursue their studies according to their own schedule. The portability of mobile technology means that Mlearning is not bound by fixed class times; Mlearning enables learning at all times and in all places, during breaks, before or after shifts, at home, or on the go. Interestingly, however, while Mlearning is portable, it is not necessarily associated with physical movement. According to a study conducted by Vavoula, few people actually utilize the time spent in transit to learn (Sharples, Taylor, &Vavoula, 2005). Mlearning, as Visser and West (2005) suggest, can also increase access in those situations where cost represents a significant barrier to learning. For those in rural or remote areas where environmental and infrastructure challenges hinder other learning modalities, particularly eLearning, Mlearning presents great opportunities. For the individual learner, mobile technology is much less cost-prohibitive than other technologies like personal computers and broadband connections that are necessary for eLearning. In as much as mobile technology presents a less cost-prohibitive medium for learning, it represents an important avenue by which to reduce the gap between the haves and the have-nots in contemporary society where access to knowledge and information is increasingly important (VanWeert, 2005).

In regards to cost, the benefit of increased access afforded by Mlearning is particularly relevant in the developing country context. Many developing countries are completely bypassing investments in costly, fixed telephone infrastructure for the installation of mobile phone networks (Motlik, 2008; Sharples, Taylor, &Vavoula, 2007; Traxler & Dearden, 2005). Thus, Mlearning provides a potential way forward for the expansion of education programs to larger segments of the population rather than via the eLearning model that has been adopted in much of the developed world. Mlearning allows a method of educational instructions delivery that is more cost-effective than eLearning methods, in that many people are already familiar with mobile phone applications (Motlik, 2008), more so children of age 3 year are able to use smart phones without any assistant or guidance from a teacher.

In so much as Mlearning exerts an impact on educational outcomes by increasing access, Mlearning represents a continuation and improvement of distance learning through increased utility and applicability (Keegan, 2002). Mlearning, it broadens the availability of quality education materials through decreased cost and increased flexibility while also enhancing the efficiency and effectiveness of education administration/management, policy formulation, and curriculum development and implementation.

How Mobiles phones are Promoting New Learning

Others suggest that the benefits of mobile phones are not merely limited to increased access to educational services. Mlearning, also facilitate changes in the character of learning modalities that in turn impact educational outcomes. In this regard, Mlearning represents more than a mere extension of traditional forms of education; Mlearning facilitates alternative

learning processes and instructional methods that the theories of new learning identify as effective for learning.

According to proponents of new learning, mobiles facilitate designs for personalized learning in that they are responsive to difference and diversity in the way learning occurs. They facilitate designs for situated learning by providing learning during the course of the activity – in the field for a botany student, in the classroom for a teacher trainee, or in the workshop for an engineer. In this sense, Mlearning also facilitates designs for authentic learning, meaning learning that targets real-world problems and involves projects of relevance and interest to the learner (Kukulska-Hulme &Traxler 2007; Traxler, 2007).

The supposed value of mobiles also arises from the manner in which they facilitate lifelong learning. Mobiles can support the great amount of learning that occurs during the many activities of everyday life, learning that occurs spontaneously in impromptu settings outside of the classroom and outside of the usual environment of home and office. They enable learning that occurs across time and place as learners apply what they learn in one environment to developments in another (Sharples *et al*., 2005, 2007).

Mobile phones theoretically make learner-Centred learning possible by enabling students to customize the transfer of and access to information in order to build on their skills and knowledge and to meet their own educational goals (Sharples *et al*., 2007). Mlearning thus exerts a democratizing effect on the learning experience as learners take a greater responsibility for the learning process instead of being passively fed information by an instructor. Whereas in traditional models of education the goal is the transfer of knowledge from teacher to student, Mlearning empowers students to actively participate in the learning process to make it a process of construction and not mere instruction (Dela Pena-Bandalaria, 2007). Mlearning thus represents learning that is not 'just-in-case,' education for the sake of producing a bank of knowledge, but rather represents learning that is 'just-in-time,' 'just enough,' or 'just-for-me' (Traxler, 2007). As a facilitator of new learning, Mlearning goes beyond an emphasis on the possession of information to enabling learners to find, identify, manipulate, and evaluate existing information (Brown, 2003).

Mobiles can also supposedly facilitate knowledge-centred learning by providing efficient and inventive methods by which students can learn with understanding – meaning that they deepen their understanding of a specific subject matter rather than merely memorizing large amounts of information – and then use this knowledge as a basis for new learning through integration and interconnection. Mobile devices make possible assessment-centred learning as well by enabling the provision of continual feedback throughout the learning process, presenting learners with diagnosis and formative guidance as to what might be improved or what might be learned next. Moreover, in providing prompt feedback, Mlearning maintains the appeal of learning and provides a motivating factor that can at times be lacking in traditional modes of education (Geddes, 2004). Mobile phones also facilitate community-centred learning, meaning learning that the learner deems valuable because of its relevance to the surrounding social context; Mlearning facilitates learning that can be used to achieve socio-economic goals that respond to problems, such as problems related to health or family care confronting the surrounding community (Sharples *et al*., 2007; Wagner &Kozma, 2005).

Given that social interaction is central to effective learning, as indicated by theories of new learning, mobile phones should also impact educational outcomes by facilitating communication. Mobiles permit collaborative learning and continued conversation despite physical location and thus advance the process of coming to know, which occurs through conversations across contexts and among various people. Via mobile technology, learners engage in conversation whereby they resolve differences, understand the experiences of

others, and create common interpretations and shared understanding of the world (Nyiri, 2002; Sharples *et al*., 2007).

In promoting educational modalities that accord with the theories of new learning, Mlearning should offer an appeal aspect that also impacts educational outcomes. Mlearning can be particularly appealing for those who have not succeeded in traditional learning environments; it can attract those not enamoured by traditional learning approaches that are generalized and decontextualized in nature. Mlearning is also beneficial in that it can provide immediate feedback and thus provide continued motivation for those who are not motivated by traditional educational settings. Moreover, Mlearning presents an appeal simply because the use of mobile technology in and of itself presents something new and exciting for a great array of learners (Geddes, 2004).

Mobiles, therefore, should impact educational outcomes by altering the character of education and learning because the nature of mobile technology converges with and facilitates new learning. The new learning is personalized, learner-centred, situated, collaborative, ubiquitous, and lifelong. Likewise, mobile technology is increasingly personal, user-centred, mobile, networked, ubiquitous, and durable (Sharples et al., 2007). The literature indicates that the benefits afforded by this convergence should exert a positive impact on educational outcomes.

Use or Implementation of Mobile Learning, mobile teaching and mobile education world over www.opencolleges.edu.au/informed/features/how-educators-are-practicing-mobile-learning

In a few decades, mobile technology has spread to the furthest corners of the planet. Of the estimated 7 billion people on Earth, 6 billion now have access to a working mobile phone. Africa, which had a mobile penetration rate of just 5% in the 1990s, is now the second largest and fastest growing mobile phone market in the world, with a penetration rate of over 60% and raising daily.

The phones themselves are not advanced by developed nations' standards. Most people in developing countries have what are called "feature phones," which are less sophisticated than smartphones and have fewer features. But have numeric keypads, and can access the internet on a tiny screen–which, by the way, is not a tiny screen to them but a window of vast opportunity.

Mobile technology has spread to various corners too. In areas where schools can't afford to receive traditional educational materials, mobile devices have moved in. One library in Ghana that has no books on its shelves, but now has an e-reader, giving the students access to hundreds of books that could never have been physically sent to the library.

UNESCO reported that 250 million students worldwide cannot read, write, or count, even after four years of school. How schools respond to the growth of mobile devices will affect generations of students and their readiness for college and the workforce.

Examples of the world's meducation/ Mteaching initiatives;

1. Eneza Education, Kenya

In Kiswahili, "eneza" means "to reach" or "to spread." Eneza (originally called mPrep) is a mobile assistant for teachers that gives schools and parents access to solutions such as quizzing platforms, performance dashboards, and tips for helping their students. Through SMS or the Web, students can receive educational content, browse through Wikipedia, and ask teachers questions.

2. Ustad Mobile, Afghanistan

Ustad Mobile phone (Mobile Teacher) is a mobile course creation tool developed in Afghanistan. The open source toolkit has already been used by policewomen in Afghanistan to develop literacy courses in local languages. Smartphones or feature phones can be used to access the content, developed by instructors on computers. The software is a free download, and can be used to design quizzes, multiple choice questions, math drills, and so on. Instructors can use the cloud reporting tool for real time access to detailed reports on effort and performance.

3. One2Act Mobile Feedback, Norway

Mobiles phones can be used to get real-time feedback from learners' devices using One2Act, allowing teachers to provide rapid and customized feedback to learners. Teachers get an instant dashboard of the students' understanding of the topic covered, using this to increase classroom interaction, group collaboration, and peer learning as a springboard for reflection and discussion.

4. TBR Mobilization & Emerging Technology, Tennessee

This research and resource project from Tennessee showcases what is possible in the 'm-campus' with social networking and mobile devices enabling gaming, simulations, and virtual worlds. These can be used to increase recruiting, retention, and graduation rates; to improve teaching, learning, and workforce development; and for meeting the needs of 21st century workforces.

5. OER4Schools Programme, Commonwealth

OER4Schools is a Commonwealth professional development programme for low-resourced primary schools. Interactive teaching of mathematics and science is supported with digital technology. Interactive teaching is possible with and without ICT.

6. UNESCO, Nigeria

In Nigeria, UNESCO is piloting a program with English teachers. Program leaders send messages daily with examples of how to teach English language to teachers throughout the country. It also allows teachers to share their learning with one another, previously very difficult to do between remote rural villages. An agreement with the mobile provider keeps costs for users low.

7. Open Education Resources University, Worldwide

A recent initiative that will reduce the cost of obtaining a formal education is the Open Education Resources University (OERu), which is a consortium of accredited universities around the world that is planning to offer formal courses at a significantly reduced cost, making education affordable to millions of students. The OERu will play an important role in lifelong learning around the world since learners of any age can complete courses at an affordable cost, and will have a major global impact if the courses are delivered on mobile devices.

How educators and stakeholders are making a difference in mlearning, mteaching and meducation use world over.

To improve access to mlearning, mteaching and meducation educators and other stakeholders are enhancing their effective use in schools by;

1. Do more with less.

Creative doesn't always mean complicated. In developing countries, mobile connectivity has leap-frogged fixed line connectivity. Students and teachers who weren't connected are now

connected and have access to volumes of online materials enjoyed by those in developed countries.

2. Encourage the use of apps that work on smartphones and basic phones alike.

3. Advocate for clear policies.

The uncertain policy moment plaguing most of the world does not exclude Australia and the U.S. Becoming active in your school's mobile technology policy sends a clear message to leadership that you've considered mobile learning.

4. Help parents understand the benefits of mobile learning.

Contrary to popular parental belief, mobile technology neither distracts learners nor disturbs learning environments –especially if it isn't made taboo by authority figures.

5. Create Open Educational Resources with a mobile, international audience in mind.

Traditional course material should be designed properly to facilitate flexible delivery. In addition, make your OER easy to locate. A 2011 study found that two major obstacles for teachers' use of OERs are locating and finding the most appropriate resources. Tag your OERs properly so that anyone from anywhere can locate them.

6. Use mobile tech to reinforce newly learned material in Pakistan.

In Pakistan some young women, students would travel to a central location for lessons in Urdu, then return to their remote villages for several weeks. The only way for teacher's to reach them quickly was through text messages that reminded them about reading and discussion assignments. This practice played a very important role in the teaching and learning environment of these women.

7. Convince your colleagues it doesn't have to be expensive. Teachers to develop mobile data that is cheap and be similar to how it's sold to smartphone users in the United States and other developed nations.

8. Make content easily digestible and user friendly.

In the digital era, information is now recorded in an electronic format, allowing learners to access it anytime, anywhere. Mlearning courses should be designed in modules of four to eight hours.

9. Design content and choose platforms that can be used in the workplace.

It's a fact that people are now using mobile devices throughout their lives, it only makes sense that we should design mobile learning platforms and course content to be easily transferrable from school environments to professional settings.

10. Provide input to software and hardware companies.

Frequently, mobile applications are developed for business and entertainment rather than for education. But educators need to provide input to both hardware and software companies to develop appropriate, multi-purpose mobile technologies that meet education needs.

11. Spend more time explaining content than creating it.

A lesson on mathematics can be developed and validated by experts at one educational organization and placed on the Internet for everyone to access rather than having millions of teachers around the world developing the same lesson.

12. Support your own professional development.

To really achieve our mobile access goals, teachers need to stay informed through use of mobile phones

13. Ensure quality.

What constitutes quality in mobile learning still has yet to be clearly defined and agreed upon on a global level, but we know that it can differ greatly from what constitutes quality in traditional settings. Educators should ensure Mlearning quality in the 21st century.

CONCLUSION

From reviewed literature and desktop analysis, the study concludes that, Mlearning, Meducation and Mteaching are in separable realities in modern education access and provision. The future of modern education lies on the effective use of mobile phones by the education managers, teachers, learners and all stakeholders in all levels of education. Educationist and other stakeholders should embrace mobile phones uses in the whole process of education and be in the fore front in fight misconceptions and untruthful myths on Mobile phone uses in education by learners and other stakeholders. Mobile phone uses in education will highly boost access to education in all levels.

RECOMMENDATIONS

All developed countries of the world in general and in particular of sub-Saharan Africa and south Asia should continue investing heavily in mobile phone education provision plat form. Kenya ministry of education need to carry out a comprehensive analysis on, The effectiveness of mobile phone uses in enhancing access to education in the country as in line to Sustainable development goal number 4 and the vision 2030 social pillar.

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INTEGRATION OF SIGN LANGUAGE IN TECHNICAL TRAINING AT UNIVERSITY LEVEL IN KENYA-A CASE OF KIRINYAGA UNIVERSITY

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Abstract

This paper focused on assessing the extent of integration of sign language in technical training in university education in Kenya. Sign language as spatial visual language is not limited to gestures, hand/forearm movement but also the non-dexterity markers such as facial expression. It is necessary to ascertain the extent of integration of sign language in technical training as a way of empowering the deaf and hard hearing individuals who may wish to pursue careers in technical areas such as engineering, building and construction. In education settings, though the technical signs may be different from one course to the other and one instructor to the next for the deaf or hard of hearing students, it is important for trainer to have basic education in sign language to enhance transfer of knowledge. Earlier researches have explored integration of E-learning platform for the deaf people for technological solution in sign language translation. Identifying the extent of integration of sign language among the trainers in technical areas would provide an opportunity for building individual capacity and reduce common reliance on voice communication in various activities. The sample used comprised of trainers in technical areas namely engineering, building and construction and textile technology in Kirinyaga University. Primary data was collected using unstructured questionnaires and personal interview schedules. The analysis showed that most of the trainers in technical areas within universities did not have any basic knowledge in sign language and they could not be able to transfer knowledge to people with hearing impairment. From the analysis it was evident that trainers were ready to learn sign language and integrate it during training.

Keywords: Sign Language, Technical training, Integration

INTRODUCTION

Spoken language is the most predominant mode of communication in the world; this has therefore rendered other forms of communication such as the use of Sign Language (SL), weaker since they do not conform to the norm. (Safder, Akhtar, Fatima, & Malik, 2012). The exclusiveness of SL is due to the fact that unlike spoken language (used by the majority) which is sound based, SL is a patterned visual gestural system whose main users, the deaf, are a language minority wherever they live in the world (Mweri, 2016). Sign language has been used for many years as manual communication to convey meaning for the deaf and those with hearing problems. This manual communication involve simultaneously combining hand shapes, orientation and movements of the hands, arms, body and facial expressions to express the speakers thoughts. Vision is an instrumental tool in sign language through which the deaf have to communicate and receive information (Marschark & Hauser, 2011). It is important for the recipient to understand the sign language to ensure the information communicated is not misinterpreted. Sign language shares some linguistic properties such as sounds and how space is used grammatically (Parasnis, DeCaro, & Raman, 1996). Although signing is majorly used by those with impaired hearing it is also used by persons who can hear but cannot physically speak or have difficulty in communicating with spoken language. In addition, people affected with diseases and infections around the mouth, trachea, throat and respiratory track may have trouble in communication hence may adopt signing to convey their thoughts albeit for a short period before they recover. As technology advances, use of cochlear implant has been used globally to help the hearing impaired in reception of sounds hence remarkable development of language (Swanwick & Tsverik, 2007).

According to National Institute of Deafness and other Communication Disorders(NIDOCD, 2017)most of persons using cochlear implant become bilingual in spoken language and sign language hence improving their educational development. Speech habilitation and rehabilitation practices have been adopted to assist the population of deaf and hard of hearing students who use sign language in developed countries such as United States where focus is given to facilitating auditory, speech and spoken language development(Nussbaum, Smith, & Doyle, 2012)

There are about 137 documented sign languages contained in British Sign Language Dictionary and also in American Sign Language Dictionary which have adopted English as a language. Other sign languages have been developed in different areas with little linguistic input such as the Al-Sayyid Bedoin Sign Language (ABSL) used over 75 years by both hearing and non-hearing people in isolated Bedoin village in Israel (Marschark & Hauser, 2011). Sign languages may differ from one region or country to another depending on regional accents and dialects, local culture, ethnicity and age; all this adds to the diversity in signing and evolution of sign languages. However there are some common signs that are shared such as alphabets and simple phrases in salutation. The deaf and hard hearing community in Kenya uses Kenyan Sign Language developed in early 1980's with English and Swahili as the main language where American Sign Language was used as the main reference. The following agencies have contributed largely to promoting use of sign language in Kenya; Kenya National Association of the Deaf (KNAD); Kenyan Sign Language Research Project (KSLRP) at the University of Nairobi; Kenyan Sign Language Interpreters Association (KSLIA); and Kenyan Interpreters and Translators Association (KITA).

According to Nussbaum, 2012 sign language of a nation forms an important deaf persons community culture, hence the need to allow diversity in signing. The writer further emphasizes on the need to promote sign language so as to facilitate relationship and integration between deaf and hearing people. Most of the deaf and hard hearing individuals are taught sign languages by parents especially children and additional people such as

teachers contribute in language acquisition. In United States most schools have been modelled to integrate persons with hearing disabilities through creation of specialized units for tutoring the deaf students at different levels of the education system (Safder, Akhtar, Fatima, & Malik, 2012).

The world federation of the deaf has estimated the population of the deaf to be 70 million people who use sign language as their first language and mother tongue (Safder, Akhtar, Fatima, & Malik, 2012). According to a state report on Convention on the Rights of Persons with Disabilities 2014, Kenya has 187, 818 persons with hearing impairment which is approximately 5% of the county's population. The report indicates that most of the hearing impairments are caused by accidents, diseases and others are in-born.

To support and assist people with hearing impairment in Kenya various guidelines enshrined in policies such as National Disability Policy of 2003 have been given to ensure they are given equal opportunities in education, health, employment and other sectors. According to (Nzioka, Maganjo , & Kariuki, 1992), people with hearing impairment require accessibility to the built environment with good visual indications such as fire alarms, sounds of falling objects and other sound signals. In addition, since some hearing problems may medically lead to imbalance of the body, ramps and hand rails should be installed in buildings for safety. Persons with Disabilities Act provides for rights and rehabilitation of persons with disabilities to ensure equalization of opportunities. National Council of Persons with Disability (NCPWD) formed under the Act works to ensure persons with disabilities have access to employment opportunities, funding from various institutions, education, legal services and facilitate disability mainstreaming programmes. Education forms the basis for empowering the persons with disabilities to facilitate their growth in various sectors of the economy. Free Primary Education, 2003 was developed to improve literacy level in Kenya among all persons. However even with introduction of free primary education there was limited focus on installing adequate facilities to ensure persons with disabilities have equal access to education (Nzioka, Maganjo , & Kariuki, 1992)

Most of the persons with hearing impairment have access to primary and secondary education in Kenya since at this level the government has trained personnel to facilitate their education (Mweri, 2016). However, as the deaf and hard in hearing persons transition to tertiary education they get limited opportunities to develop their skills in given areas since there are limited human resources. Most of the universities in Kenya offer technical courses in areas such as building and construction, textile industry, mechanical production and engineering, where persons with hearing impairment can benefit in skills which can contribute immensely in building individual capacity and also in economic growth of our country as earmarked in Vision 2030.

According to Gallaudet Research Institute Annual Survey of Deaf and Hard of Hearing Children and Youth 2009-2010, some of the major challenges faced by persons with hearing impairment in universities include lack of understanding and cooperation from administration and faculty, difficulty in finding interpreters, limited time for interpretation per student per week and inadequate faculty with skills in use of sign language. The survey indicated that most of the universities and tertiary level education institutions were not prepared to integrate persons with hearing impairment in their education and training systems.

This study therefore sought to assess the extent of integration of sign language in technical training at Kirinyaga University as a case study.

Statement of the problem

The Persons with Disabilities Act of 2003 requires inclusion of persons with disabilities in all sectors within the Kenyan economy to ensure they are empowered to live sustainable lives.

However, there are major challenges that hinder integration of these persons which include lack of adequate infrastructures for rehabilitation, inadequate funding to disability mainstreaming programmes and inadequate human resource to assist persons with disability.

Persons with hearing impairment though with minimal physical disability, equally suffer from exclusion in obtaining technical skills at university education level. Though they may have intellectual capacity and passion in gaining various skills at university level inability to use spoken language for communication hinders them. At primary and secondary school level in Kenya persons with hearing impairment get access to education since there are teachers and personnel trained in use of sign language. However at tertiary level where these persons are supposed to focus on specialized areas there are few and inadequate trainers equipped with sign language as way of supporting the deaf and hard in hearing in acquiring some technical skills. Hence, the inability to access skills in various technical areas limits the deaf and hard in hearing in accessing employment in given technical areas such as building and construction industry.

Kirinyaga University as a global institution lacks a policy or a guideline to promote and facilitate training of person with hearing impairment and other physical disabilities in general. The Employment Act of 2007 requires that when institutions are employing one of the employees should constitute persons with disabilities, however if these people are not equipped with relevant skills then it may be virtually impossible to include them in the work force. Hence the deaf and hard in hearing persons are denied a chance to gain technical skills that would improve their ability to access jobs or promote their entrepreneurship skills in various sectors. Consequently, this creates a social and economic gap among people who are delimited by use of sign language as opposed to spoken language.

Research questions

a) What extent of sign language is used in technical training in Kirinyaga University?
b) Are there any available structures to facilitate use of sign language in the University?
c) What challenges are faced by persons with hearing impairment in Kirinyaga University?

Research objectives

a) To determine the extent to which sign language has been integrated in technical training in university education.
b) To determine the structures available to facilitate use of sign language in KyU
c) To identify challenges faced by persons with hearing impairment in KyU.

Study justification

In Kenya university education provides an avenue for globalization, knowledge transfer, resource capacity development that has a major influence with the country, regionally and globally. To promote inclusion of persons with hearing impairment in growth of the country, the universities in Kenya must form frameworks and policies that will facilitate training and their integration in the education systems especially with main focus on training in technical areas. Faculty working in universities should have basic skills in use of sign language so as to ensure students with hearing impairment are well supported and relevant skills are adequately transferred. Promoting use of sign language will provide an alternative for overreliance on spoken language among instructors in the universities and consequently, this will enhance social interaction in the universities.

METHODS

The study adopted a qualitative case study design. A sample of twenty university tutors from Kirinyaga University were selected and given a questionnaire to fill to establish the extent to

which they utilized sign language in teaching as a way of transferring skills to those with hearing impairment. To select the sample the population was stratified into various technical departments under the following areas; clothing and textile technology, hospitality management, building and construction and mechanical and production. After stratification a sample of five tutors was randomly picked from each department. Interviews were used to generate data from the university human resource office and other administrative offices. Partial field analysis was done before a focussed group discussion with staff members in the university was conducted. The group discussion aimed at identifying some of the challenges they encountered in assisting persons with hearing impairment in the university. Analysis of data followed a grounded theory which included segmenting and arranging data according to themes and sub-themes. In order to achieve the objectives the following parameters were used in collecting and analyzing data; tutors teaching experience, gender, age and appropriate qualification.

RESULTS AND DISCUSSIONS

The first objective sought to determine the extent to which sign language was utilized within the university during teaching. It was established out of the sampled population 90% did not have any basic skills in use of sign language and could only express themselves using spoken language while the other 10% had some basic skills in sign language which they could use to instruct a student. This 10% population constituted tutors in clothing and textile department hence all the other departments did not have tutors who would handle students with hearing impairment. All of the tutors constituting the 10% had education background in textile technology which they had trained at diploma level and later progressed to bachelor degree level.95% were not aware of existence of Kenyan Sign Language used in training the persons with hearing impairment.

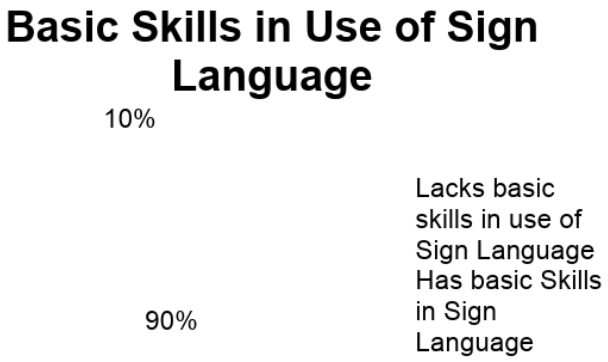

Figure1: Basic skills in use of sign language

Asked how they would integrate students with hearing impairment as part of their class; 50% indicated that they would need interpreters, 20% would learn how to use sign language to empower the students, 20% felt it would be hard to integrate the students while 10% indicated they would use available videos and other E-resources to impart knowledge and transfer skills.

In objective two; to determine existing structures that promote use of sign language in the university. All of the respondents indicated that they were not aware of any policy, guideline

and strategies to promote use of sign language in the university and argued that students with hearing impairment seeking to gain certain technical skills would not be admitted to the university or would be advised to consider other institutions. The respondents also felt that the university would need to breach the gap to promote inclusion of persons with disabilities not only in their work force but also providing an enabling environment for development of skills. Some of the respondents indicated that though the university could not accommodate all persons with varying disabilities there was need to focus on specific ones such as use of sign language and enhance safety in accessibility of built environment. Adoption of sign language would make a difference to students with hearing impairment and would also build capacity among the tutors in promoting social interaction and reduce the stigmatization.

There was a general feeling that the university would be required to develop teaching strategies for persons with hearing impairment so as to ensure they are integrated during training in technical areas. The following were suggested as some of the strategies to be adopted;

a) Training tutors with basic sign language and lip reading which they would combine with spoken language while training and teaching students.

b) Introduce a unit on sign language as part of communication skills to ensure students are able to build a relationship with those with hearing impairments.

c) Encourage research work in seeking ways to integrate E-learning as a tool of promoting use of sign language in transferring knowledge this would also provide an avenue for development of software that can incorporate sign language.

d) Integrating various forms of assessment in the curriculums such as practicals as opposed to written tests to as to award creativity and innovation among those who have hearing impairment and may be limited in expressing themselves through writing. Further to enhance this it would be helpful for students with a hearing impairment to have an individual orientation to laboratory equipment or computers to minimize anxiety, particularly in cases where class sizes are large and where it may be difficult to see or hear the demonstrator.

e) Provide audio-visual lecture rooms and auditoriums that would provide an opportunity for flexibility in delivery of materials through the electronic media. This would also improve visibility and legibility of materials and information used for training.

f) Use of signing as opposed to written illustration in the built environment would promote use of sign language such signage for fire alarms, falling objects and so on.

g) Develop policies and guidelines that would facilitate use sign language in training and in curriculum implementation

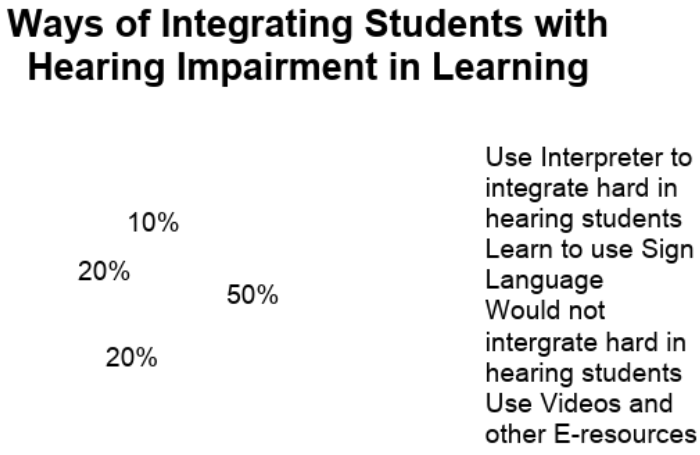

Figure2: Ways of integrating students with hearing impairment in learning

The third objective was to identify some of the challenges faced by persons with hearing impairment in the university. It was established that the university student population did not have a significant number of persons with hearing impairments however a few students using cochlear implant and other hearing aids were identified. Though the impact of hearing impairment was dependent on the type, extent and timing of the hearing loss, some of the challenges identified among the few students were; poor academic performance, low self-esteem that lead to poor socialization, difficult in communication through spoken language, slowness in learning, lower reading level, increased anxiety and poor participation in tutorials. The respondents felt that though the university did not have a significant population of people with hearing aid there was need to invest in necessary structures to ensure that challenges faced by the few forming the population were remedied accordingly.

CONCLUSIONS

The study has shown that use of sign language has not been integrated in technical training at Kirinyaga University. Although the university was established for promoting equalisation to access to education, research, technological innovation and development persons with hearing impairments have been discriminated. There is need for the university to work on various structures, policies and guidelines to create an environment conducive for inclusion of persons with hearing impairment in technical training in various areas.

The university should focus on improving the existing physical structures such as lighting, accessibility, provision of audio-visual electronic media and sound proofing in lecture rooms, laboratories and auditoriums to ensure the environment is favourable for persons with hearing impairment. Secondly, the university should sensitize the tutors and other staff in the university on the need for adopting sign language as way of training and transferring knowledge to ensure inclusion and improved academic performance among those with hearing impairment. In addition the university should develop policies and guidelines that would promote use teaching strategies to support those with hearing impairment. Research work in the university focused on solving some challenges faced by persons with hearing impairment would also be crucial as this would stimulate technological development of amenities that would help in empowering other people with physical disabilities. Consequently when universities develop training systems that are inclusive of persons with hearing impairment they will promote socio-economic growth that will have a trickle effect on various social groups and communities.

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COST–EFFECTIVENESS OF SMASSE PROGRAM IN THIKA DISTRICT: A CASE OF KAMWANGI DIVISION

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Abstract

SMASSE stands for Strengthening of Mathematics and Science subjects in Secondary Education, an In-service training for mathematics and science teachers. Training started in 1998 by the government of Kenya and the government of Japan through JICA. Aimed at; strengthen pedagogy in mathematics and science subjects in secondary schools, to improve performances in these subjects and to achieve the MDG of Kenya industrialization by 2020.This study was out to find, how cost-effective was SMASSE program in Thika District. It employed survey design in data collection and data analysis. Semi-structured questionnaires were used to collect data from teachers. Interviews and Key-informant collected data from SMASSE center organizers and administrators, 210 persons were used and categorized as Center organizers, Mathematics and science teachers, principals/deputy principals from 24 secondary schools in Kamwangi Division, District SMASSE administrators and SMASSE trainers. Simple random sampling methods and cluster sampling were used to select sample schools and teachers. Purposive sampling was used to select SMASSE center organizers and administrators. Data collected was organized, coded, tabulated and analyzed quantitatively and qualitatively. The findings were discussed and explained in line with the cost- effectiveness theoretical and conceptual framework adapted from Alkin M 1970. The findings; SMASSE Program started in Thika in 2004, funded by GoK and JICA, teachers' attitude towards the program was negative, was too expensive and none cost – effective, no direct benefits accruing to teachers, indirect benefit for SMASSE was socialization and interaction among the teachers. It was facing problems like; lack of a method to measure its cost-effectiveness, negative teacher's attitude, poor method of financing it and high cost of maintaining and repairing equipment's and instruments. Recommendations; The program needs to be modified and be decentralized, diversify its financing, only willing teachers to attend, remunerate teachers in attendance and be made competitive by issuing merit certificate.

Keywords: Cost- effectiveness, JICA, Program, SMASSE, Decentralization

INTRODUCTION

SMASSE is an in-service education and training for all science and mathematics teachers country wide aimed at improving student performance in these subjects in the Kenya certificate of secondary education (KCSE).In-service education according Carter Good (1973), means the efforts of administrators and supervisors to promote professional growth and involvement of educational personnel. Bolam R. et al (1978), sees in-service as the collection of limited tasks which have a direct impact on quality of instruction offered. UNESCO (1983) 'If education is to meet the demands of time and of the coming decades the organization, content and methods of teacher education must be constantly be improved.

SMASSE as an in-service program was started by the joint efforts of the Kenya Government through the ministry of education science and technology (MOEST) and the Japans Government through JICA in February 1998 (JICA 1998).Thuku (2003), noted that in general teachers in different countries have different needs and therefore INSET (In-service

Education and training programs) may have different purposes. Bolam (1978) says in country like Britain INSET Programs equips head-teachers with skills and expertise necessary to help them cope with increasing complex tasks of leadership. In Australia, Canada and New Zealand INSET programs have five objectives to meet.

Countries in Africa like Zimbambwe have Zimbambwe science Teachers Training projects (ZIMSTP) which trained teachers between 1980 and 1992, and which had the aim of improving the quality of teachers in terms of subject's knowledge and teaching methods (KJE 1996) in Munyenje (2007).

In Kenya, there were other In-service teacher training programs offered by Kenya Education staff Institute (KESI), the MOEST, private organizations and NGOs like UNICEF and UNESCO. SMASSE in secondary schools has added to the list. Munyanje (2007), says although high school teachers in Kenya undergo pre-service teachers education for at least four years while primary school teacher trains for at least two years. In-service programs serve the fresh the knowledge and skills learnt in college, they equip Teachers with new skills required to deal with new problems in the society, they also inform teachers about the changes in curriculum. They also challenge teacher to be innovative in their teaching with this respect. UNESCO (1975) insists that Pre-service and in-service education should therefore be integrated to foster the concept of life Long learning and the need for recurrent education.

On sustainability, the ministry of education was committed to continue SMASSE program beyond the stipulated project period. This was captured in the Sessional paper No. 1 of 2005 and was among the investment program espoused in the Kenya Education Sector Support Programme (KESSP). JICA on its part was concerned that some head teachers were charging parent additional money, claiming to support SMASSE project instead of allocating funds from the recommended source. Therefore every economy must have concern about it science and technology because they leads to industrialization, which plays a big role in poverty alleviation.The other major concern was that SMASSE funds were said to be misused by head teachers andSMASSE administrators and extra levies were being charge on parent illegally. DEB had authority to levy Ksh. 200 per student. PTA fund is supposed to be applied for by the schools every year with clear explanations on how it was to be utilized, and unless money collected in the previous year is accounted for, the authority would not be granted

Statement of the problem

Despite the fact that mathematics and science education is necessary for industrial and technological development, Africa has often lagged in teaching mathematics and science and in getting good results in these subjects. "The greatest concern over the year was sustenance of SMASSE activity to become real" observed the PS. SMASSE was a strategic move through which Kenya could attain her dream of becoming industrialized by the year 2020 (Educational insight, June 2006).This study was on cost effectiveness of SMASSE program in Thika district. The questions to be addressed were; Do we wholly attribute the dismal improvement in performance in mathematics and science in KCSE year 2006 to SMASSE or to other factors?,Is SMASSE program cost effective and sustainable?

The current research was set to evaluate the Cost-effectiveness of SMASSE in the light of the above dismal improved performance particularly in mathematics and science subject in KCSE.

The purpose of this study was to evaluate the cost-effectiveness of SMASSE program in Thika District.

This study was guided these objectives;

- To establish direct and indirect cost of SMASSE program and cost effectiveness of the program.
- To identify direct and indirect benefits accruing to teachers/schools through SMASSE program.
- To identify other factor that contribute to improvement in performance in mathematics and science in KCSE exams
- To identify problems faced by SMASSE program trainers, teachers and educational administrators in the implementation process of the program
- To determine teachers attitudes towards SMASSE program.

The study aimed to give insight to all stakeholders of SMASSE program by identifying cost effectiveness of SMASSE program. The study gives the way forward for SMASSE program after JICA withdraw of sponsorship. The study was conducted in Kamwangi division ofThika district. The study was carried out between June 2007 and November 2007.

Theoretical framework

Orodho (2004), Wiersman (1985) noted that theoretical framework or under pinning is an important component of research proposal. That is theories and proposition about a concept or concerts and relationship have to be formulated and theories help to provide a framework by serving as the starting point in pursuit of research problems. This study was centered upon cost effectiveness theory, also called the evaluation model discussed by Alkin (1970).

Conceptual framework

Kombo K.D. (2006) Define a concept as an abstract or general idea inferred to or derived from specific instances. Therefore conceptual frame work is defined as a set of broad ideas and principles taken from relevant fields of inquiry and used to structure a subsequent presentation.

The figure 1.1 below shows the cost-effectiveness model for SMASSE program

Figure 1. Cost-effectiveness model for SMASSE program

Source: Adapted from Alkin (1976:226)

Evaluation cost effectiveness of instructional program. In Wiffrock, M.C and Willey, D.E (Eds).The evaluation of instructional issues and program USA Aolt.

The cost effectiveness model was modified slightly to suit this study. The model comprises of the following elements, external system, students inputs, financial input, manipulated characteristics and outcomes.

History of SMASSE program

SMASSE project has been on the Kenyan education scene for over six years now. During this period the project has undertaken several activities aimed at realizing the project goal of enhancing the capacity of young Kenyans in mathematics and science with the first five years being a pilot phase. The main activity is the provision of In-service Education and training (INSET) for serving teachers of these subjects. Among the main outputs that were expected from the phase of the project were

- Establishment of an In-service Training (INSET) system at Kenya Science Teachers College(KSTC)
- Establishment of an INSET system in the pilot district

The pilot phase having been successfully implemented came to an end on 30th June 2003 ushering in Phase II July 1 2003. Phase II of SMASSE project covers all district within the republic of Kenya and includes a regional components that covers members countries of the SMASSE – WECSA (Western, Eastern, Central and southern Africa) Association. During this second phase the major outputs expected for the Kenyan components were of course similar to those of the pilot phase namely:

- Enhancing the capacity of the NationalINSETCenter
- Establishing an INSET system in the districts that were not covered during the pilot district and 68 for newly included districts. All of the newly included districts had experienced Cycle 1 of the INSET.

The successful implementation of SMASSE project Phase 1 have been due to focused and well coordinated activities aimed at addressing the problem identified by the Baseline Studies (SMASSE 1998). These problems among them were poor performance in mathematics and sciences subjects, lack or shortage of teaching/learning materials including text books, negative teachers attitude to word teaching mathematics and science subjects and lack of laboratory equipments and materials in schools. Activities of each cycle of SMASSE INSET

were designed to address specific issues from the Baseline Studies findings with the focus for each cycle being the theme or objectives of the INSET. Outlined below are the INSET objectives of the four cycles of SMASSE INSET

Challenges of SMASSE program

Education Insight, (June 2006), Uncertainty over the future of SMASSE fears are rife in the education ministry and the sectors in general over the sustenance of center for mathematics, science and technology Education in Africa (CEMASTEA) as JICA's ten- year support draws to a close in two years time. The support period began in 1998 and expected to end in 2008. Access to secondary education is becoming a major social and political challenges as countries are moving towards university primary education (UPE). Africa countries need to develop educational program that are adapted to Africa's resources and needs, to focus on the relevance of what is taught, to diversity the kind of learning available and to develop sustainable financial model that will provide for mass education. The ad hoc group will also explore the issue of how best to prepare young people for past primary professional life

Despite the fact that mathematics and science education is necessary for industrial and technology development, Africa has often lagged behind in teaching mathematics and science and in getting good results (http/www.smasse-wecsa.org/information on 7th may 2007)

On practice work currently: in all system of education, science teaching is set to involve practical work. Practical work approach to the teaching/learning of science enable learners to get more interested in the subject matter by seeing and or by deforming for themselves and their enthusiasm in learning of the subject is enhanced. It also enable them to conceptualized with a lot of ease and develop the scientism in them.

In most schools in our country, there are science rooms, some with large demonstration desks at the front and a number of experiment tables for the learners. This is quite evidence of our sincere acceptance of the usefulness of both the individual and the demonstration methods of experimentation, inadequacy of equipment/apparatus notwithstanding. Practical work forms the backbone to 'good' science teaching. (Lelei P. atel, SMASSE 2005) says…. SMASSE has capacity – built these centers by equipping them with printers, digital printers, computers, stationery, apparatus, chemical and references books and other materials. After the project period, SMASSE will stop providing these materials. It is therefore very crucial that the district properly managers the resources at the SMASSE office so that they are able to continue training teachers after the project period. Attention must also be paid to the care and use of facilities at the INSET center. Ariyadasa, A.K (1976), writing on problem of in-service teachers training, says most of the trainees complained about traveling difficulties. That was transport problem to reach the INSET center.

Cost of teachers education

Carnoy, M (2000) says a full economic accounting of the cost teachers education includes direct program expenses (wages of training staff, use of equipment and facilities, and certain overhead cost) direct cost incurred by participants (books and materials, relevant transportation cost) the cost of participants time, and the implicit cost of the time devoted by the staff to the activity.

Internal and external efficiency of SMASSE program

Carnoy, M (2000) much of the teachers in teachers education in OECD members countries focused on the effectiveness of different approaches, although the results of this work are seldom presented in ways or the assessment of internal and external efficiency…. Internal efficiency may include the balance between its theoretical and practical elements, the balance between initial teachers' preparation an in-service education and training. The question here is whether the knowledge and skill required by teachers might be best acquired over a longer period of time rather than through the "front-load" approach characteristics of teacher's

education in most OECD countries in the early 1990's. One important consequence of the shift towards in-service teachers education training is that it may be possible to use the system's present capacity for initial teachers more effectively. This could reduce the cost arising from the tendency of programs aimed at initial teacher's preparation to operate above or below capacity.

External efficiency is where teachers' education is evaluated with respect to outcomes, particularly the effect on pupils attributable to the stocks of knowledge and skills acquired by teachers via teachers' education. However the effect apparently varies by schools level, student characteristics, subject matter, and the type of achievement being measured. Hay McBeer (2000) in Belmas (2006) on teaching effectiveness identified three factors influencing pupil progress as; teaching skills, professional characteristics and classroom climate.

Teaching Methods and curriculum

EFA (2000), Secondary School teachers are trained at University and Diploma level colleges. One area of concern is the wide curriculum covered at the Bachelor of Education level which leaves less time for pedagogical training. Secondly some of the trainers at the university are not themselves trained trainers or teachers. This raises the question of the teaching methods utilized at the secondary schools. EFA (2000) the government has already reduced the subject studied at the secondary school level but it is necessary to: Revisiting the curriculum to ensure that it is appropriate, relevant and includes non-cognitive aspects, De-emphasize teaching for examination…MPE&T (1997-2010), While a small proportion of secondary continue to offer satisfying well-rounded education programmes the greater majority of schools fall short of proving for the learning needs of their students . Poor academic achievements in key subjects in the curriculum and increased indiscipline. This unsatisfactory situation is associated with a number of factors. First, perception of curriculum relevant tends to favour mechanical impartation of practical skills, attitudes and values.

Critical review

From reviewed literature, it was clear that Most of the writes emphasized on SMASSE program general issue. Education in sight emphasized on continuation of SMASSE program after the end of support by Japan government through JICA by 2008. The writers did not tackle the question on benefits nor the unit cost of running SMASSE program per year. The writers have failed to identify any instrument to be used to measure it cost effectiveness. Even though, one of the main objectives of SMASSE program was to change teachers' attitude toward teaching sciences and mathematics. The literature reviewed just mention in passing about this objective. None of the writers on SMASSE focus on how SMASSE program achieves its objectives, worse off no writer focused on teachers attitude before the start of the program and of course during the training so that this will be compared at the end of the program.

METHODOLOGY

This study was a formative evaluation study, which was on cost effectiveness of SMASSE program in Thika district. Descriptive survey design was employed in data collection and data analysis. Descriptive survey research is intended to produce statistical information about aspect of education that interest policy makers and educators. (Gay, 1976).According to Mugenda and Mugenda (2005), a survey is an attempt to collect data from members of a population with respect to one or more variable.

The study variables were cost-effectiveness of SMASSE program being the dependent variable and academic performance, trainer's attitude, teacher's attitude, direct and indirect cost consideration direct and indirect benefits remuneration of teachers and trainers and programme implementation problemwere independent variables.

This study was conducted in Kamwangi division of Thika district. Kamwangi division is one of the seven divisions of Thika district which is located some 12 kilometer North of Thika town. The division is divided in three education zones, namely Githombokoni, Chania and Mangu.

Target population

Borg and Gal (1996) define target population of a study as all the members of real or hypothetical set of people events or objects to which the researcher hopes to generalize the results of the research study. In this study the target population comprised of all mathematics and science teachers from Kamwangi division, school principals in the division, Mary Hill SMASSE INSET trainers and Thika Districts SMASSE administrator. The study population was 210 respondents. They were categorized as follows, 168 mathematics and science teachers, twelve Mary Hill SMASSE INSET trainers, 24 principals and six district SMASSE administrators.

The Sample and Sampling Procedure

The sample size for this study was 50% of target population. Random sampling techniques was used to ensure that each subject within the population was given equal chances of being included in the sample (Orodho, 2004). Stratified sampling was employed to ensure all zones were represented in the sample. Simple random sampling method was used to select schools and teachers each zone. Principals/deputy and teachers of selected schools automatically become part of the respondents. The DEO and SMASSE administrator were purposively selected. The selection of SMASSE trainers was purposive in that one was in-charge of INSET center organizer, the other was INSET chairperson while the other four were respective subject trainers of an INSET center.

The main research instrument that were employed in this study to collect data were questionnaires and interview schedules/guides

Piloting

A sample of 10 teachers, one principal and two SMASSE trainers not in the sampled schools and inset center were used in pilot study. The instruments were administered a month before the fieldwork started. Instruments were tested for variability and reliability. After pilot study the instrument were revised to enhance contact validity and reliability.

The researcher obtained a research permit from the ministry of education office head quarter one month before embarking on fieldwork.The researcher administered questionnaires and all the interviews to the respondent. Complete instruments were collected from the respondent two weeks after they were administered to the respondent. The instruments were arranged, organized and serialized ready for data analysis.

Findings

The study established that: SMASSE program in Thika started in year 2004. There were three INSET centers namely Mary Hill, Gatanga and Karinga Girls.'Most of mathematics/science teachers were in job group L and in age bracket 30 and 40 year. Most SMASSE trainer's and school principals were in job group M and aged 35 years and above. There was gender disparity in the management, attendance and training of SMASSE. Management was dominated by women while training and attendance were dominated by men.Most of the schools in Kamwangi Division were under staffed with science teachers and physics/biology combination was a rare combination among teachers in Kamwangi Division. The combination of most teachers was mathematics/science or mathematics and another subject.

i. Most head teachers/principals/deputy principals were non- science oriented, they were also not aware or sure about the cost and benefits of SMASSE program. They wanted the program modified or else be stopped in Kamwangi Division

ii. The main objectives of SMASSE program were to change teacher's attitude and improve performance in mathematics/science subject in Kenya. These two objectives had not been achieved because teachers attitude were still negative and they disliked attending SMASSE program. Teachers were forced to attend the program. They also wanted the program be stopped as it was expensive and time wasting with little direct benefits them.

iii. SMASSE program in Thika is not cost -effective because the cost incurred by students, school, government and JICA exceeded the direct benefits of the program. The foregone (opportunity) cost for teachers were too high, which included unattended holiday tuitions, lack of holiday visits to friends and relatives, non attendance to school based degree program e.t.c

iv. There were no set methods/procedure or instruments being used by SMASSE administrators to measure the cost and benefits of SMASSE program. The only assumed instrument used to measure benefits was examination performance. This instrument is un-able to explain whether the recorded improvement in performance was as a result of SMASSE training or from other factors like reduced number of examinable subjects in K.C.S.E and non-classroom activities like student attendance to mathematics contest and science congress.

v. Newly employed teachers and those on teaching practice (TP) were the only one who had not attended any SMASSE program by the time of the study.

vi. SMASSE was facing some problems which included:-

- Unchanged teachers attitude towards the program itself or their attitude towards teaching mathematics and science subjects.
- High cost of maintaining and repairing equipments and instruments used during the program.
- Lowering levels of government and JICA financing for the program and this burden was being thrown to schools and to individual student.

CONCLUSION

The study concluded that SMASSE program in Thika District was not cost effective. This was because direct and indirect cost exceeded both direct and indirect benefits of the program and Teachers never identified themselves with the program.

Teacher's attitude towards SMASSE program remained negatively as they opposed the whole programs. They only attended due to the fact that they were coerced to attend.

There was need to search for other means or sources of financing SMASSE program if the program was going to be continued and achieve all of its goals and objectives.

Finally, more studies needed to be carried out especially on cost-effectiveness of teachers training program in education. The area of cost effectiveness of a training program or any program was poorly researched on, therefore this study being one among other the few of its kind which contribute positively in this field of the study.

RECOMMENDATION

This study recommends that:-

- SMASSE program be modified to meet or suit teachers needs and aspirations whereby such modifications would include the teachers to attend the program one or two days in a month during the terms and during the holiday
- Mathematics and science teachers to be given training allowances like their counterparts in other government ministries and departments.
- This program be made competitive and willing teachers to attend the program and the certificate issued be on merit not for attendance where trainees sat for SMASSE examinations.
- The program needed to be decentralized to divisional or zonal levels. This would lower transport cost and ensure effectiveness and efficiency of the program.
- To establish SMASSE program evaluation instruments which could be used country wide were necessary. Such instruments would be able to measure direct and indirect cost and benefits of the SMASSE program.
- For all teachers and schools to benefit INSET centers had to operate independently and needed to be set on independent ground/venue.
- There was need for establishment of SMASSE program evaluation instruments that would be able to measure direct and indirect costs as well as direct and in-direct benefits of the program.
- There was need for all people taking part in SMASSE training to be properly remunerated i.e teachers needed to be given training attendance allowances as a way of motivating them to continue attending the program.

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USE OF ICT IN CURRICULUM PLANNING IN SECONDARY SCHOOLS IN NYERI COUNTY, KENYA

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Abstract
The use of ICT in Kenya in curriculum planning is still in its formative phases and the perceptions and experiences of teachers do play an important role in the use of computers and related technologies in curriculum planning practices. The purpose of the study was to examine the extent of ICT usage by teachers in curriculum planning in secondary schools in Nyeri County of Kenya. The objectives of the study were to; assess the perception of teachers regarding the use of ICT in curriculum planning, determine the curriculum planning practices performed by teachers and evaluate the opportunities and challenges in use of ICT in curriculum planning. The study used Integration Theory and adopted the descriptive survey research design as its research methodology. Stratified random sampling was used to sample teachers in secondary schools in Nyeri County. The sample size comprised of 180 teachers with data collected using questionnaires as the research instruments. Quantitative data was analysed using both descriptive and inferential statistics which included percentages, means, standard deviation and Pearson correlation coefficient while qualitative data was analysed descriptively using content analysis. Data was presented using narration and frequency tables. The results reveal that teachers still have inadequate ICT skills and there are limited financial resources for effective curriculum planning in secondary schools. Intensive ICT training for teachers is recommended for effective curriculum planning practices as much as investing in ICT infrastructures in secondary schools.

Keywords: ICT, Curriculum Planning, Secondary School Teachers

INTRODUCTION

Information and Communication Technology (ICT) continues to advance in developed and Asian countries while African countries still experience a lag in its implementation and that continues to widen the digital and knowledge divides (UNESCO, 2009). Kiptalam et.al **(**2010), observed that access to ICT facilities in education sector is a major challenge facing most African countries, with a ratio of one computer to 150 students against the ratio of 1:15 students in the developed countries. According to a World Bank Institute survey, the state of ICT infrastructure in African educational institutions can be summed up as "too little, too expensive and poorly managed." The average African university has bandwidth capacity equivalent to a broadband residential connection available in Europe and pays 50 times more for their bandwidth than their educational counterparts in the rest of the world." Another study carried out for the African Virtual University (AVU) found that while most of the partner institutions either have an ICT policy in place or are developing one, they lack the resources to implement it. This situation may be changing however.

Two countries in sub-Saharan Africa, Kenya and South Africa, have already developed national research and education networks and several others are in the process of doing so. The goal of the Kenya Education Network (KENET) is to "establish sustainable communication and networking among educational institutions in Kenya that will facilitate wide use of internet technology in teaching, research and sharing of other information resources to the general populace at affordable cost." This initiative is spearheaded by

Kenya's institutions of higher learning to establish a high-speed, reliable and sustainable network for the interconnectivity of all learning institutions (Republic of Kenya, 2005). In Kenya whereas ICT has penetrated many sectors including banking, transportation, communications and medical services, the Kenyan Educational System seems to lag behind.

Report by the National Council for Science and Technology (2010) indicated that computer use in Kenyan classrooms is still minimal. Information society is mainly a consequence of continuing development in new technologies and requires people who use computer technologies. In this new era, educational systems seek to prepare teachers and students for the work force and computer literacy becomes vital in secondary schools (Republic of Kenya, 2010). This is particularly important for the curriculum planning. The rationale for involving the teachers in this study was because they were in charge of day to-day management of secondary schools' curriculum planning. It is the responsibility of teachers to plan, manage students, students' activities, time, teaching and learning resources of the schools through the application of vital competencies. This puts them in a situation to identify the curriculum planning practices that teachers generally perform and the challenges encountered in these curriculum planning practices.

Statement of the problem

Planning in the educational sector is expected to play a critical role in both instructional and non-instructional activities including data management, lesson preparation and communication. Teachers are supposed to effectively plan their teaching practices, improve the delivery of curriculum content and plans for ways of ensuring that instructional delivery provides training in the skills students need to enter the modern workforce. The use of ICT in planning of activities byteachers in secondary schools appears not be result-oriented hence there is poor state of planning and coordination of school activities.The high processing of data manually in planning for curriculum supervision, relevant tasks for students, termly performance report, appointment of prefects, inter-house sports and organizing students adequately for co-curricular activitiesshows that teachers appear to find it difficult to use computers. The education policy on ICT in Kenya has laidemphasis on the use of computer technologies in teaching and learning processes. Therefore the inadequate use of ICT in schools would result in inefficient curriculum delivery and gross inadequacies in attainment of curriculum objectives. This prompted the researcher to examine the extent of ICT usage by teachers in curriculum planning in secondary schools in Nyeri County of Kenya.

Literature Review

ICT and Curriculum Planning

Information, Communication and Technology (ICT) is the term generally accepted to mean all devices, networking components, applications and systems that combined allow people and organizations to interact in the digital world (Tinio, 2003). ICT comprises both the internet-enabled sphere as well as the mobile one powered by wireless networks. It also consist of antiquated technologies, such as landline telephones, radio and television broadcast - all of which are still widely used today alongside cutting-edge ICT pieces such as artificial intelligence and robotics. A number of components, such as computers and telephones, have existed for decades. Others, such as smart phones, digital TVs and robots, are more recent entries. ICT also refers to the combination of manufacturing and services industries that capture, transmit and display data and information electronically (OECD, 2002).

Curriculum refers to the lessons and academic content taught in a school or in a specific course or program. Educators employ the term curriculum typically to refers to the knowledge and skills students are expected to learn, which includes the learning standards or learning objectives they are expected to meet; the units and lessons that teachers teach; the assignments and projects given to students; the books, materials, videos,

presentations and readings used in a course; and the tests, assessments and other methods used to evaluate student learning (KIE, 2006). For example, an individual teacher's curriculum would be the specific learning standards, lessons, assignments, and materials used to organize and teach a particular course. Commonwealth of Learning (2000) define curriculum as all that learners experience in school and it involves all the actions of the school, which are aimed at getting the child to begin a course and at the end attain educational goals.

School curriculum is seen as a programme of selected content and learning experiences offered by a school and capable of either modifying or changing the behaviour of learners (Tanner & Tanner, 2007). According to Henderson and Hawthorne (1995) it involves interaction between teachers and learners, between learners and learners, between learners and curriculum content. Teachers often develop their own curricula, regularly refining and improving them over years. Although it is also common for teachers to adapt lessons and syllabi created by other teachers, use curriculum templates and guides to structure their lessons and courses, or purchase prepackaged curricula from individuals and companies. Sometimes, schools purchase comprehensive, multigrade curriculum packages—often in a particular subject area, such as English—that teachers are required to use or follow.

There are several definitions of curriculum planning. Curriculum planning is a complex process where school or departments define intended learning outcomes, assessments, content and pedagogic requirements necessary for student success across an entire curriculum. It is the process of preparing for the duties of teaching, deciding upon goals and emphases, determining curriculum content, selecting learning resources and classroom procedures, evaluating progress, and looking toward next step (KIE, 2006). It is the process of structuring academic experiences, using expertise knowledge of the teacher. It is the activity which teachers get involved in before the actual implementation.It is a continuous process which involves activities characterized by interrelationships among individuals and groups as they work together in studying, planning, developing and improving the curriculum, which is the total environment planned by the school. It is the advance arrangement of learning opportunities for a particular population of learners. The above definitions implicit the following ideas that: there is a source from which content and learning experiences are selected, one or more teachers select content and learning experiences, their selection is based on specified criteria and /or influenced by a number of factors and the learner should experience a change in behaviour and these changes should be those expected by educators in the teaching learning process. For any school curriculum to achieve the listed ideas requires curriculum planning.

Curriculum planning requires decision-making, which is, choosing from among alternative future courses of action (Lee & Dimmock, 1999). It is a process of formulating and selecting curriculum objectives and content as well as the actions to achieve them. It is used to describe the designing and mapping out of activities, decisions and strategies for curriculum delivery. The rationale of curriculum planning is that curriculumis one of the foundational elements of effective schooling and teaching, it is often the object of reforms, most of which are broadly intended to either mandate or encourage greater curricular standardization and consistency across states, schools, grade levels, subject areas, and courses. School curriculum planning is a dynamic, ever changing series of planned learning experiences.

The need for efficient and effective curriculum planning cannot be overemphasized.The need for exactness and particularity in making decisions about ends and means demands scientific curriculum planning. Curriculum planning develop well-coordinated, quality teaching, learning and assessment programs, which build students' knowledge, skills and behaviors in the disciplines, as well as their interdisciplinary and/or physical, personal and social

capacities(Republic of Kenya, 2002). The full ranges of learning needs of students are addressed.Unplanned teaching and learning is a recipe of wasting time. Curriculum planning ensures: a shared vision, shared understandings and a common language in the school community, optimum coverage of all domains within the curriculum, continuity of learning between domains across year levels, the full range of learning needs of students are addressed. Students are given opportunities to develop deep understanding, cohesiveness in teaching, learning and assessment practices, elimination of repetition of learning activities without depth or breadth across levels, improved student learning outcomes. The curriculum is likely to be good one if there is good curriculum planning; and conversely, the curriculum is likely to be mediocre one if there is a mediocre curriculum planning.

Perceptions and Attitudes towards ICT in Curriculum Planning

One of the major roles of secondary school teachers involves the application of curriculum planning practices that are aimed at fulfilling the anticipated goals of the school. The curriculum in *21st century schooling is focused on relevance, understanding, rigour and depth, engaging all students in authentic learning (Ayiro & Sang, 2010). ICT capabilities are integral to improved learning outcomes that enable young people to engage effectively with and work in an increasingly complex world. Innovative and effective use of ICT is transforming pedagogies, empowering teachers to focus on student-centred active and interactive learning.*The successful implementation ofthe educational technologies depends largely on the attitudesof the educators. In Israel (Klieger, Ben-Hur, &Bar-Yossef, 2010), Australia (Pierce & Ball, 2009), USA (Glazer *et al*., 2009; Hixon & Buckenmeyer, 2009; Liu & Szabo, 2009), Turkey (Goktas, Yidirim, & Yildirim, 2008)and Asia/Far East (Sang, Valcke, Braak, & Tondeur, 2010) based studies still consider the attitude of teachers towardsICT as an important issue.

According to Huang and Liaw, (2008), teachers' skills, attitudes and perceptions influenced their acceptance of the usefulness of ICT and its implementation in schools. Research conducted by European Union (EU), school net in 2010 (cited by Andoh, 2012) involving teachers' use of Acer netbooks in six EU countries, revealed that a large number of participants perceived use of netbook had positive impact on their learning, elicited interest, promoted individualized learning and helped to lengthen study beyond school day. On the other hand, research by Korte and Husing, (2007) suggested that small number of teachers perceived benefits of ICT in schools were not clearly identified. Most of teachers viewed ICT as waste of time and expensive. On his study of UK teachers Becta, 2008(cited in Andoh, 2012) revealed that teachers' positivity about possible contributions of ICT in schools, was moderated as they became rather unsure and sometimes doubtful about specific and current advantages of it.Teo (2012) found that teachers' attitudes towards computer use in Singapore were more positive about their attitude towards computers and intention to use them, than the helpfulness of computer towards teaching and learning.

In Africa, teachers play an important role in the implementation of ICTs in curriculum planning. According to Hennessey, Harrison & Wamakote (2010), teacher development is key in implementing ICT in teaching and learning hence improving the standards of education. The Government of Kenya has paid attention to the teacher factor while implementing ICTs in teaching and learning by equipping schools with ICT infrastructure and capacity building of teachers (GoK, 2010). Keengwe, (2007); Rockman, (2004); Becker, (2001); and Allen, (2001) affirm that, among manyother reasons for the lethargy in the uptake of ICTs in teaching, is the negative teacher attitudes towards technology. This stands out as one of the main reasons for slow adoption and use of ICT in curriculum planning. If teachers are not put in the lime light, just like in the earlier attempts of integrating ICT in teaching and learning, the process would be bound to fail.

Teachers have the responsibility to prepare students for the demands of an ever-changing world by facilitating learning in a technology-rich environment where students and teachers do not just learn about technology, they use it to achieve powerful learning and teaching and improve student learning outcomes. If teachers perceive ICT programs to either satisfy their own needs or their students' needs, it is likely that they would implement it in curriculum planning. Teachers' adequacy, skills and attitudes influence successful implementation of ICT in schools (Keengwe & Onchwari, 2011). When teachers' perceptions are positive toward use of ICT, then they can easily provide useful insight about its implementation. Simonson (2008), in his study revealed that teachers' skills, perception and attitudes were related to their use of ICT in teaching and learning. The more skilled teachers were in ICT, the more likely they were to use it in curriculum planning. Drent and Meelissen (2008) revealed that positive attitude, personal entrepreneurship and computer experience had a direct positive influence on adoption and use of ICT by teachers.

For successful transformation of school practice, Woodrow (2002) points that teachers need to develop positive attitudes toward innovations. Positive computer attitudes by teachers are expected to foster implementation of ICT in schools (Van Braak, Tondeur, & Valcke, 2008). These studies support that teacher's skills, perceptions and attitudes influence adoption and use of ICT in schools. Bullock (2004) found that, the attitude of teachers is a major enabling/disabling factor in the adoption of the ICT. Equally, Kersaint *at al*. (2003) found that, the teachers with positive attitudes towards the ICT feel more comfortable while using it and them usually incorporate it into their curriculum planning activities. Therefore, the teachers' attitudes towards computers are one of the significant factors in enhancing and use of ICT in curriculum planning.

Curriculum Planning Practices Performed By Teachers

It is most important that every school teacher plans ahead the steps to be taken in order to achieve the school's curriculum objectives. This can sometimes be affected in conjunction with others (during staff meeting) and in conjunction with the parents (during the Parent Teacher Association meeting), or at the beginning of the school year (Jaiyeoba, 2004). The teacher need to prepare a plan that would embrace students': affairs, supervision, interpersonal relationship, curricular and co-curricular activities, remedial teaching, subjects in the school curriculum, the number of students, the number of classes, the level of students, the instructional materials that are required for the curriculum, assessment and evaluation mode and data management. He/she should ensure that the time-table for instructions is prepared in such a way that clashes are avoided. The concept of curriculum planning thus includes the teacher giving attention to both instructional and non-instructional tasks.

Planning practices involves learning, teaching, assessment and reporting which refer to how schools lead, enable and support the use of ICT to transform learning and teaching, extending learning opportunities and improving learning outcomes (Davidson, 2014). This can be achieved by: supporting teachers to recognize and integrate a variety of rich uses of ICT in curriculum planning and delivery that is underpinned by state-wide student learning initiatives; using ICT for improved, more timely and relevant assessment; collecting, communicating and collating student assessment data to inform curriculum design and to report on student progress; using digital environments to provide access to digital resources for improved curriculum planning; using ICT to deliver curriculum, extending and differentiating student learning opportunities and supporting students to manage and direct their own learning, andbuilding a culture of ethical, safe and responsible use of ICT. To get

beyond engagement in use of ICT to improve learning is hard work that takes effort and time. Teachers will need to invest in and be supported to use ICT, not just to enhance student engagement but for purposeful teaching as well (Florence, 2011). Moreover, ICT is likely to become an integral part of teaching and learning activities when teachers use it for planning andclassroom teaching. When curriculum planning is the focus of the school, then teachers must be encouraged and supported to use technologies in class. It shifts the focus from individual research and administration to the integration of ICT with the work that students do.

Opportunities in Use of ICT in Curriculum Planning

Investment in the educational technologies has gained an increasing trend all over the world. The use of these technological facilities in learning environments has also gained importance. Therefore teachers are supposed to perceive the use of technology as a natural part of their profession in order to be able to conjoin these investments for enhancing the learning of students. There are several processes the teachers are supposed to overcome before they can fully employ technology in planning (Mills & Tincher, 2003; Proctor, Watson& Finger, 2004; Russell, O'Dwyer, Bebell, & Tao, 2007; Yang & Huang, 2008). On initial stages, the teachers tend to use the technology almost not at all. However later on, they consider the technology as an instrument which necessities to be taught. In the meantime, as the use of technology increases, teachers tend to perceive it as an instrument to aid the instruction, rather than being a core educational topic (Hixon & Buckenmeyer, 2009). Training in ICT for teachers in colleges is important. In order to realize successful training we need to be aware of the user's attitudes toward computers (Zoltan & Chapanis 1982). Exposure to computer related devices may be a factor in determining ones attitudes toward computers.

Effective ICT use in education increases teachers' training and professional development needs. If ICTs are to be used effectively, adequate time must be allowed for teachers to develop new skills, explore their integration into their existing teaching practices and curriculum and undertake necessary additional lesson(UNESCO, 2002).On the other hand, ICT can be an important tool to help meet such increased needs, by helping to provide access to more and better educational content, aid in routine administrative tasks, provide models and simulations of effective teaching practices and enable learner support networks, both in face to face and distance learning environments and in real time or asynchronously. ICT enable teachers to have access to multimedia learning resources, which support constructive concept development. It also allows teachers to focus more on being a facilitator to a learner by providing personal attention. Teachers use ICT to plan lessons more efficiently and more effectively. ICT increases efficiency in planning and preparation of work due to a more collaborative approach.

Challenges in Use of ICT in Curriculum Planning

Early studies explored why teachers do not use computers in their planning and teaching (Rosen & Weil, 1995; Winnans & Brown, 1992; Dupagne & Krendl, 1992; Hadley & Sheingold, 1993). These earlier researchers found a list of inhibitors such as: lack of teaching experience with ICT; lack of on- site support for teachers using technology; lack of ICT specialist teachers to teach students computer skills; lack of computer availability; lack of time required to successfully integrate technology into the curriculum and lack of financial support. In recent times, challenges experienced in use of ICT depend on the financial and human capacity of an institution among others. A number of factors have been pointed out as barriers to ICT integration in curriculum planning. Some of the barriers include but are not limited to: inadequate appropriate software, inadequate time for training and the use of ICTs, inadequate technical support, inadequate competence to use ICT, inadequate follow up for

new skills, lack of differentiated training programmes and technical faults with ICT equipment.

Moreover, teachers are already burdened people and when they are confronted with barriers such as these, they tend to avoid integration all together so that they are not burdened further (Hew & Brush, 2007).Teachers are an important component in the integration of ICT in curriculum planning. They are expected to adopt and use ICTs appropriately in their teaching hence implement the changes expected in pedagogy. Dawes (2001) note that, this potential may not easily be realized because problems arise when teachers are expected to implement changes in what may well be adverse circumstances. Successful implementation of ICT depends mostly upon staff competence in the integration of ICT into instruction and learning. Venezky and Davis (2002) in their study noted that technology by itself may not be any useful as a catalyst for any meaningful school change, but can be a potent lever for planned change implementation.

There are several obstacles that teachers face in the course of implementing ICT integration and the major obstacles being the teachers themselves. Even though several teachers believe that ICT has the ability to improve classroom learning, an almost equal number of them still find it difficult to understand ICT' specific benefits or how it can be used so as to achieve maximum results (Oldfield, 2010). Korte & Husing (2007), Oldfield (2010), Blanknskat et al(2006) and Becta (2008) have tried to bring to the fore these contrasting perceptions of teachers and even revealed that despite the continuous hype of the advantages of ICTs in teaching and learning, there is still a small group of teachers who do notsee any considerable benefit to plan while using ICTs.

Investment in new ways of teaching and learning is not the same as investment in technology and infrastructure, the balance seems to tip towards the later. According to Ofsted (2001, 2002), there is need for teacher motivation to develop their pedagogy and practice; clarification on what students should learn using ICT and how teachers should facilitate this. Nevertheless, with no proper guidance and taking into account the teachers own theories about teaching and learning which are recipes for integration, then the much desired change will most likely be limited (Mumtaz 2000). Another major hindrance is the teachers' reluctance to abandon their existing pedagogy which Rodgers (2002) views as an obstacle to teacher development in classroom use of ICT than even limited resources.

Teachers' beliefs about their own efficacy (Ertmer& Ottenbreit-Leftwich, 2010) play an important role in integrating technology into instruction. The above impediments according to Bruce & Rubin, (1993); Ertmer, (2005); Hughes et al, (2005); Windschitl & Sahl, (2002); Zhao et al.,(2002) , play a predominant role in how teachers conceptualize and use ICTs in curriculum planning. In reality this proves that unless teachers see the connection between technology and the planning of the subject content they teach, they are unlikely to develop a technology-supported pedagogy. The importance of ICTs in the future of education cannot be underrated and therefore identifying the possible obstacles to the integration of these technologies in schools would be an important step in improving the quality of teaching and learning (Bingimlas, 2009). These difficulties most of which affect teachers, continue to be encountered during the process of adopting these technologies (Balanskat, Blamire and Kefala (2006).

In 2010, the Government of Kenya through the Ministry of Education released funds under the Economic Stimulus Programme (ESP) for equipping 1050 secondary schools, at least about five schools in every district, with ICT infrastructure and capacity building of teachers. It was expected that the adoption and integration of ICT in education would play a critical role in the transformation of Kenyan society into a knowledge based economy, in line with the Vision 2030(Republic of Kenya, 2010). The programme's exclusive aim was to enable

teachers to use modern technologies in their preparation and delivery of curriculum in order to enhance access and promotion of quality of education (Ang'ondi, 2012).

A number of ICT champions were trained at the Kenya Institute of Education (KIE) and the Kenya Education Management Institute (KEMI) to oversee the implementation of the ESP programme, provide technical support to schools, train teachers and provide mentorship as the teachers embarked on using the ICTs in their lessons. The implementation of this program was not as smooth as expected because there were several unexpected milestones ranging from law quality equipment, delays caused by the disbursement of funds, unsupportive school heads and teacher attitudes among others. While it was easier to deal with the issue of law quality equipment by ICT champions simply giving them what has popularly come to known as the 'red card', it was more challenging dealing with the issues of unsupportive heads and teacher attitudes.

In regards to planning for teaching, ICT integration faces serious challenge in a system where everything done in class must have an examinational implication. A number of teachers do not see why they should waste their time using ICTand incorporating to curriculum planning when it is not an examinable subject anyway and not a requirement for students in writing their national examinations. The school curriculum is loaded with too much work against the backdrop of little time allocation to the extent that teachers have to find extra time to complete the syllabus. This naturally discourages the teachers from using ICT which they claim is time consuming. Teachers have a feeling that with ICT the syllabus will never be completed and therefore their learners will be disadvantaged. Teachers maintain that the curriculum should offer direction on how subjects should be taught. The teachers' fears may be valid from a layman's point of view, given that ICT is a relatively new concept. Furthermore, ICT is simply a medium for planning and teaching hence how a teacher decides to use it is entirely based on their own discretion.

METHODOLOGY

Survey research design was used and both quantitative and qualitative approaches were employed (Mugenda & Mugenda, 1999). Stratified random sampling and simple random sampling were used to get a sample of 180 teachers across the county. Open ended and closed ended questionnaires were used to collect data from the teachers. Data was analysed both and qualitatively and quantitatively using percentages, means, standard deviation, correlation co efficiency and content analysis. It was presented using tables, percentages and narrations.

RESULTS AND DISCUSSION

The result and discussion were presented as per objectives:

Teachers' perception toward ICT use in curriculum planning

Attitude towards ICT	Disagree		Not sure		Agree	
	F	*%*	*F*	*%*	*F*	*%*
Use of ICT make planning work easier	75	41.6	15	8.3	90	50
I prefer to use ICT to traditional planning methods of curriculum planning	102	56.7	8	4.4	70	38.9
I seek opportunities to learn new ICT skills	84	46.6	7	3.8	89	49.4
I consult ICT experts widely to support my curriculum	111	61.7	12	6.6	87	48.3

planning activities						
I like using computers in planning most of instructional activities	116	64.4	11	6.1	53	29.4

In regard to teachers' perception toward ICT use in planning, the result reveals a negative attitude toward the use of ICT. Majority of respondents disagreed with these statements; I like using computers in planning most of instructional activities 116 (64.4%), I consult ICT experts widely to support my curriculum planning activities 111(64.4%), I prefer to use ICT to traditional methods of curriculum planning 102(56.7%). This is an indication that computer use by teachers in Kenyan secondary schools is still minimal. This is in line with Huang and Liaw, (2008), who assert that teachers' skills, attitudes and perceptions influenced their acceptance of the usefulness of ICT and its implementation in schools. Keengwe, (2007); Rockman, (2004); Becker, (2001); and Allen, (2001) affirm that, among many other reasons for the lethargy in the uptake of ICTs in teaching, is the negative teacher attitudes towards technology. Information society is mainly a consequence of continuing development in new technologies and requires teachers who use computer technologies.

Planning Practices Performed by Teachers

Planning Practices	**Disagree**		**Not sure**		**Agree**	
	F	***%***	***F***	***%***	***F***	***%***
Schemes of work	85	47.2	9	5	86	47.8
Lesson planning	100	55.5	18	10	62	34.4
Planning for instructional materials	120	66.6	10	5.5	50	27.7
Exam setting	70	38.7	5	2.8	105	58.3
Exam processing	79	43.9	6	3.3	95	52.8

The study reveals that main curriculum planning practices which the teachers performed using ICT were: exam setting 105 (58.3), exam processing 95 (52.8%) and the preparation of schemes of work 86 (47.8%). A significant number of teachers did not use ICT in curriculum planning practices identified. However, majority of teachers disagreed that they use ICT in preparation of instructional materials 120 (66.6%) and lesson planning 100 (55.5 %) and had the least usage of ICT.

Challenges in use of ICT in curriculum planning

Challenges in use of ICT	**Disagree**		**Not sure**		**Agree**	
	F	***%***	***F***	***%***	***F***	***%***
Inadequate ICT skills	93	51.6	6	3.3	81	45
Inadequate administrative support	99	55	13	7.2	68	37.8
Inadequate ICT facilities in schools	113	62.8	10	5.6	57	31.7
Urgent and often competing curriculum activities	105	58.3	15	8.3	60	33.5
Lack of statistical skills in ICT	110	61.1	4	2.2	66	36.6

The challenges encountered by teachers in use of ICT in curriculum planning include inadequate ICT facilities in schools 113 (62.8%), lack of statistical skills in ICT 110 (61.1%) and urgent and often competing curriculum activities 105 (58.3%). Unfortunately, these challenges have an impact on teachers and therefore the effective use of ICT in curriculum planning cannot be assured. This is in line with Hew and Brush (2007) who support that

teachers are already burdened people and when they are confronted with barriers such as inadequate facilities and lack of statistical skills in ICT, tend to avoid integration all together so that they are not burdened further.

CONCLUSION

The study sought to find out the perception of teachers toward the use of ICT in curriculum planning in secondary schools. The study indicated that teachers have a negative perception toward the use of ICT in curriculum planning, asmost of respondents disagreed with the statements that: I like using computers in planning most of instructional activities, I consult ICT experts widely to support my curriculum planning activities, I prefer to use ICT than traditional methods of curriculum planning. This is an indication that implementation of ICT in schools may take longer than expected. The much desired goal to establish sustainable communication and networking among educational institutions in Kenya that will facilitate wide use of internet technology in teaching, research and sharing of other information resources to the general populace at affordable cost may not be realized soon.While ICT has penetrated many sectors in Kenya, the Educational System especially in secondary schools seems to lag behind due to negative attitude toward computer use. The study recommends the change of perception in order to align our educational institutions with vision 2030 where ICT in educationis expected to play a critical role in the transformation of Kenyan society into knowledge based economy.

Teachers use ICT mostly in exam setting, exam processing and the preparation of schemes of work. However, teachers' use of ICT in planning was found wanting especially in preparation of lesson plan and preparation of instructional materials. This portrays teachers' resistance to adoption and use of ICT which may also affect the curriculum implementation in this digital era. The use of ICT allows instant flows of up-to-date information between different teachers, thus creating an atmosphere of transparency and connectedness, improving the curriculum performance. Use of ICT improves the teaching and learning process through the provision of more interactive educational materials that increase learner motivation and facilitate the easy acquisition of basic skills.

The study found that some of apparent challenges encountered by teachers in use of ICT in curriculum planning included: inadequate ICT facilities in schools, lack of statistical skills in ICT and urgent and often competing curriculum activities. This means that despite the continuous hype of the advantagesof ICTs in teaching and learning, there is still a group of teachers who do notsee any considerable benefit to plan while using ICTs. Although the scarcity of resources is real, the teachers' reluctance to abandon their existing traditional method of curriculum planning is an obstacle to teacher development in use of ICT.Though there are limited resources, teachers' beliefs about their own efficacy play an important role in integrating technology into curriculum planning.

RECOMMENDATIONS

The study recommends:

i. Teachers motivation and change of attitude towards ICT use in curriculum planning
ii. Continuous in-service training of teachers on newer ICT skills
iii. Improvement of ICT infrastructure to support curriculum planning inschools

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DEVELOPMENT OF AN INFORMAL CADASTRE USING SOCIAL TENURE DOMAIN MODEL (STDM): A CASE STUDY IN KWARASI INFORMAL SETTLEMENT SCHEME MOMBASA

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Abstract

The Kenya Government together with development partnershas embarked on the development of informal settlements. Mombasa County has more than 70 informal settlements; Information about the settlements and their relationship to the existing cadastral spatial layer covering the entire Mombasa County needs to be determined in order to support decision making for sustainable development.

This paper evaluates the Social Tenure Domain Model (STDM) land tool in the development of an informal cadastre by capturing, storing, and manipulating social and spatial information in Kwarasi Informal Settlement in Mombasa. This case study is an example that can be replicated to the rest of the informal settlements in Mombasa forming a single informal cadastral database for the entire County. Participatory enumerations and the STDM tool were used in this research to present the situation of Kwarasi informal settlement.

The housing structures were adopted as the spatial unit for the informal cadastral over which the rights of the inhabitants were adjudicated, customized and uploaded into the STDM where social tenure relationships were created to form the cadaster in the STDM system. The spatial component of Kwarasi informal cadaster was overlaid on the Mombasa cadastral layer and their relationship determined. It has been demonstrated that the relationship would be useful for decision making to support sustainable development intervention, and ease land administration by maintaining a detail record of the informal settlements.

Key words: Cadastre, Informal settlements, STDM, Kwarasi.

INTRODUCTION

Millennium Development Goal number 7 that seeks to ensure environmental sustainability, Target 11to have achieved a significant improvement in the lives of at least 100 million slum dwellers by 2020, the Kenya Government has initiated programmes in order to improve living conditions in the informal settlements on its own and with the help of other development partners such as the Un-Habitat, World Bank and United Kingdoms' Department for International Development (DFID). The initiatives are namely Kenya Informal Settlement Improvement Project (KISIP) Kenya Slum Upgrading Program (KENSUP) Mombasa Slum Upgrading Project (MSUP) with the aim of improving the livelihoods of people living and working in slums and informal settlements in the urban areas of Kenya through the provision of security of tenure and physical and social infrastructure (Muraguri, 2011). However more information is required about individual informal

settlements before any reasonable development intervention can be sustainable. An informal settlement inventory report prepared by the Mombasa county government in collaboration with Pamoja Trust shows that 65% of population in Mombasa County live in informal settlements that count to 70 in number and of various sizes (Mombasa County Report, 2013). The spread of informal settlements in Mombasa County is shown on Figure 1, providing an overview of the situation of informal settlement in Mombasa County.

TheCadastre is a methodically arranged public inventory of data concerning properties within a certain country or district, based on a survey of their boundaries. The outlines of the property and the parcel identifier normally are shown on large-scale maps which, together with registers, may show for each separate property the nature, size, value and legal rights associated with the parcel. It gives an answer to the question where and how much (Henssen, 1995).There is a growing recognition in many countries, international organisations and with land administration practitioners that land administration, and particularly the core cadastral system, has an equally important role in supporting sustainable development objectives, rather than the traditionally narrow focus on land markets (Wiebe and Meinzen-Dick,1998).

In UN-HABITAT (2008) the various types of land rights are viewed as existing along a continuum, with some settlements being more consistent in law than others. This view makes it possible to include the people with the weakest tenures pursuant to the idea of sufficient legal access, see Figure 2.

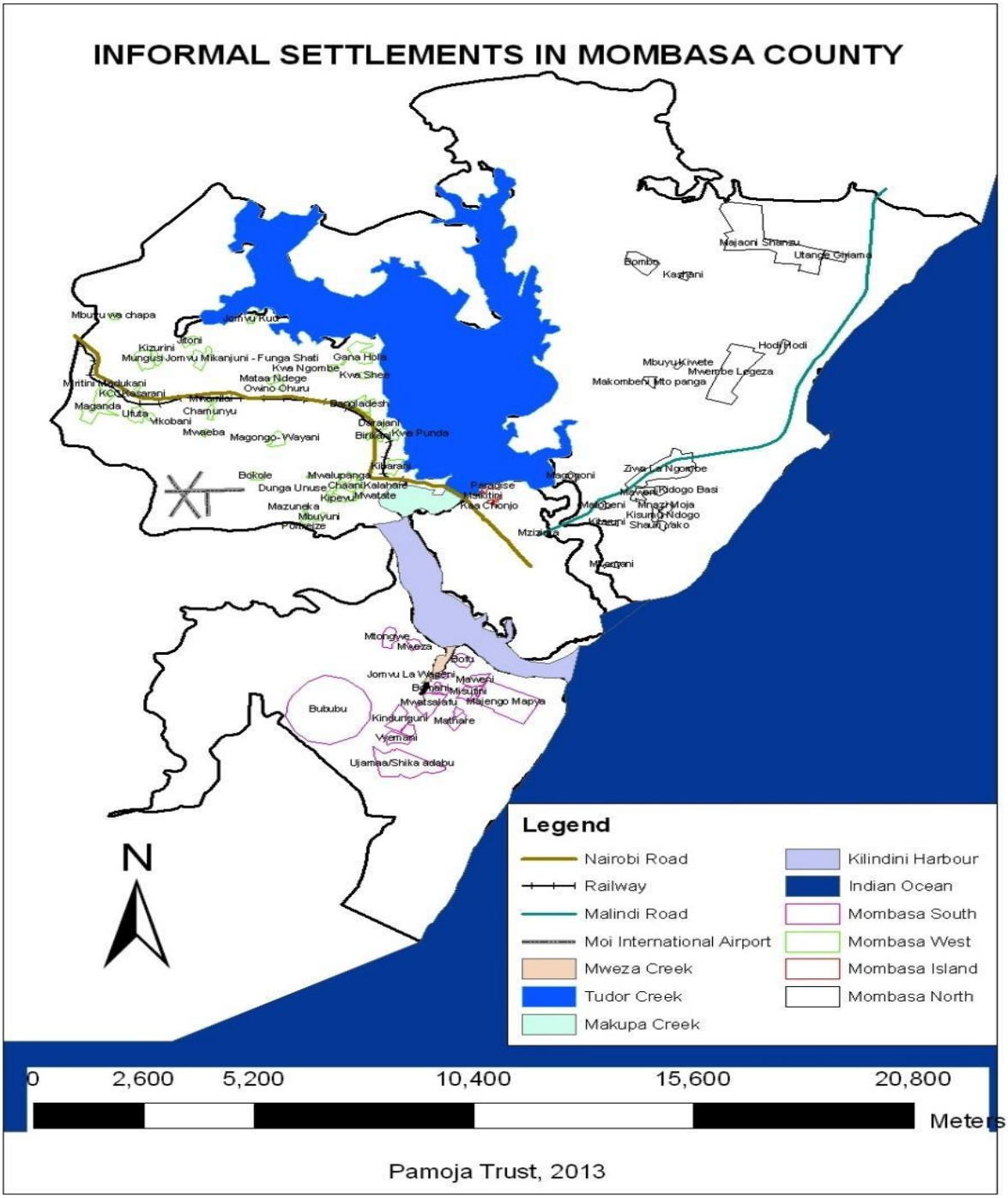

Figure 1. Spread of informal settlements in Mombasa County (Mombasa county report, 2013)

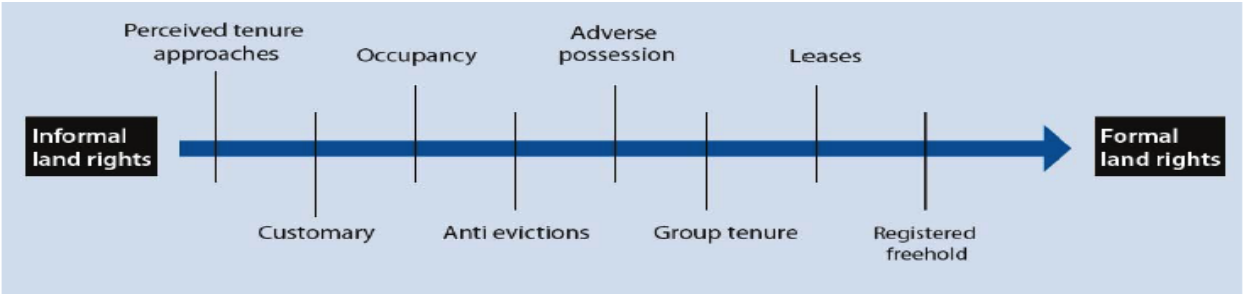

Figure 2. Continuum of land rights (UN-HABITAT, 2008)

The Social Tenure Domain Model (STDM) STDM is a pro-poor land tool developed to serve primarily, the needs of the poor (Lemmen, 2010). STDM is a land information system that has been developed using the standards of Land administration Domain Model LADM which is ISO certified and hence data integration is made possible (Lemmen, 2010; Enemark, 2009). Developed by the the Global Land Tool Network (GLTN), facilitated by UN-HABITAT together with coalition of international partners, (Un-Habitat, IIR, GLTN, 2012). GLTN partners support a continuum of land rights (see Figure 2), which include rights that are documented as well as undocumented, including slums which are legal as well as illegal and informal (Un-Habitat, IIR, GLTN, 2012). STDM is a conceptual model that is descriptive and not prescriptive and records the status quo leaving people-land relationships intact (Charisse, Asad, Sunil, 2013).

The main objective of this project was to evaluate the Social Tenure Domain Model (STDM) land tool in the development of an informal Cadaster in order to support decision making for sustainable development intervention in the informal settlements in Mombasa County. This is by bringing out into view and put into record the informal settlement details of Kwarasi informal settlement in Mombasa County as a model to be used for replication to all the other informal settlements in the County and the rest of the country.

This was achieved by:

(i) Adjudication of the informal rights within Kwarasi informal settlement, relating the rights with the spatial unit and create the social tenure relationships for the settlement in the STDM system.

(ii) Using the spatial and attribute cadastral data in the STDM database to generate reports and produce certificates of residence directly from the system and lastly

(iii) Overlaying of the informal cadaster on the formal cadaster to bring out the relationship between the formal and the informal cadastral information in Kwarasi in order to aid in decision making for sustainable development.

The obtaining legal regime in Mombasa County

The Land Titles Act cap 282 laws of Kenya (repealed), *formerly the Land Titles Ordinance (LTO)* is the only law that came close in recognising and institutionalising informal land rights in Kenya. It is a deeds registration act that was enacted in 1908 and operated in the ten nautical miles strip inland of the Kenyan coast including Mombasa town where the project area is situated. The act recognised rights that may be termed as informal including traditional customary or any describable right and hence phenomena of informal land rights are not new to the persons of the project area. However the system is manual and therefore for ease of management would have required computerisation so that the interests therein could easily be retrieved. The act was designed as both a land adjudication and registration act at the same time. It was institutionalised by the establishment of a court presided by a recorder of title which is only subordinate to the high court of Kenya and a chief surveyor for

mapping the adjudicated claims. The principle land registrar administered the registration part.

Most land registration systems adhere to the Latin maxim "QuicquidPlantatur Solo, Solo Cedit" which means "whatever is affixed to the ground belongs to the ground." Hence the owner of the title owns all that is permanently attached to the land such as buildings trees crops etc.

Under this law, fixtures are recognised and can be registered independently and owned by a different person from the title owner. As an illustration, the interest registered over the parcel of land under the LTO was a fixture that would be considered as part of the land in other statutes. *Makuti* houses in the documents are usually owned by a different person from the owner of the title. The *makuti* house may have been constructed with the consent of the owner of the title of land without necessarily subdividing the land or selling it to the owner of the structures. This is evidence that such a situation is a record able possibility in this registration system and may include water wells, permanent plants such as coconut and mango trees. This has been possible due to the fact that the registration model was designed to accommodate such occurrence and designed in consideration of the culture lifestyles and traditions of the local people. Such a state is not feasible in other acts of registration but was possible in the LTA and can be used to enhance STDM. It is very clear that for any process of upgrading informal settlements to succeed; detailed knowledge and information will be required on the prevailing systems of land administration together all the vested interest by the tenants, extralegal powers and absentee slum lords (Omwoma, 2013).

METHODS

Study area

The study area is Kwarasi informal settlement situated in Mombasa County. Mombasa County located along the Kenyan Coastline (Latitudes 3° 80' and 4° 10' S and Longitudes 39° 60' and 39° 80' E) and has a population of about one million people (See Figure 3). Mombasa is the second largest City and oldest Municipality town in Kenya which is a port city that also doubles up as a County managed by a County Government. Kwarasi informal settlement is in Mombasa mainland west, Changamwe constituency.

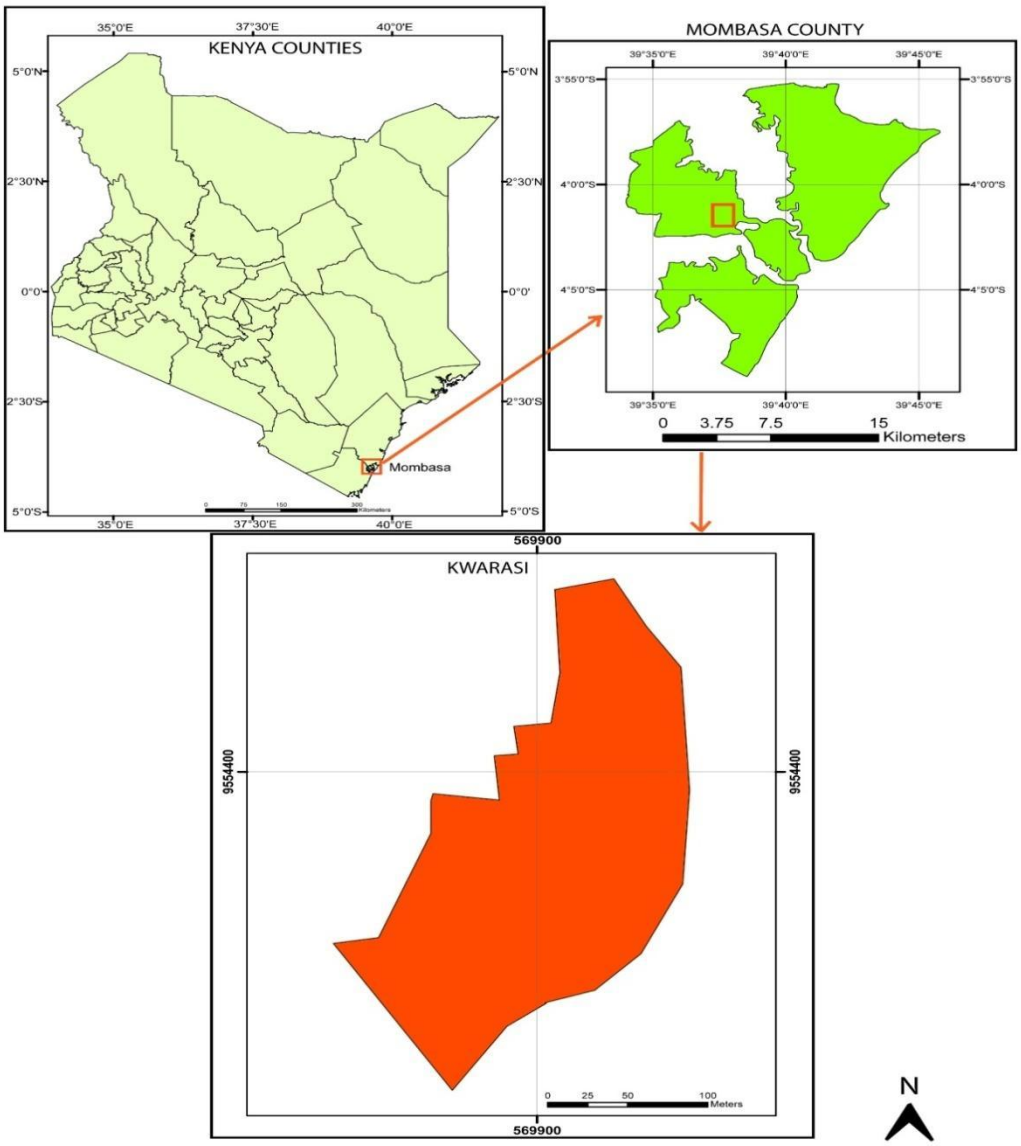

Figure 3. Location of Kwarasi informal settlement

The settlement is composed of tenants and landlords with a total population of about 200 people within an area of about 4 acres.

The constitution of Kenya 2010 categorises land as public, community and private land. The National Land Policy (NLP) states that Squatters are found on public, community and private land. Prior to this categorization of land informal settlements already existed in Mombasa County. On examining the informal settlement inventory for Mombasa County the following types of land situations are host to informal settlements:

a) Informal settlements on public land

These are settlements that are situated on public land that is not alienated or land reserved for a public facility such as a school, social hall or any other public amenity.

b) Informal settlements on private land

Informal settlements that are on registered land held by any person under any freehold or leasehold tenure and any other land declared private land under an Act of Parliament.

c) Informal settlements on land owned by absentee landlords

These legally fall in the category of private land whose owners appear on the lands registry record but cannot be traced. They are mainly people who were registered in the early 20th century as owners on free hold interest or long duration leases who then relocated to other countries mostly Portuguese, Arabs, Asians and Britons.

d) Squatting on riparian reserve

Informal settlements on riparian reserves in Mombasa are mainly areas that abut the high water mark of the Indian Ocean, mostly grown with mangrove trees, this land falls under the category of public land.

e) Tenants at will

Tenants at will in Mombasa is where Land lords allow tenants to construct houses on their land at a deposited amount of money and subsequently a monthly rent under a lease agreement that is private, perpetual and for aslong as the house is in existence. The developments are temporary, not planned and are not part of the City main stream plan. The land lord who holds the free hold title indicates the site of construction in disregard of planning regulations.

All the above settlements constitute structure owners and tenants on residential and small businesses within the informal settlements.

METHODOLOGY

Figure 4 shows the general flow of research activities undertaken.

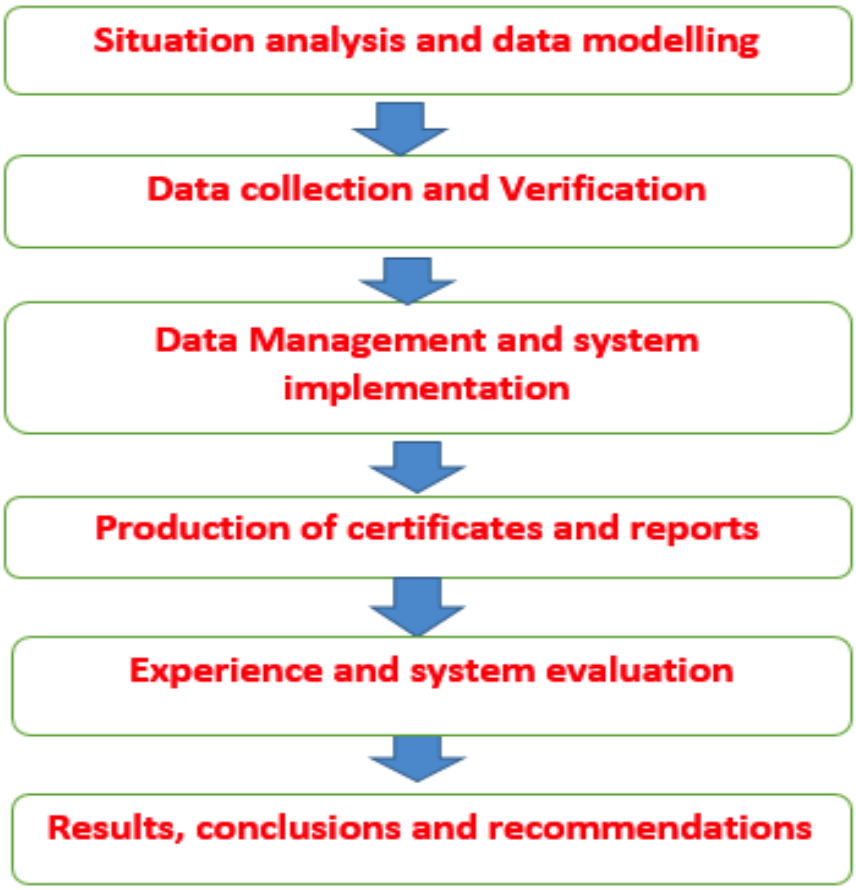

Figure 4. Work flow diagram

Attribute cadastral data modelling was done using Unified Modelling Language (UML) tools in Dia software. Through the situation analysis that was observed from the Mombasa

informal settlement inventory and County Government records it was noted that the persons that represent the party in the STDM were mainly structure owners and tenants. Structures were adopted as the spatial units for the STDM since there were no land parcels as in the formal cadastral systems in the case of Kwarasi.

Datasets and materials

(i) **Spatial data**

The Mombasa County Government has completed the preparation of The Integrated Spatial Urban Development Plan (ISUDP) for Mombasa City for up to the year 2035. Part of the data used for the project in the custody of the County Government is the Mombasa County aerial photo image in digital format that has been geo-referenced and sheets combined into one continuous mosaic for the whole county. The co-ordinate system of the photo-mosaic is UTM Zone 37 arc 1960 projection. This image acquired in the year 2014 was used in this project to identify and map the structures, the spatial unit of the STDM informal cadastral spatial data.

The entire Mombasa County digital cadastral layer was another product of the preparation of ISUD and is also in UTM Zone 37 arc 1960 projection that was used as part of the project data. Others were the Site and service scheme plans of World Bank housing Project II, and site location plans from the county government of Mombasa. The informal settlements including Kwarasi lie on the un-serviced areas of Chaani site and service scheme and spill beyond into other properties.

(ii) **Attribute data**

The Mombasa County assisted by the National government through KISIP has embarked on an exercise of regularisation of informal settlements. For that purpose attribute data was collected from Kwarasi and other settlements in order to inform the regularization exercise. Kwarasi is one of the settlements where the data was collected and released to the county government. The Data was used in this project to decide on the model to adopt for customisation to the STDM data Model (schema). The data was acquired through the process of public participation by questionnaires and focus group discussions direct from the inhabitants of Kwarasi during the regularization exercise carried out by consultants in collaboration with the County government department of Land for the National government ministry of land, planning and urban development KISIP project.

The structures were assigned numbers that were written on the doors of the structures. The numbers referred to as structure numbers were identified with the persons who held an interest on the structures. The relationship type between the people to structures noted in existence was tenants and landlords, and the spatial units were identified and accepted to be the structures that were marked with unique number labels.

GPS coordinate readings were used to identify the position of the structures on the photo image for those that had full details enough for cadaster data requirement. The house number which was on the door was logged into the GPS coordinate reading and which is the same number used as the structure identifier tabulated with the people relation. This way it was easy to identify and digitize the structures on the QGIS canvas. The Secondary attribute data sources were from existing records at the county Government of Mombasa.

Existing data was verified during the GPS survey where the owners could positively identify themselves in relation to the structures that were already numbered. Although the attribute data included other socio-economic information such as availability of amenities and development priorities only ownership, tenancy and party attribute information was considered for the informal cadastral model. Some owners and tenants were not available

during the verification exercise and hence full information was not availed and to be sourced on another day.

The verification of the structure ownership and tenancy was done at the same time with GPS readings to verify and identify the structure owner with the building and the tenants. The form for party linked the social information with the mapped structures by use of GPS (i.e. link socio-economic with spatial STDM).

Project implementation process

The STDM system was used to integrate all the relevant data into one, generate reports, print certificates, upload photos and any other information that was of use such as personal details.The tool was used for the digital record, data analysis and production of certificates and reports. The plans that had the required spatial data were scanned, geo-referenced and then digitized into the GIS to extract the spatial information for the cadaster. These included the entire Chaani site and service scheme and the peripheral informal settlements including Kwarasi to show their relation to the site and service scheme. The numbered structures were identified on the QGIS canvas by use of the GPS control points that were obtained by use of Garmin Handheld GPS. The GPS control points were imported into the QGIS canvas from an excel sheet which was saved in CSV comma delimited format.

The digitized structures were identified by numbers that were inscribed on the doors. The Chaani site and service scheme development plan was digitized and over-laid on the photo mosaic of Mombasa County. This enabled the serviced area to be separated from the un-serviced area by creating a boundary between the serviced parcels of land that appear on the development plan and the informal settlements. The other part extent of the settlement was determined by skirting the area that has built up structures that abut the main Changamwe storm drain by digitisation. This allowed the inclusion of all the structures that were within Kwarasi Informal Settlement Scheme in the project area. Mapping the project spatial extent in order to delimit the project extent was thus completed. The perimeter of the project area was here determined and overlaid on the geo-referenced aerial photo mosaic of Mombasa County to show the structures that fall within Kwarasi informal settlement.

The developments on the project area were clearly visible on the aerial photo at the scale of 1:2,500. The digitization of existing manmade and natural features that are relevant to the project was possible and hence the structures were digitized as the spatial unit for project. These enabled the creation of the structure layer on the QGIS canvass. A layer of GPS control points was also created. Open spaces for passages for passages were also clearly visible at that scale.

Data processing and analysis was done on the platform of the open source QGIS software then imported into the STDM system. The STDM plug in was used for creating the social tenure relationships between the spatial and party attributes to form the cadastral database within the STDM system.The import of spatial data and attribute data into the STDM and creating the relationships was done after cleaning the spatial data and customising the attribute data to the STDM Model. Note that the STDM does not accept data that is topologically non-compliant or incorrect hence only the digitised layers of structures were imported into the STDM. The Kwarasi informal settlement structure layer was overlaid on the Mombasa spatial cadastral layer so that the position of the structures in Kwarasi informal settlement in relation to the formal cadastral could be determined to aid in decision making for sustainable development intervention.The attribute data was linked to the numbered structures to form the social tenure relationship (STR) within the STDM domain. Reports were to be generated by use of PostgreSql which is adopted by STDM by answering queries from the attribute data.A certificate template was designed to suit the study area and the

information in the STDM database. The template was used as a tool in the STDM system for extraction of certificate details directly from the informal cadastral database.

RESULTS AND DISCUSSION

The results of the project were to assist in the evaluation of Social Tenure Domain Model (STDM) as a Land Administration tool for use in decision-making in sustainable development of informal settlements in Mombasa County. One of the expected results in this research project was an attribute and spatial database hosted in the STDM system that consist of information about the inhabitants of Kwarasi and their relationship to the structures they live in or own within the informal settlement scheme. This overlaid on the formal cadastral spatial layer of Mombasa County in order to show the position of the informal settlement in relation to the existing formal cadastral parcels of land for decision making in sustainable development. With the spatial and attribute cadastral data in the STDM system reports and certificates of residence were to be generated.

The process of determining the extent of the project area resulted in a perimeter line that included structures that form Kwarasi informal settlement. This was helpful in restricting operations of the project within the project area. Figure 5 shows the extent of the project area overlaid on the Mombasa aerial photo mosaic.

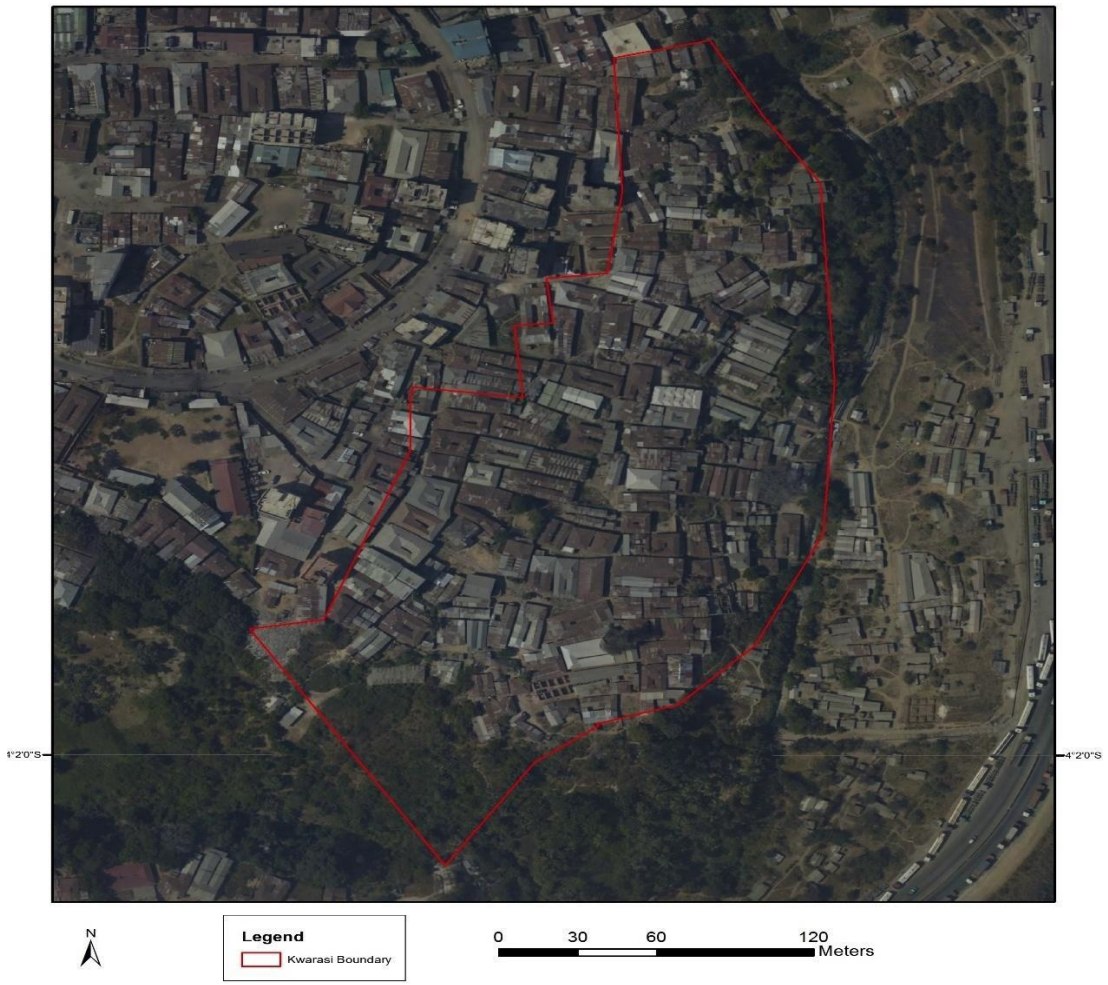

Figure 5. Showing the extent of the project area overlaid on the Mombasa aerial photo mosaic

Verification by GPS

In the case where owners and tenants were available during the verification exercise and hence full information was availed the structures were identified by GPS readings and given a different colour. This is shown in Figure 6.

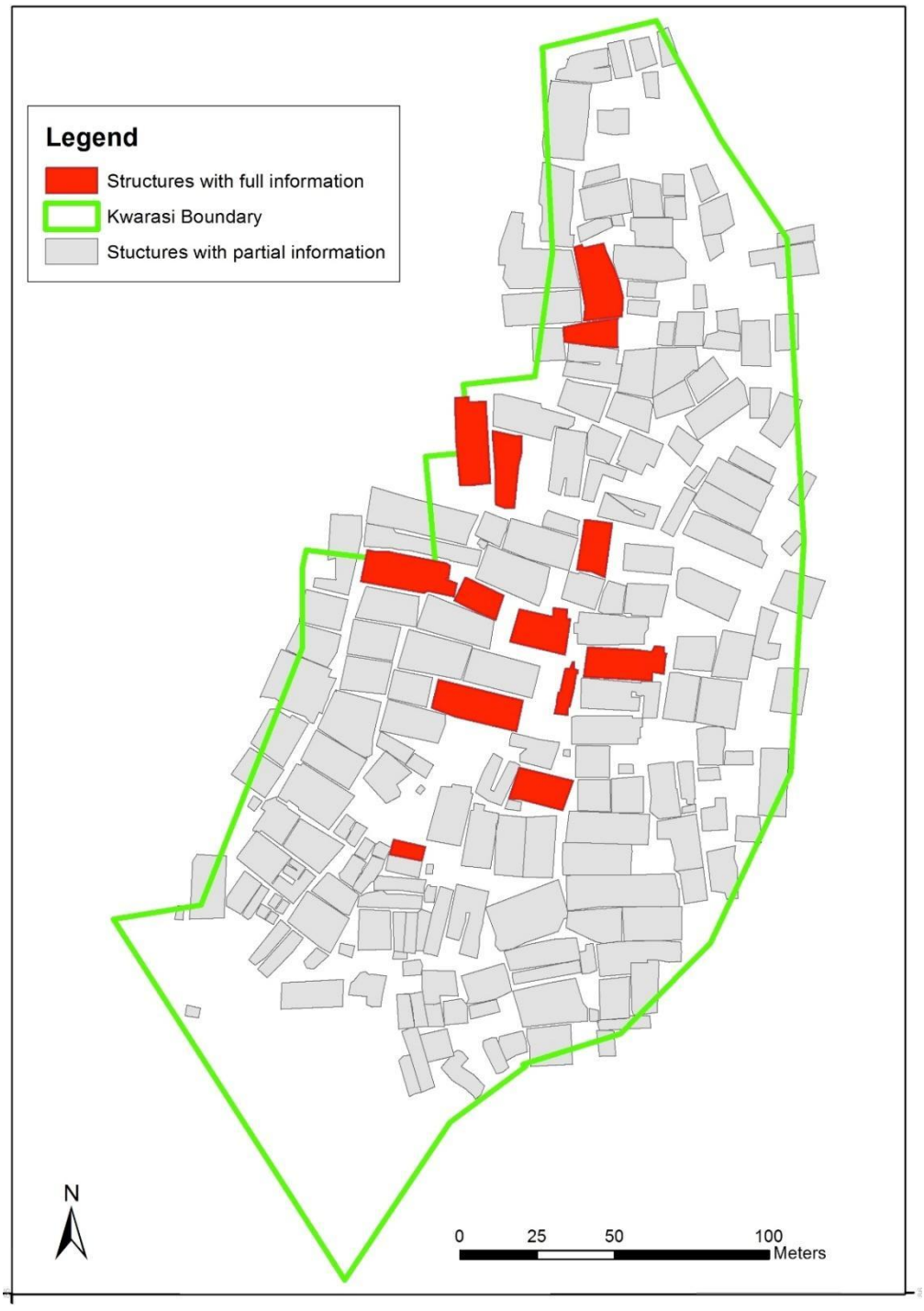

Figure 6. Structures with full information picked byGPS ground control points during verification

Informal cadastral database

Attribute informal cadaster information was formed within the STDM system by creating social tenure relationships between the party and attributes. Spatial units of the cadaster, the structures were represented in the STDM database system complete with structure numbers in order to identify their relative positions for identification. The structure numbers are linked to the party information by the structure number which is in this case the primary key of the

party relation. Figure 7 shows the structures with their numbers and GPS points that were used as datum to identify the structures that had full information.

Figure 7. Digitized structures as they appear on the STDM system, the GPS points that guided digitization and structure numbers are displayed

Certificate of residence

Certificates of residence were automatically generated based on the template by extracting information directly from the database. This enabled production of certificates of residence only for the persons that exist in the database and hence in the settlement scheme excluding non-residents. Figure 8 shows a certificate of residence generated automatically from the STDM system.

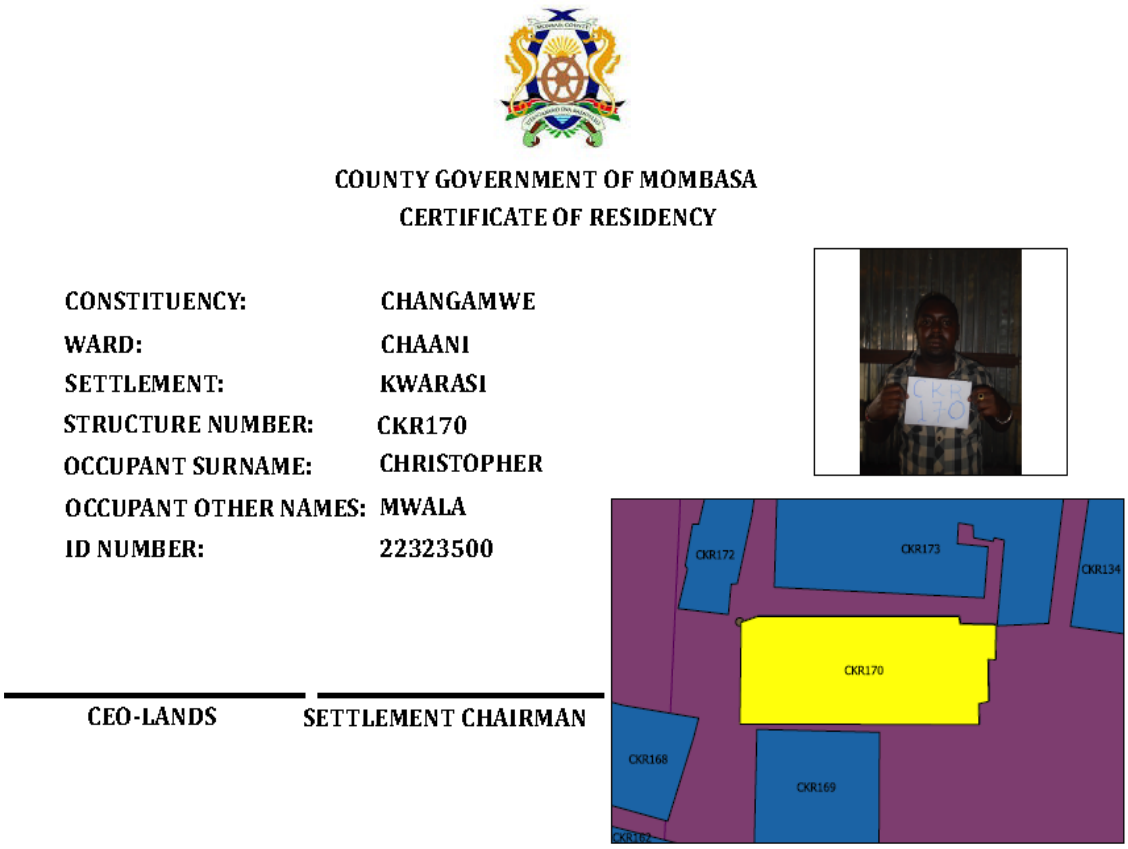

Figure 8. Certificate of residency generated directly from the STDM data base

In addition to certificates and maps, reports too can be generated from the database.

The overlay of Kwarasi informal settlement spatial layer of the structures over the Mombasa county spatial cadastral layer revealed the position of the structures in relation to the formal cadastral. Figure 9 shows the structures in Kwarasi informal settlement that fall on parcel number MN/V/3849 which is the Chaani site and service scheme (public land), those that fall on parcel number MN/V/2648 which is privately is privately owned and the others that fall on the boundary of the two parcel. This result would answer the question on what type of informal settlement is Kwarasi.

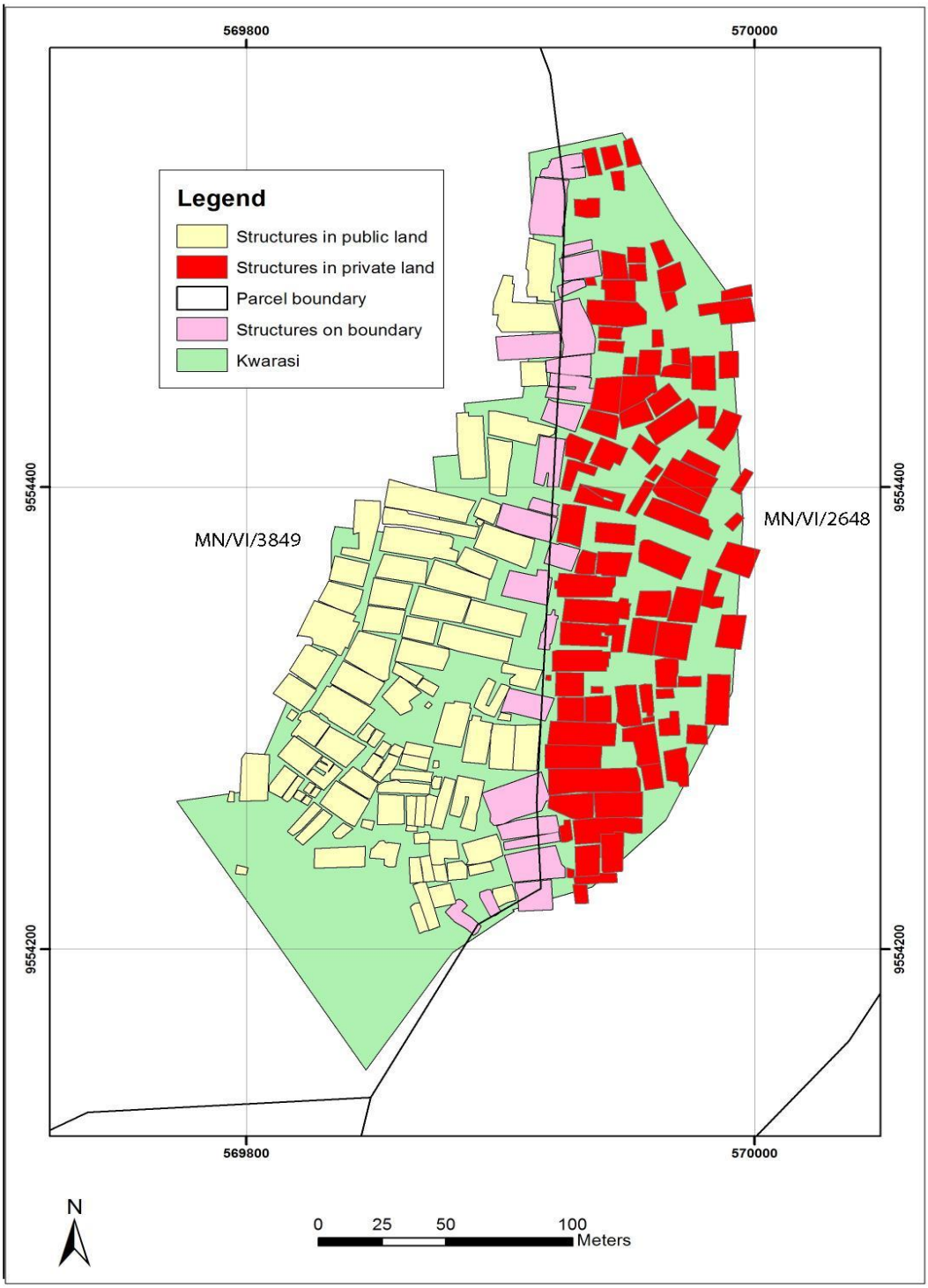

Figure 9.Structures in Kwarasi informal settlement that fall within the public, private and on the boundary between the two

CONCLUSION

The main objective of this project was to evaluate the Social Tenure Domain Model (STDM) land tool in the development of an informal Cadaster in order to support decision making for sustainable development intervention in the informal settlements in Mombasa County. With the use of the STDM land tool the project research has demonstrated from the results that spatial and attribute information data can be captured and managed in the STDM system.

Informal cadastral data acquisition, documentation, storage, manipulation and its integration with socio-economic, spatial and informal rights data in the informal settlements was achieved.

The party's informal rights over the structures within Kwarasi settlement scheme were adjudicated by participatory approach and the social tenure relationships documented hence creating an informal cadaster for the settlement using the Social Tenure Domain Model (STDM) to support decision making in sustainable development.

Certificates of residence were generated directly from informal cadastral database within the STDM system so that they only respond to residents of the informal settlement meaning that if you do not belong to the settlement as a land lord or tenant the system will not recognise you nor respond to your details.

The spatial component of the informal cadaster was overlaid over the formal cadastral layer of the Mombasa County and their relationship determined at the Kwarasi area. Hence position of structures in relation to the Mombasa cadastral layer for decision-making.

This shows that STDM has the capability to host an informal cadastral system and compare it with the formal cadastral spatial layer in the same environment as initially expected in the start of the research project hence STDM has successfully been evaluated and qualified as potential Land Administration tool for use in the enhancement of sustainable development of informal settlements in Mombasa County.

The experience of STDM at Kwarasi should be replicated to all other informal settlements in Mombasa County to create a complete overlay of all informal settlements of Mombasa County over the existing cadastral layer. Revision of the Mombasa cadaster layer needs to be prioritized for accuracy and up-to-date information. STDM should be used for both formal and informal cadastral as a tool to assist in decision making for implementing sustainable development, managing conversion from informal to formal land tenure and contribute as an input in land policy formulation.

STDM is recommended as a quick means of informal cadastral data capture, storage and management for the Mombasa informal settlements. Stakeholder participation is recommended for data collection in sustainable development.

While the County Government should maintain and manage the database for informal settlements in the entire county individual settlements should take care of their own data through committees formed by the county Government in order to manage changes.

Mombasa County needs to formulate an administrative framework to assist in the management of the informal cadastral to serve along the formal cadastral creating a continuum of rights as in Un-Habitat, 2008 (see Figure 2) for the ease of land management in Mombasa County.

ACKNOWLEDGEMENTS

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ESTABLISHMENT OF MOBILE BASED STREET AND PROPERTY ADDRESS SYSTEM FOR NAIROBI

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Abstract

Mobile Physical Addresses are of essential public good which facilitate the provision of services, increase efficiency for aid and emergency services, helps in navigation, contribute to the enhancement of social and economic development at the broader scale. While some

countries already have physical addresses systems which allow them to carry out their postal needs sufficiently, many countries around the world still lack a countrywide infrastructure due to technical, political or financial limitations at any stage of the addressing life-cycle.

The use and enhancement of geospatial technologies such as Geographic Information Systems (GIS) and remote sensing have made the process of creating and maintaining addresses more effective and cost-efficient. Since addressing data are inherently spatial, in the sense that parcels, roads, administrative boundaries and natural features have specific geographic locations in space, they can be easily collected, organized, mapped, visualized, and analysed in a GIS environment.

This research introduces geospatial concepts and relates them directly to the field of addressing by summarizing what should be done and describing the steps that a city should take to integrate GIS and other geospatial techniques into their own addressing projects. The process of using GIS for the creation of physical address system is discussed in this study. Additionally, the research introduces new techniques on how a cadastral base map with physical addresses can be uploaded in a mobile platform to collect new information, update, navigation, and service management within a city.

Key words: Address System, Cadastral Map, Geodatabase, GIS, Mobile Platform, Navigation

INTRODUCTION

Street and Property Addressing system is a component that is used for way finding. While some countries already have either postcodes and/or addresses which allow them to carry out their postal needs sufficiently, many countries around the world including Kenya still lack a countrywide infrastructure due to technical or financial limitations at any stage of the addressing life-cycle. The Universal Postal Union's (UPU) 2009 "Addressing the World (ATW) – an address for everyone" initiative emphasized the importance and helped to establish the foundations for the creation and adoption of addresses around the world. In 2012, the Doha Declaration C 82/2012 was passed which emphasizes the need to adopt new technologies for the development of address infrastructures, thus identifying the measures which should be taken to ensure that the ATW initiative can be fulfilled. (Stephanie R, Patricia V.2014). The absence of street names and property numbers coupled with the mounting rate of urbanization presents a disturbing development trend. Government of Ghana, (2010)

Recently, Nairobi City has experienced extremely rapid infrastructure growth. This has created a scenario where many buildings are not identified in the systems of the National and county Governments. Key services have not been extended to them and so inadequate identification systems have created a worrisome predicament for urban services. Street addressing is a System that makes it possible to identify the location of a plot or property on the ground, that is, to assign an address using a system of maps and signs that give the numbers or names of streets and buildings (Godin, L. 1987). This concept may be extended to urban networks and services: in addition to buildings, other types of urban fixtures, such as public standpipes, streetlamps, Surveillance Security cameras and taxi stands also get addresses.

Nairobi city has been confronted by demographic explosion and therefore urban management has become all the more challenging amid the current trend towards decentralization of urban services. With little experience in urban management, Nairobi City government has often been unable to develop the resources they need to deal with urban growth. Against this backdrop, systems for identifying streets, buildings, and plots have simply been unable to keep up with the pace of urbanization. As a result, more than 70% of the city streets in

Nairobi have no names and therefore no addresses. Statistics by the Courier Industry Association of Kenya (CIAK) show that lack of appropriate addressing system in Kenya has slowed down the growth in e-commerce. In Kenya alone, miss-deliveries owing to lack of clear addresses amount to 17 per cent, delayed deliveries are at 58 per cent and non-deliveries are at 25 per cent. The main objective is to set up a street and property address system database on built and spatial environment which will be the source of urban information and available to improve efficiency in location and service delivery to general Public by the relevant agencies, Kenyan government and Nairobi city county government. This is specifically to develop a Geodatabase of the city CBD that can be used by different Government units for efficient revenue collection and service delivery. It is also to design a mobile based data model capable of uploading location based property addresses to the web portal and to enable the portal to be updatable and expandable to accommodate future spatial developments and ease of navigation. The addressing system is not a substitute for a cadastral-type system of coordinates, but it can be a complementary to such a system. The World Bank Group, (2009).

MATERIAL AND METHODS

Study Area

The Study area will be Nairobi City's Central Business District (CBD). This is the area enclosed by Uhuru Highway, Haile Selassie Avenue, Moi Avenue and University way. This area is divided into two zones, 1 and 2, where the boundary is Kenyatta Avenue in the CBD.

Nairobi city lies at the Latitude of 1°16.9998′ S and a longitude: 36°49.0002′ E and covers an area of 695.1 square kilometers. Nairobi County borders Kiambu County to the north, Machakos County to the South and Kajiado County to the west. It has a population of approximately 3.2 Million people making it one of the highly populated counties in the country and in the east African region. Almost all people live in the urban areas since all parts of the County are urban areas.

Nairobi County is generally flat with an altitude of 1795 meters above the sea level, this attributes explains the moderate climatic patterns that are experienced in the county. The coldest period is experienced in June and July while the hottest months are January and December. The mean temperatures range between 10 degrees Celsius and 24 degrees Celsius but this is projected to change as a result of climate change and global warming of the necessary measures is not put in place. The County also experience bimodal rainfall that falls in different times of the year. The average amount of rainfall is approximately 1500mm per annum. Soils in Nairobi are red volcanic soils which contain all the major plant nutrients and this enables some of the residents to practise agriculture on large scale and small scale. There are several financial and micro finance institutions that provide financial services to the city residents.

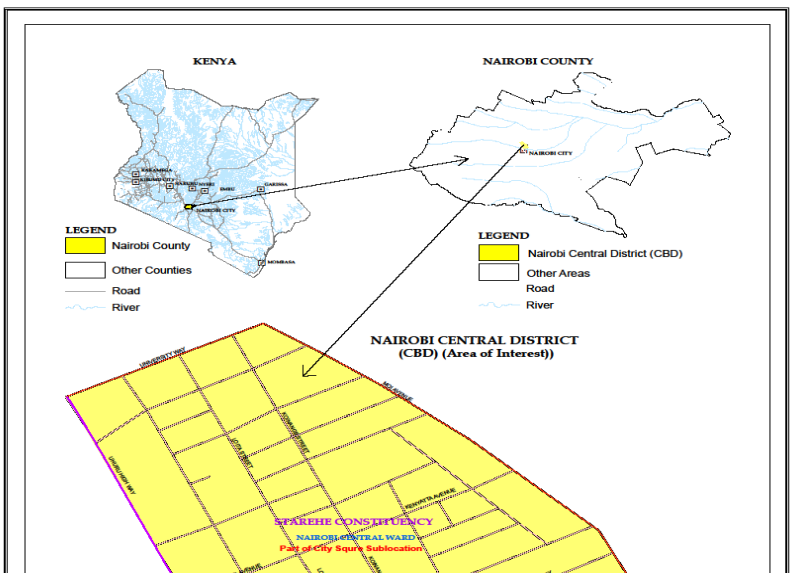

Figure 1: Study Area as an inset in the map of Kenya

Datasets and materials

Various datasets were obtained from different sources to compile a base map. The Cadastral map for Nairobi Central Business District was obtained from survey of Kenya. This was very useful in identifying the property boundaries, the Land reference numbers and the streets which are the basic information required for establishment of a physical address system. Aerial photographs were sourced from the Directorate of Urban and Metropolitan Development. The cadastral maps were overplayed on the aerial photographs to check on the accuracy of the cadastral data. Street centre lines data was sourced from the Kenya Urban roads Authority. Primary data was collected through field survey to identify all the names of the buildings on each property.

The Study Approach and Flow Diagram

Figure 2 graphically shows the steps followed in establishing a Mobile based Physical address system. The procedure involved data collection, base map preparation, codifying streets, assigning property numbers, preparation of street and property address map, database system design and development, address verification and confirmation by carrying out ground truthing, Updating of the Integrated Nairobi CBD properties address Geodatabase, Publishing the spatial data to the web portal and Configuring the web portal**.**

Figure 2: Research Flow Diagram

RESULTS AND DISCUSSIONS

A GIS Based Physical Address System base map is developed to be up loaded to the web portal.

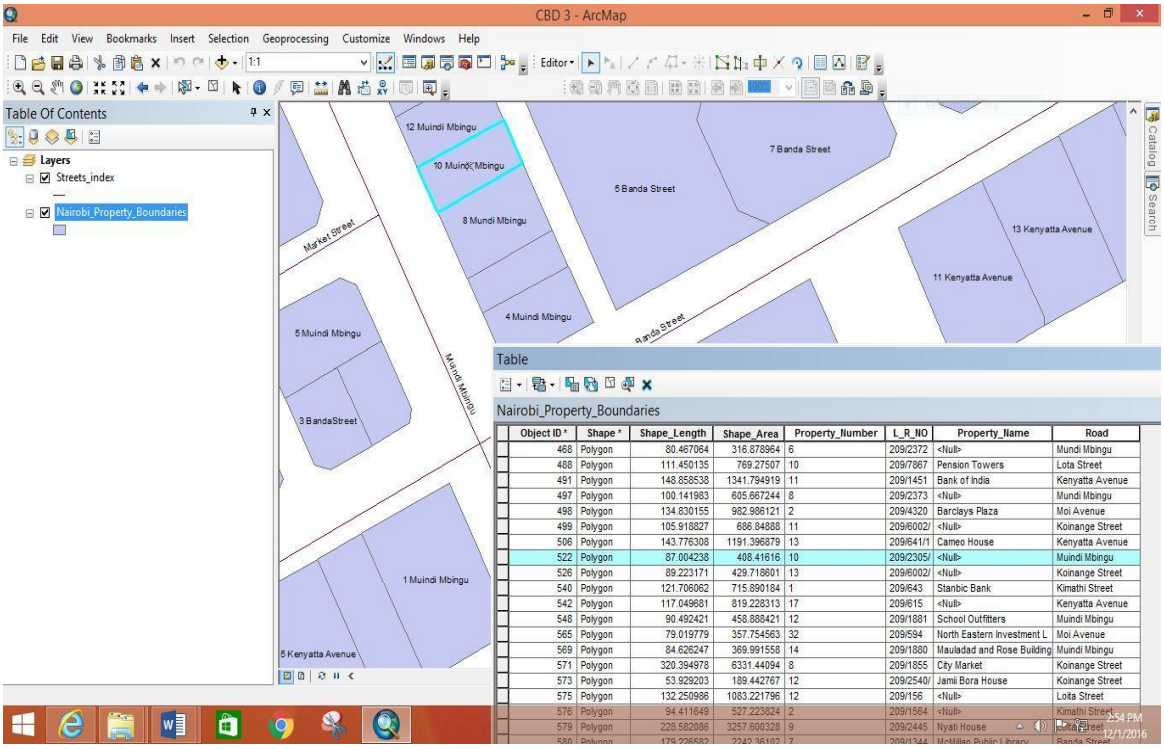

Figure *3: A GIS Based Physical Address System Database*

Development of the Web Portal

The service was published directly from ArcMap where one can expose the same map in both ways if one chooses so. One can alternatively publish feature services from a shapefile. The viewer's functionality is exposed through sections of prewritten code called widgets. Widgets can be thought of as the building blocks of Flex viewer applications. For example, one widget enables clients to switch between base maps in the map display, while a different widget allows clients to find an address on the map. In the Application Builder, one can choose and configure the widgets they want to include in one's viewer.

The portal was enabled so that one can add, remove, and customize widgets as needed. Many core widgets, including the Edit, Overview Map, and Query widgets, are provided with the installation, but one can also develop custom widgets using the ArcGIS API for Flex. ESRI ArcGIS Resource Center, 1995.

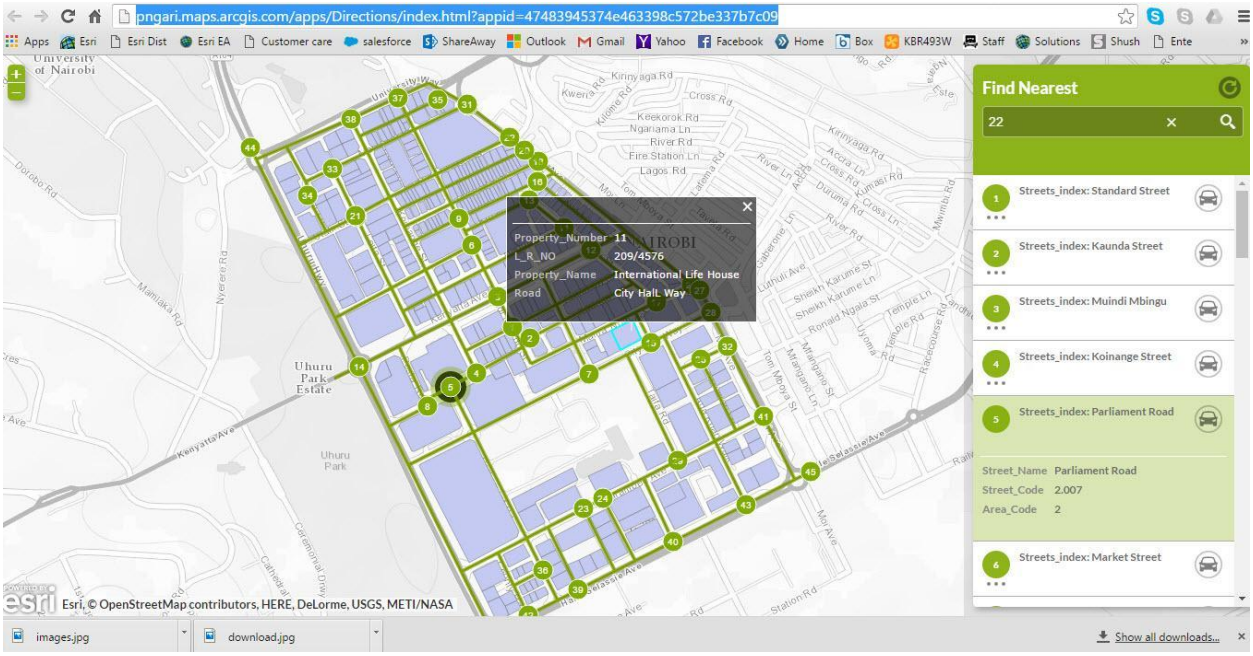

Figure 4 A published map that can be accessed universally for update and manipulation which includes navigation within the area of coverage.

Mobile Application Configuration

The mobile application was configured with the portal and enabled functionalities such as Collecting, updating information in the field and accessing the portal to download the maps for updates. This configuration also enables one to see on the portal, the location of the mobile device, capturing photos to geotag them and upload to the portal

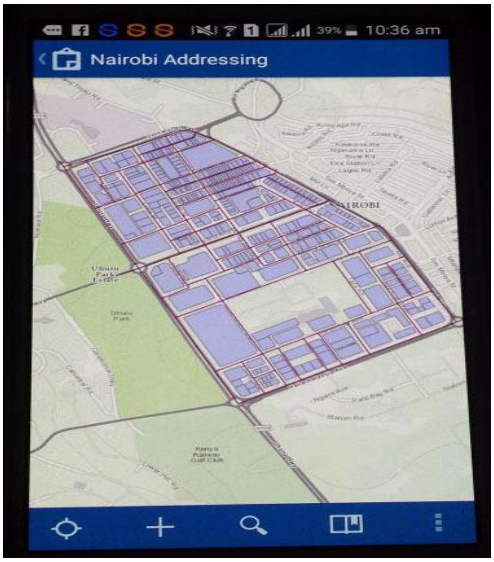

Figure 5: Mobile Application

Development of Navigation Module

Getting directions is a key feature of any addressing system, this is where the user will input the address into the mobile application and the application will give the user directions to that

address. The application will be able to provide a turn-by-turn navigation in both offline and online modes. Users can enter a destination address, landmark, or business name, and then the app automatically calculates directions and distance to the destination.

In feature development, real-time traffic data (where available) may also be factored and a prediction made on arrival time to the destination. The application was customized on the online portal and can be accessed via GPS android enabled phones, tabs or via web browsers depending on the gadget someone is using.

Below is a screen short of how the application functions.

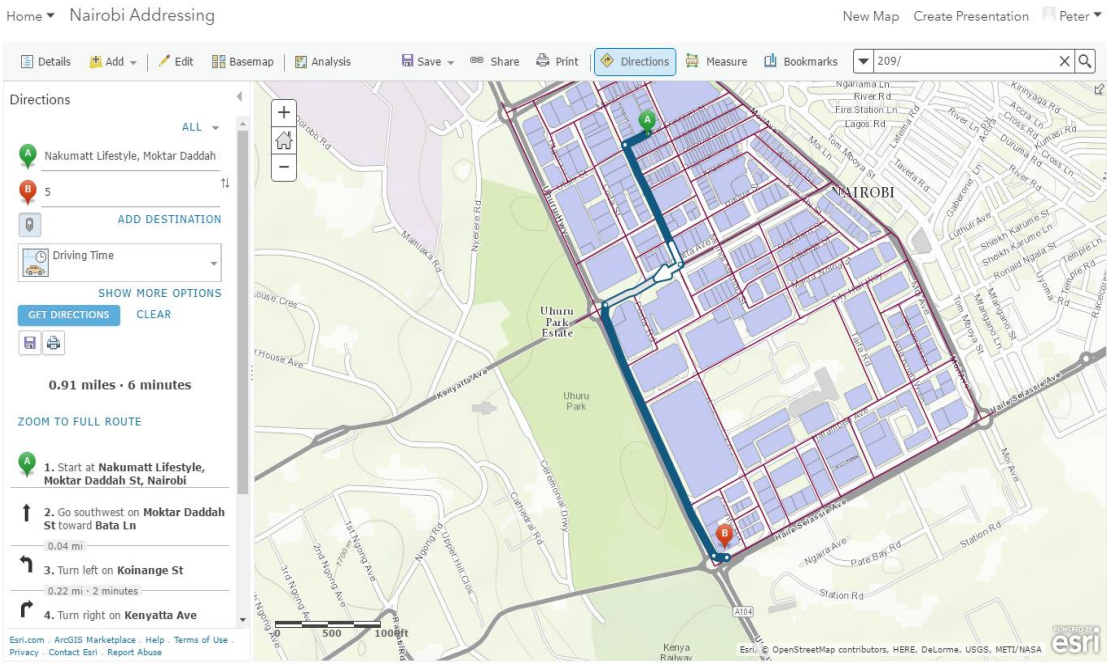

Figure 6: Navigation application

CONCLUSION

The use of GIS and geospatial technologies is highly effective and is increasingly used in the field of addressing. Mobile Physical address system can generated for the whole country. This should cover urban areas, informal settlements and rural areas. Urban areas have accurate cadastral information and well defined road network and therefore well suited to have accurate physical address based on property and road network.

Physical addressing System has a lot of social economic and political benefits as detailed in this research. However, this study was only conducted to the level of primary addressing of street and property (parcel) which is not adequate as it has addressed formal cadastral parcels of land and on established street network.

A general addressing procedure in GIS should be established to avoid multiple individual solutions that are not harmonised. The market should be regulated so that there are not thousands of small solutions proposed by private companies, but instead, a general framework which can be used to establish an internationally acceptable physical addressing system. This can be achieved by having a government agency taking a lead in matters of addressing while at the same time providing financial support necessary to drive the process.

Regulators are required at the national level to oversee and ensure that projects are following the best practices. Judging from the examples and discussions presented in this study, GIS is the future of mobile Physical addressing system.

Further research should be carried out to inform Secondary level addressing that will take care of multi-level building, rural and Informal settlements to have an address for everyone. Physical addressing system can be adopted as an e- commerce platform necessary to boost and spur economic growth for any country. This is made possible by many economic benefits associated with the system.

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USING GIS AND REMOTE SENSING IN ASSESSMENT OF WATER SCARCITY IN NAKURU COUNTY, KENYA

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Abstract

Water is at the core of sustainable development and is critical for socio-economic development, healthy ecosystems and for human survival. This research study has been carried out in Nakuru County, a tropical region in the Rift Valley of Kenya, bounded between latitude 0.28°N and 1.16°S, and longitude 36.27° E and 36.55°E .The objective of the study has been to use GIS and remote sensing in assessment of water scarcity using Land use Land cover area changes, standard precipitation index and crop yields. Landsat satellite images for the year 1985, 1995, 2005 and 2015 were used. Classification was done using maximum likelihood algorithm while classification accuracy assessment entailed the use of confusion matrix method and ground truth data. Post classification change detection results gave percentage cropland areas as 21 % in 1985, 29% in 1995, 53% in 2005 and also 53% in 2015. Eleven (11) ground rainfall stations and TRMM satellite rainfall data from 1985 to 2015 has been used to show meteorological drought. Validation of rainfall data done using correlation coefficient (R^2) and root mean square (RMS) methods showed that ground rainfall data and TRMM data correlate. Modelling of 3month SPI for each of the three seasons (MAM, JJA and OND) has been done using interpolation distance weighted method (IDW). 3 month SPI time scales curves gave October 1984 May 1993, and July 2004 as water scarce and dry seasons and were categorized as either Normal, moderately dry, severely dry and extremely dry. Crop yield trends curves showed crop yield decrease in this identified water scarce and dry years. Conclusion reached is that crop yields is not dependent on size of land ploughed only but mostly on rainfall quantities. Therefore the findings of this research can be used as drought monitoring tools.

Keywords: Land use Land cover (LULC), Meteorological drought, Standard precipitation index (SPI), Water scarcity

INTRODUCTION

Water is at the core of sustainable development and is critical for socio-economic development, healthy ecosystems and for human survival itself (International decade for action "Water life 2005-2015", 2015). On the other hand, agriculture is the largest consumer of water in Africa and Asia and plays an essential role in economic development and poverty reduction in these regions (Rebelo, Johnston, & Karimi, 2014).

Water scarcity caused fully or in part by human activities and reflects conditions with long-term imbalances between available water resources and demands (WIREs Water, 2015), can lead to common effects like reduced production of crops, higher costs of commodities and political stresses (Stratfor global intelligence, 2014). The water scarcity is being further compounded by droughts which affect both surface water and groundwater resources and can lead to reduced water supply, deteriorated water quality, crop failure, and disturbed riparian habitats. Hence ,this research study has been carried because understanding drought and modelling its components have drawn attention of ecologists, hydrologists, meteorologists, and agricultural scientists (Belal, El-Ramady, Mohamed, & Saleh, 2012).

Furthermore, uncertain effects of future climate change on water scarcity can add to the need for clarity on the concept of water scarcity since water scarcity may also limit food production and supply, putting pressure on food prices and increasing countries' dependence on food imports.(UN Water, 2003).Because of these facts this research study in Nakuru County, Kenya has been carried out in order to investigate if there is a reason behind decrease or increase of crop yield during different rainfall seasons. A study had been previously carried to show the relationship between economic efficiency and farm size (Mburu, Ogutu, & Mulwa, 2014) but none has been carried out to show that rainfall quantities is the reason to decrease in crop yields and not the farm size.

METHODOLOGY

Description of the study area

Nakuru County is located in the Great Rift Valley region and is very reach in diversity since it has as tourist attraction sites for local and international tourists caused by its beautiful slopes of Rift valley, Menengai crater, Mau complex and several lakes including the Lake Nakuru and Lake Elementaita. It is a region in Kenya bounded between latitude 0.28°N and 1.16°S, and longitude 36.27° E and 36.55°E. It also has Sub Counties including Kuresoi, Naivasha, and Molo, Nakuru town, Rongai and Subukia amongst others. Figure 1 below shows the location of the study area

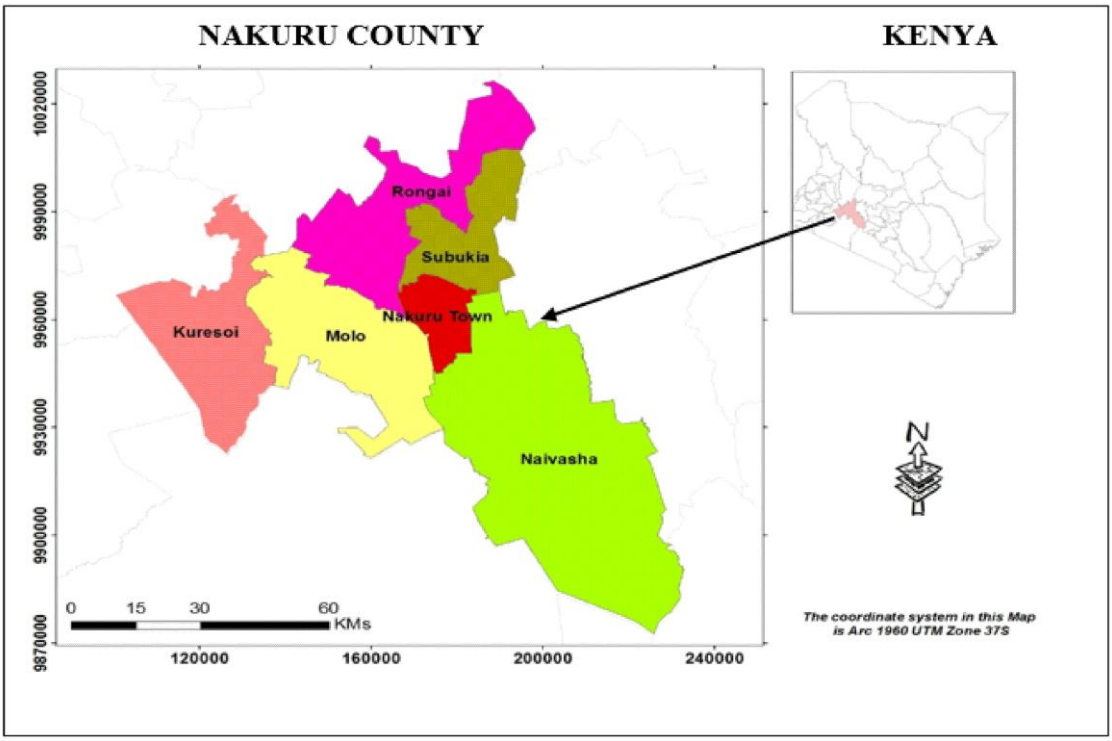

Figure 1. Map of the study area

Objectives of study

a) To characterize various land cover and land uses within Nakuru County and to analyze if land occupied by crops affects the crop yield.
b) To model water scarce and dry seasons in the study area using standard precipitation index (SPI) and according climatic seasons(MAM, JJA and OND)
c) To show the relationship between standard precipitation index (SPI) and crop yields trends.

Datasets, their sources and the flow diagram of methodology

This project involved three types of data sets which includes; Land sat TM satellite imageries, rainfall data from both ground and tropical rainfall monitoring mission (TRMM) and crop yield data. Land sat TM images were downloaded from USG through Regional Centre for monitoring and resource development (RCMRD), ground stations rainfall data were collected from Kenya meteorological station while rainfall satellite data were downloaded from TRMM satellite through precipitation processing system (PPS) .On the other hand, crop yield data were collected from both Ministry of Livestock and fisheries office in Nairobi city Headquarters and the Nakuru County office, department of agriculture. The software used was; Erdas imagine 2014, Arc Map 10.1 Python 2.7 python and Microsoft excel 2013.Table 1 below shows the data type, their sources and the software used.

Table 1. Data types, their sources and software used.

Data type	source	Software used
Landsat TM satellite imagery	USG through Regional centre for monitoring of resources and Development(RCMRD)	ERDAS imagine 2014
Rainfall data	Kenya meteorological department Headquarters Nairobi and Trophical Rainfall Monitoring Mission(TRMM) through (PPS-Precipitation processing system)	Microsoft excel 2013, python 2.7 phthon, SPI program, Arcmap 10.1 Microsoft excel 2013
Crop yield data (90kg bag/Ha)	Minstry of a Agriculture, livestock and fisheries(Headquarters ,Nairobi) and Nakuru countyoffice(department of Agriculture)	Microsoft excel 2013

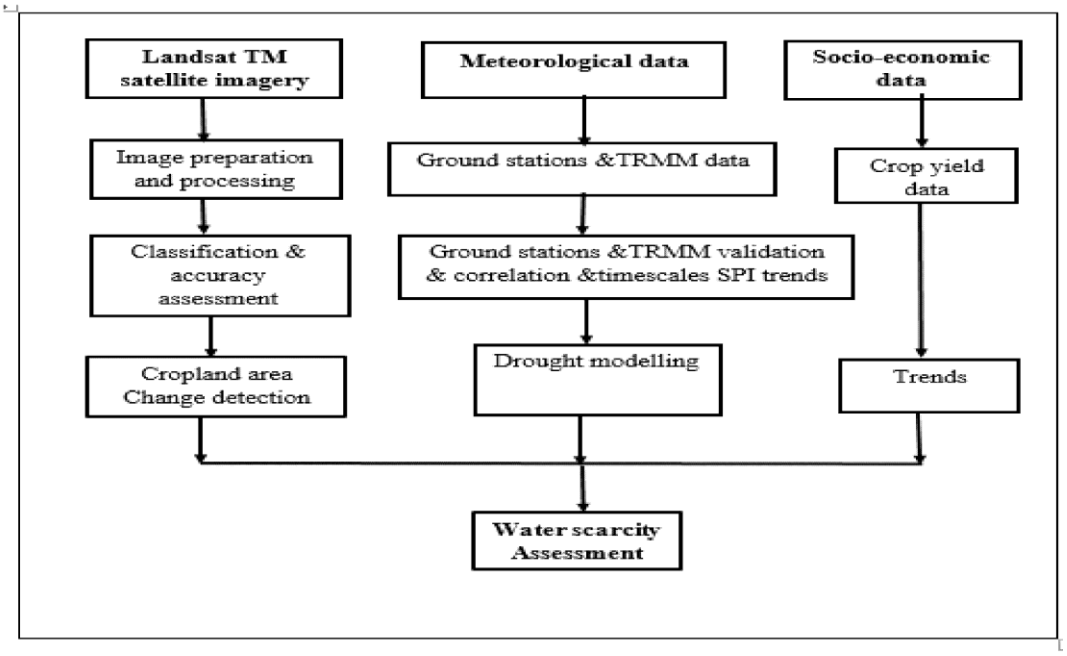

Figure 2. Flow diagram of methodology

In order to achieve water scarcity assessment the methodology employed involved integration of Land sat TM images, meteorological rainfall data and socio economic crop yields data. Land sat TM images were prepared, processed and classified. Classification accuracy assessment and area change detection was done. Meteorological data was the ground rainfall data and the TRMM rainfall satellite data which was correlated and validated before SPI timescales curves ware drawn. From the SPI timescales curves for long term time series from 1985 to 2015, drought and water scarce years were identified and modelled using McKee et al., 1993 SPI categories. Crop yields trends curves were drawn so as to come with SPI models and be able to justify the existence of water scarcity and drought in the identified years. Figure 2 is the flow diagram of methodology.

Data processing and analysis

Land Use Land Cover (LULC) classification

In order to get the areas covered by cropland,land use land cover (LULC) classification was carried out . Four(4) Landsat images of 10 years interval each with 30metres resolution were used.These images were were for years 1985,1995,2005, and 2015, and they were in tiff format since they had already been corrected for radiometric and geometric distortions errors. The processing was done using both Erdas imagine software 2014 and Arcmap 10.1.

These processess were; layer stacking,Mosaicing,reprojection,subsettin/clipping ,classification ,accuracy assessment and area change detection .The Landsat images scenes covering the study area were 169/60,169/61,168/60 and 169/61. Five classes chosen were forestland,grassland,cropland,wetland and otherland.The aim in this classification basically being to know the amount of land occupied by crops. Supervised method of classfication was used and the classification algorithm was maximum likelihood classifier.

The results of classification were presented as percentage in piecharts through the use of microsoft excel 2013 software.

Validation and correlation of ground station rainfall data with TRMM rainfall data

Validation of the both ground station rainfall data and TRMM rainfall data sets was very vital in order to do accuracy assessment of the data.Therefore two stations with 30 years timeseries rainfall data were used to validate with TRMM rainfall data.Validation was done starting from January 1998 to December 2015 since TRMM data started from 1998. Both Nakuru meteorological station (New) and Olkaria Geothermal ground stations had two sets of data overlapping for period 1998 to 2015.Ground station data was validated with TRMM rainfall data having horizontal resolution of 0.25 degrees by 0.25 degrees area covarage. Root mean square (RMS)and correlation coefficent (R^2) methods were used to do this error validation

SPI trend curves and identifying of seasonal water scarce and dry years and seasons

Data from eleven (11) ground rainfall stations with which missing data had been filled using TRMM rainfall data were used. From each ground station data, SPI trend curves were plotted using Microsoft excel 2013 program. SPI program enabled the generation of SPI timescales for long term series. Each station had five (5) SPI trend curves representing 1month SPI, 3month SPI, 6 month, SPI 9 month SPI and 12 month SPI timescales respectively. IDW interpolation method was used to map the distribution of drought and water scarcity for the years identified to be having low and negative values. McKee et al.1993 SPI classes and categories were adopted whereby, -0.99 to - 0.99 is Normal, -1.0

to1.49 is moderately dry, -1.5 to -1.99 is very dry and -2 and less is extremely dry. Table 2 below is showing SPI categories by McKee et al., 1993.

Table 2. SPI categories by McKee et al., 1993

SPI Value	Class
2.0+	Extremely wet
1.5 to 1.99	Very wet
1.0 to1.49	Moderately wet
-0.99 to 0.99	normal
-1.0 to1.49	Moderately dry
1.5 to -1.99	Very dry
-2.0+	Extremely dry

Crop yields trends

Time series Crop yield were data collected for two crops; maize and wheat .These long series data from 1985 to 2015 were organized in Microsoft excel sheets and trend curves drawn. The crop yield was in 90 kg bags per hectare. Figure shows the crop yields trends for both maize and wheat for the period 1985 to 2015

RESULTS AND DISCUSSION

LULC classification results

LULC classification results revealed that in the year 1985 land under cropland was 21% in the year 1995 was 29 %, and also 53% in both the year 2005 and 2015as seen in the figure 4**.** On the other hand,classification accuracy assessment done gave overall accuracy of 82.68% in the year 1985, 84.5% in the year 1995, 84.3% in the year 2005 and 84.78% in the year 2015 as illustrated in table 3,4,5 and 6 below.

Table 3 Classification accuracy assessment for 1985.

		Ground Classes						
		Forestland	Grassland	Cropland	Wetland	Otherland	Total	**User Accuracy**
Map Classes	Forestland	63	3	1	1	2	70	**90.00%**
	Grassland	1	47	3	1	4	56	**83.93%**
	Cropland	2	2	54	1	4	63	**85.71%**
	Wetland	1	3	2	19	1	26	**73.08%**
	Otherland	3	4	3	2	27	39	**69.23%**
	Total	70	59	63	24	38	254	
	Producer accuracy	**90.00%**	**79.66%**	**85.71%**	**79.17%**	**71.05%**		
Overall accuracy	**82.68%**							

Table 4 Classification accuracy assessments for 1995,

		Ground Classes						
		Forestland	Grassland	Cropland	Wetland	Otherland	Total	**User Accuracy**
Map	Forestland	39	3	1	0	0	43	**90.70%**

Classes	Grassland	1	57	2	1	1	62	**91.94%**
	Cropland	3	2	42	2	4	53	**79.25%**
	Wetland	1	3	1	18	2	25	**72.00%**
	Otherland	2	2	0	0	13	17	**76.47%**
	Total	46	67	46	21	20	200	
	Producer accuracy	**84.78%**	**85.07%**	**91.30%**	**85.71%**	**65.00%**		
Overall accuracy	**84.50%**							

Table 5 Classification accuracy assessments for 2005.

		Ground Classes						
		Forestland	Grassland	Cropland	Wetland	Otherland	Total	**User Accuracy**
Map Classes	Forestland	49	3	0	1	3	56	**87.50%**
	Grassland	3	51	2	0	1	57	**89.47%**
	Cropland	1	2	55	3	4	65	**84.61%**
	Wetland	1	3	0	17	2	23	**73.91%**
	Otherland	2	1	3	0	16	22	**72.73%**
	Total	56	60	60	21	26	223	
	Producer accuracy	**87.50%**	**85.00%**	**91.67%**	**80.95%**	**61.64%**		
Overall accuracy	**84.30%**							

Table 6 Classification accuracy assessments for 2015.

		Ground Classes						
		Forestland	Grassland	Cropland	Wetland	Otherland	Total	**User Accuracy**
Map Classes	Forestland	57	2	1	0	1	61	**93.44%**
	Grassland	2	39	4	0	3	48	**81.25%**
	Cropland	3	4	62	3	2	74	**83.78%**
	Wetland	0	4	0	14	3	21	**66.67%**
	Otherland	0	2	1	0	23	26	**88.46%**
	Total	62	51	68	17	32	230	
	Producer accuracy	**91.94%**	**76.47%**	**91.18%**	**82.35%**	**71.88%**		
Overall accuracy	**84.78%**							

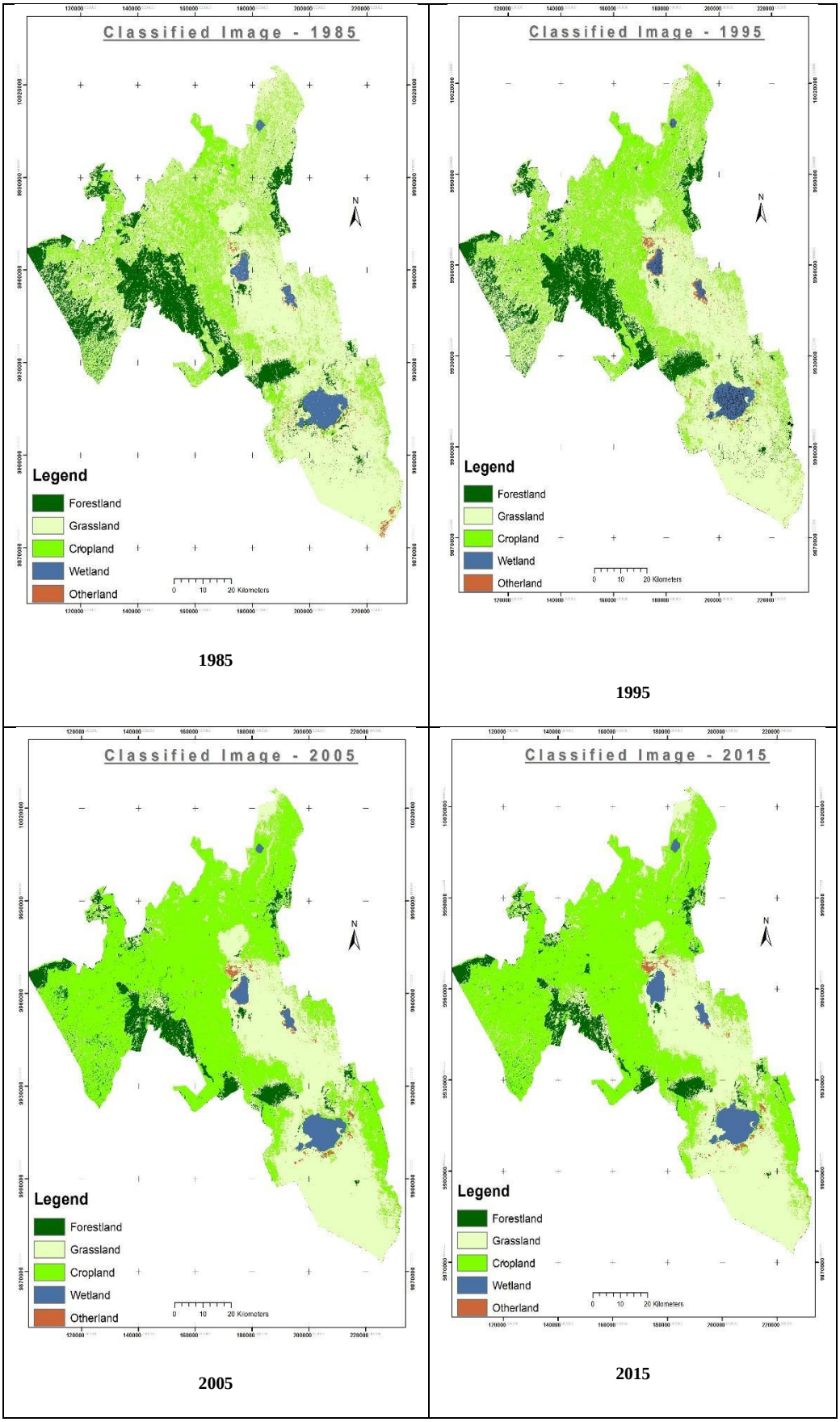

Figure 3 .Classified images for years 1985, 1995 2005 and 2015.
Source. Landsat 5 taken at March 1985, Landsat 5 taken at April 1985, Landsat 7 taken at April 2005, and Landsat 8 taken at March 2015

Figure 3 above shows classified images of 1985, 1995, 2005 and 2015.Five classes chosen were; Forestland, grassland, cropland, wetland and other land.

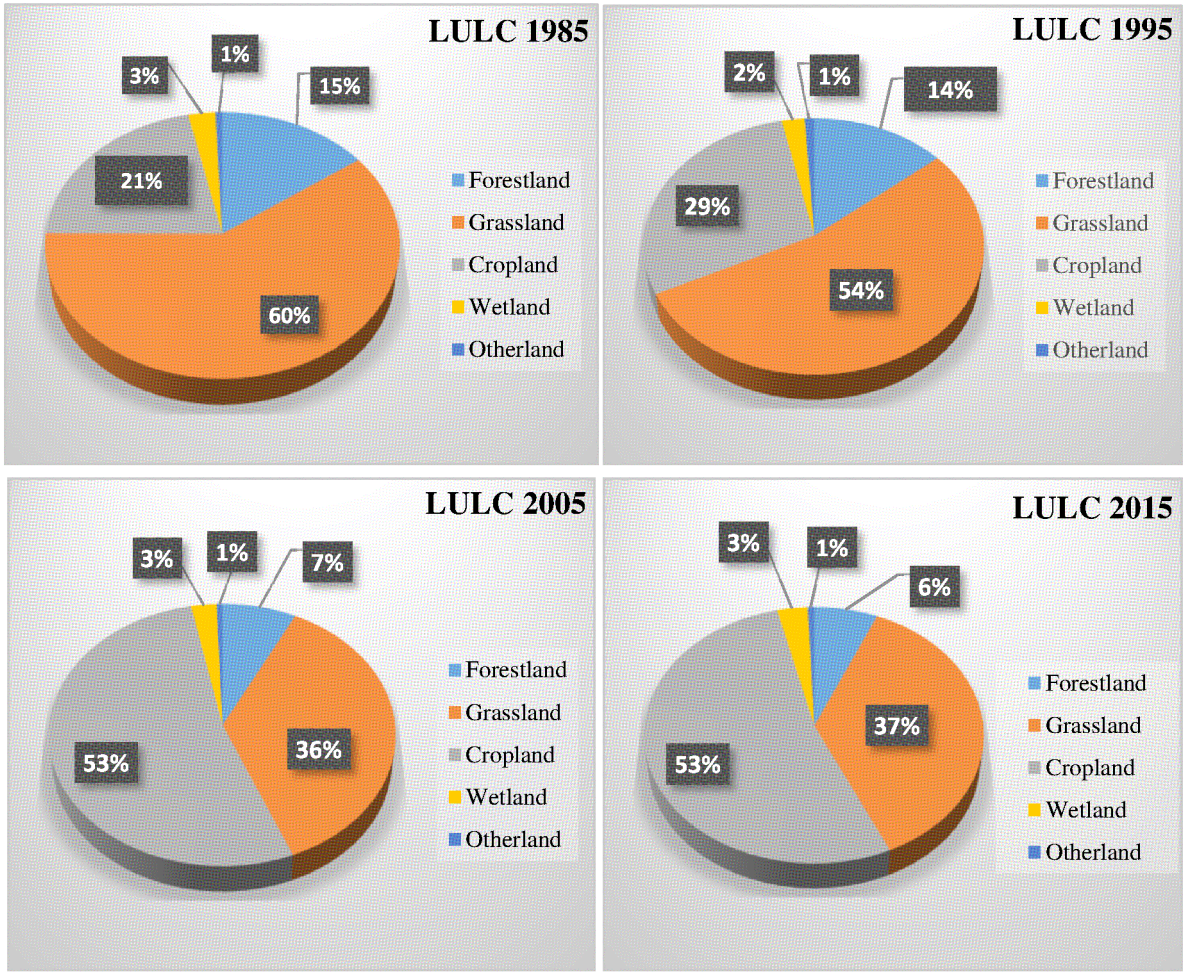

Figure 4. LULC areas in percentage

From figure 4, cropland areas are 21% in the year 1985, 29% in year 1995, and 53 % in both the years 2005 and 2015

SPI trends , Rainfall data validation ,correlation and water scarcity and drought modelling

In this research, validation of two rainfall data sets was carried out for accuracy assessment purposes.Results revealed that there was noticible correlation between ground rainfall data and the TRMM data.Validation of data sets for Nakuru meteorelogical station and Olkaria station.Correlation coefficient(R^2) is within allowable limit since is 0.725 for Nakuru meteorelogical station while olkaria station is 0.7501.This could be mainly because both ground rainfall data and TRMM have surface vertical resolution. TRMM occupies spatial extent of 25km by 25 km while ground station has point accuracy but all experiences some linearity in terms of surface resolution. Likewise the root mean square (RMS) method showed some sort of lack correlation since Olkaria had RSS of 672101.17 and the RMSE was 71.35, while Nakuru meteorological station had RSS of 296167.85 and RMSE of 39.27. Figure 5 shows correlation and validation for TRMM and ground data for Olkaria

meteorological station and figure 6 shows correlation and validation for TRMM and ground data for Nakuru meteorological station

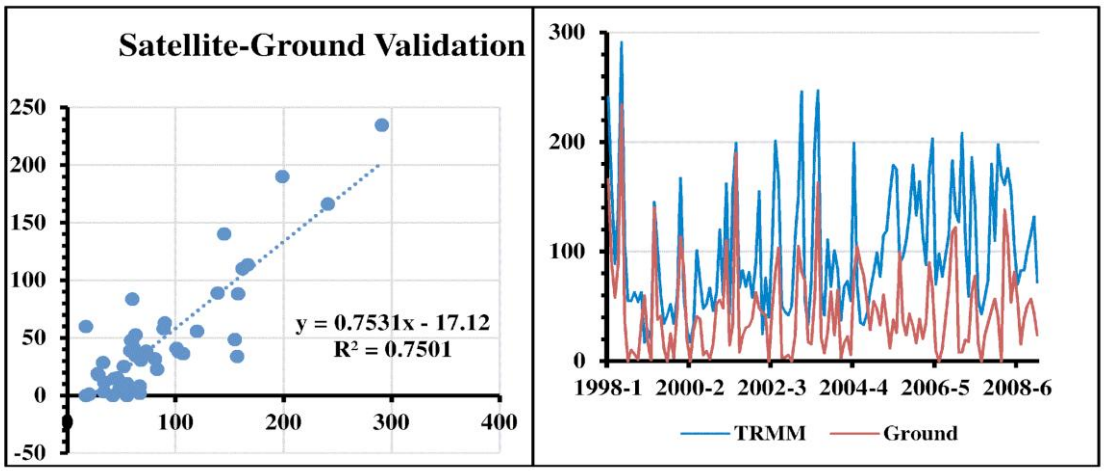

Figure 5. Correlation and validation for TRMM and ground data for Olkaria meteorological station

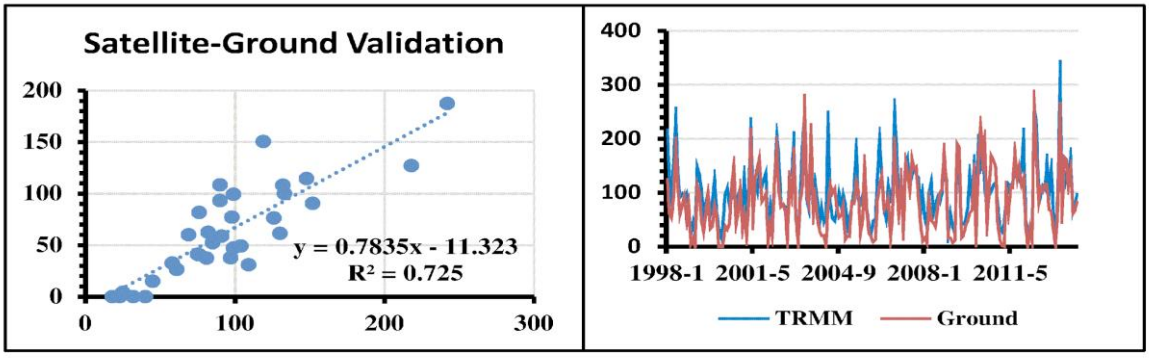

Figure 6. Correlation and validation for TRMM and ground data for Nakuru meteorological station

Standard precipitation index (SPI) application in rainfall modelling.

This procedure of rainfall modeling was done through the use of SPI timescales trend curves.From these various timescalescurves , water scarce and dry years were identified.These were the season months which had the negative SPI values.Since SPI used normal distribution curve,the values are normalized. Computation of the SPI involves fitting a gamma probability density function to a given frequency distribution of precipitation totals for a station. Figure 7 shows SPI curves for various timescales for Nakuru meteorological rainfall station and figure 8 shows SPI curves for various timescales for Olkaria meteorological station.These SPI timescales curves graphically shows the SPI values;highest being the positive value and lowest is the negative value according to McKee *et al*.,1993 in table 2.On the other hand ,Kenya has three seasons according to Kenya meteorological station. (Kenya Meteorological Department, 2016). These seasons are MAM, JJA,and OND, hence dry periods for these seasons were identified from the curves. Figure 9, figure 10 and figure 11 shows the SPI timescales curves for these three climatic seasons.Modeling the distribution of dry areas was done using IDW and categories or classes were according to McKee *et al*., 1993.

Studiess have shown that 3Month SPI is what is being used to monitor agricultural drought and soil moisture (World Meteorological Organization, 2012).Therefore the season curves are in figure 9, figure 10 and figure 11 respectivly.

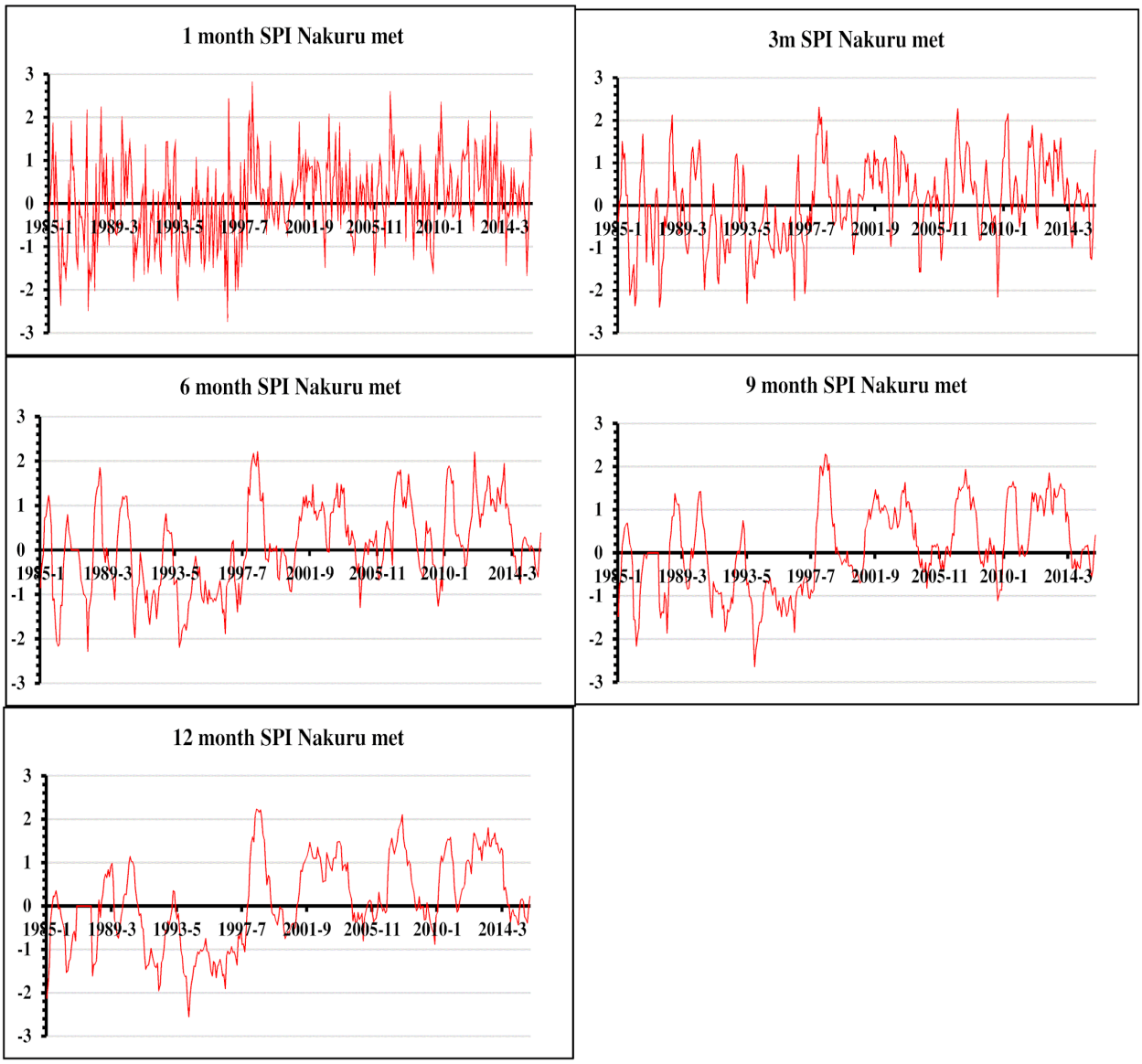

Figure7. SPI time scales curves for Nakuru meteorological station

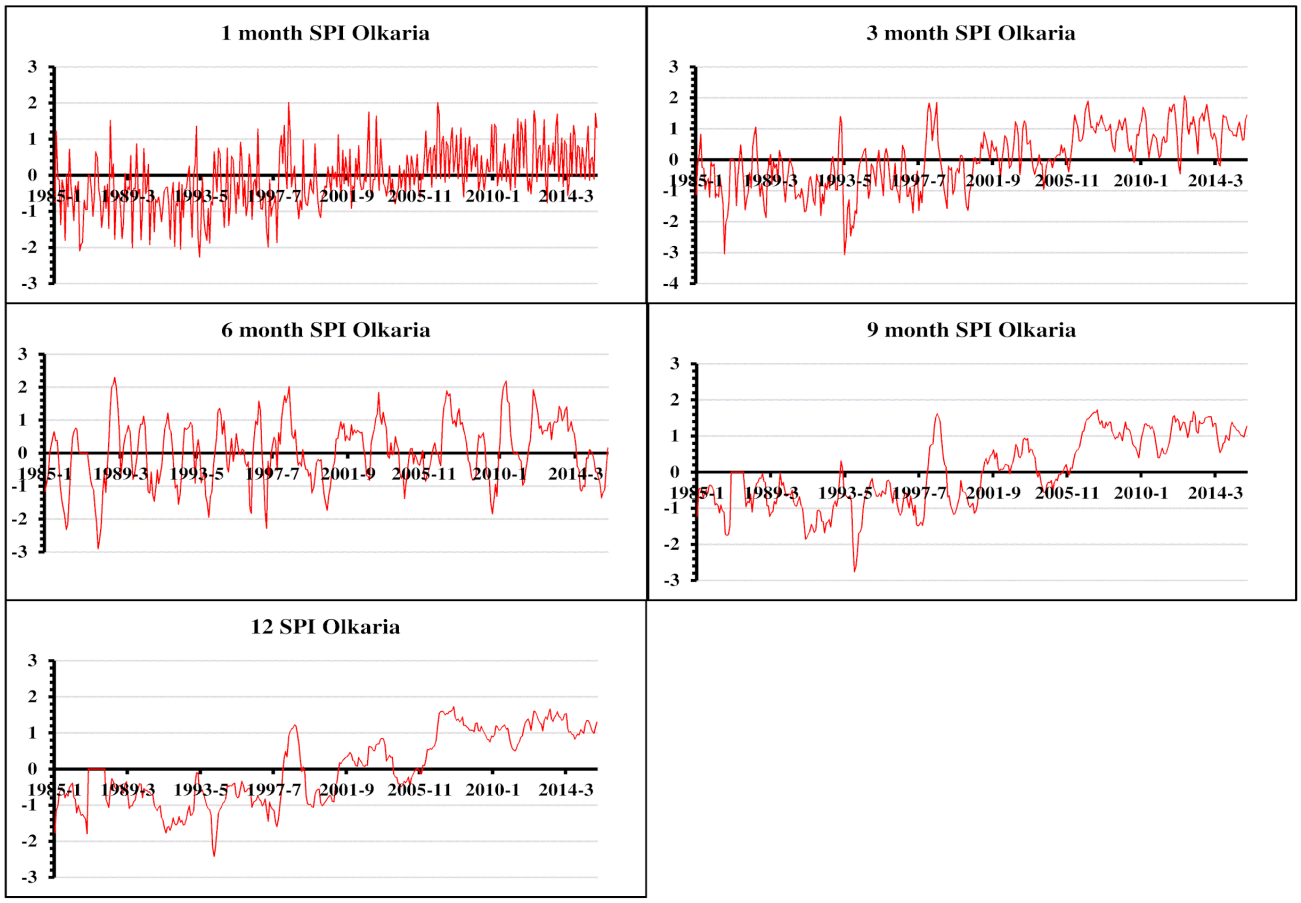

Figure 8. SPI time scales curves for Olkaria meteorological station

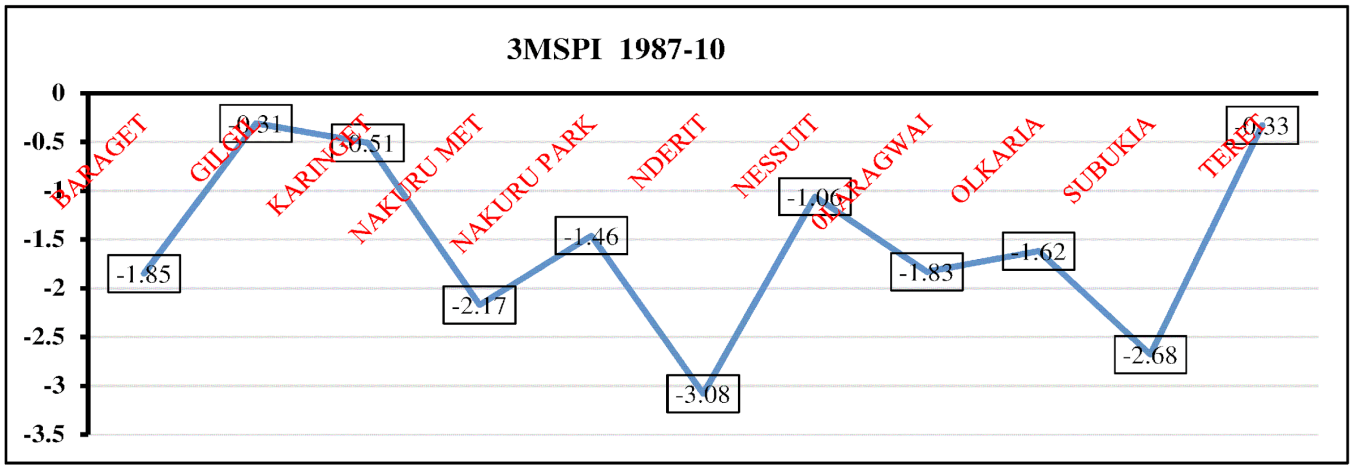

Figure 9. 3MSPI for October 1987 (OND season)

Figure 9 above shows 3month SPI for the month of October in the year 1987.October falls under OND season which is short rains reason as per the Kenya meteorological department report (Kenya Meteorological Department, 2016). The year 1987 was identified as water scarce and drought year, and from figure 9 above, all the 3 month SPI values were negative with Nessuit ground station in Molo Sub County having 3month SPI value of -3.08

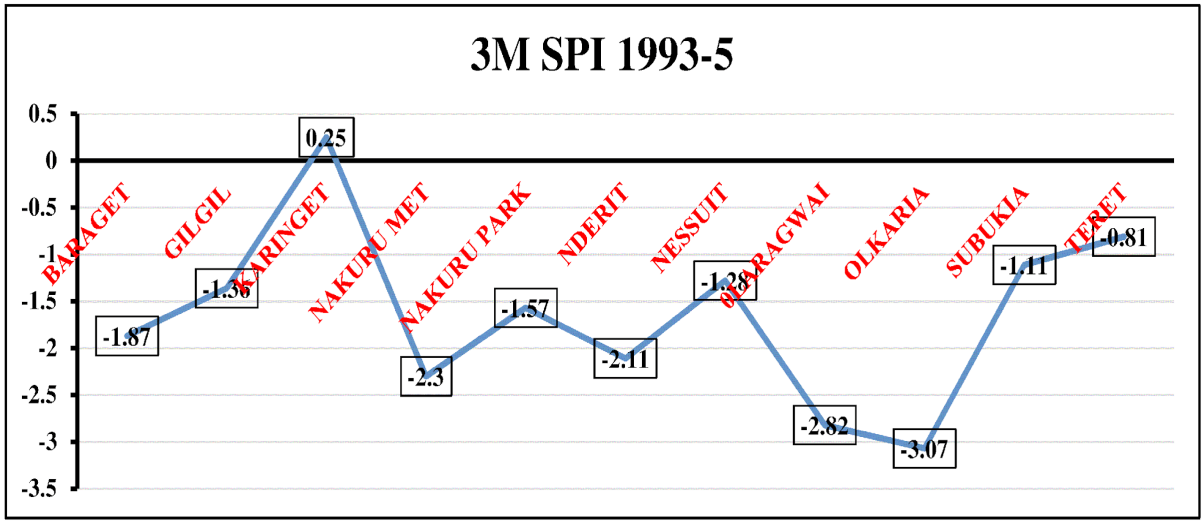

Figure 10. 3MSPI for May 1993 (MAM season)

The year 1993 was also identified as the water scarce and drought year.The month of May which falls under MAM season which is long rains period had contrary results because the 3month SPI (3MSPI) values were low since the highest positive value was 0.25 at Karinget ground rainfall station in Kuresoi sub county and lowest negative value was -3.07 in Subukia ground rainfall station in Subukia Sub county.This is shown in figure 10 above.

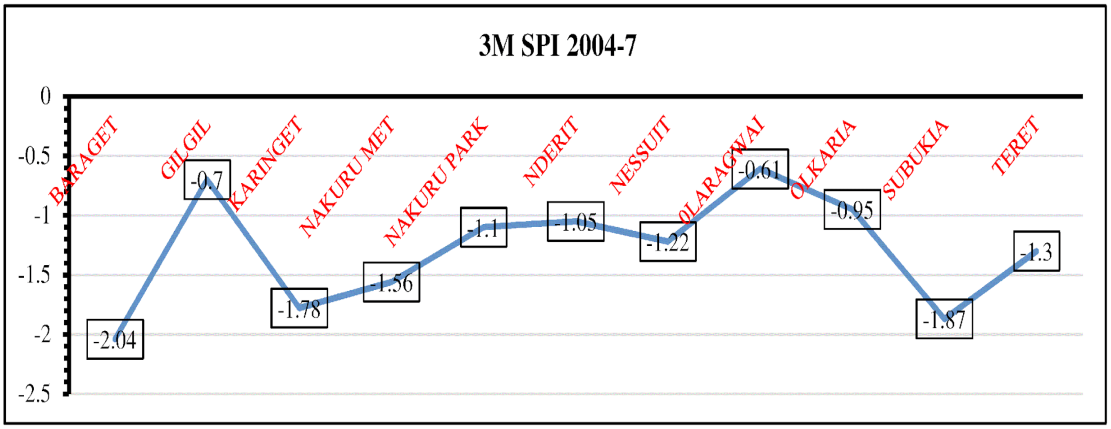

Figure 11. 3MSPI for July 2004 (JJA season)

Above figure 11 is for the year 2004 which was also identified as water scarce and drought year. All the 3 month SPI values were negative during the month of July which is JJA period categorized as dry season by Kenya meteorological department. Highest 3month SPI negative value was -2.04 at Baraget ground rainfall station in Kuresoi sub county and the lowest 3month SPI negative value was -0.61 Olkaria ground rainfall station in Naivasha Sub county.

Identifying water scarcity and drought in MAM, JJA, and OND seasons

Also,in Kenya ,there are three seasons;MAM is the long rains season,JJA dry spelt season and OND is the short rain season (Kenya Meteorological Department, 2016)**.**From all the five(5) time scales SPI trend curves of each of the ground station, water scarce and drought years and seasons were identified**.** Table 7 shows the identified drought years and seasons.

Table 7. Identified drought years and months in MAM, JJA, and OND seasons

	MAM	JJA	OND
1month SPI	1996_April	2009_June	1994_December
3month SPI	1993_May	2004_July	1987_October
6month SPI	1986_March	1993_August	1987_December
9month SPI	1997_March	1992_June	1993_November
12month SPI	1994_March	1992_August	1987_December

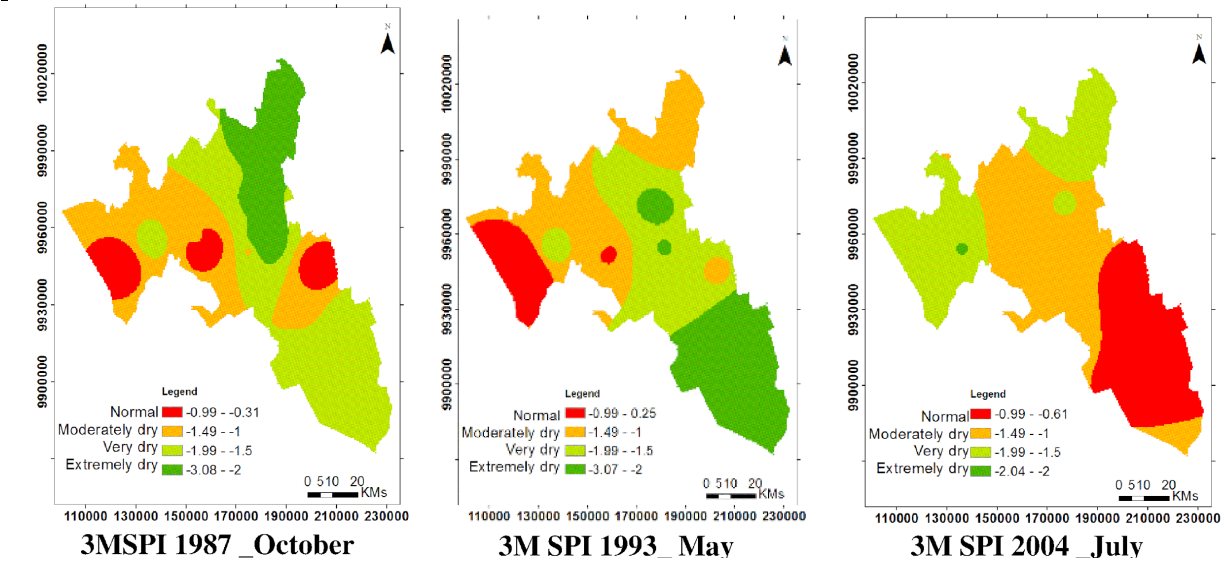

Figure 12. Modelling of identified drought years using 3MSPI in MAM, JJA and OND season

From above figure 12**,** 3 month SPI for October 1987 showed that the highest SPI negative value is -3.08 ,but it was during "short rains" season ,that is, (OND season) and most parts were categorized as very dry (-1.5 to-1.99) as seen in figure 12 above . Compared to crop yields graph, results are agreeing because the yield had decreased in this year. Upon analysing the figure12 again, 3month SPI of the month of May 1993 showed that there was a balance in distribution of moderately dry, very dry and extremely dry. Areas with normal rainfall were very small. These results explain the fact that there was a lot of water scarcity and drought during this season. This is confirmed well in the crop yields graph in figure13 which showed a decrease in yields. Same case is displayed in the year 2004 where July which is under JJA season categorized as dry season by Kenya meteorological department .Here, the extremely dry area is very small while normal, moderate and very dry are balanced distribution.

Crop yield data processing and trending of crop yield graphs

Long time series data for two dominant crops planted in Nakuru were organized in excel sheets and trend graphs drawn. The years covered was 1985 to 2015 and the two crops were maize and wheat. Results revealed that the trends for the two crops were in correlation and also it is evident that crop yields were low in the year 1987, year 1993 and the year 2004 as seen figure 13

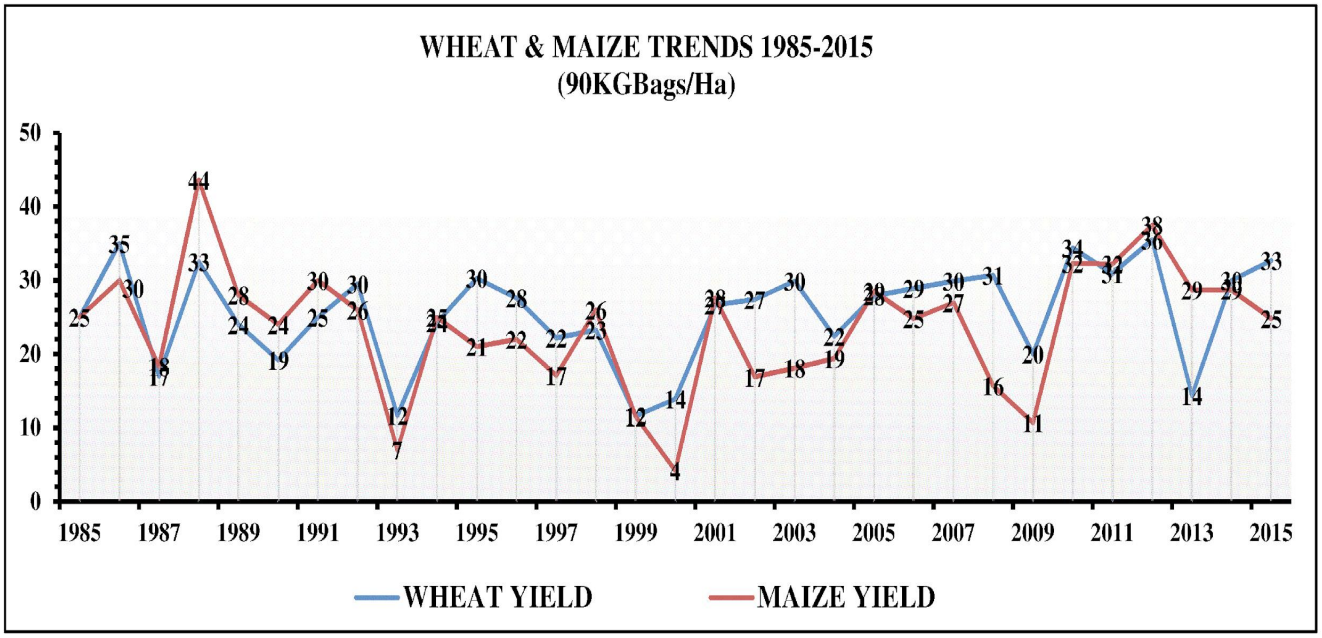

Figure 13. Wheat and Maize yields trend graph from the year 1985 to 2015

CONCLUSIONS

Conclusion on LULC classification

This research concludes that the size of land under crops doesn't necessarily determine the yields. Other factors like amount of rainfall and input may affect the yields. This is seen in respect to area occupied by crops in 1985, 1995, 2005, and 2015 in respect to the yields that was produced in those years

Conclusion on SPI time scales Rainfall trends ,validation ,correlation and water scarcity and drought modelling

From this research it has been seen that TRMM satellite data can be used incase ground stations is not available.this is bacause their validation showed correlation as seen from the correlation coefficiecy results.on the other hand ,SPI has been realized as an effective index to monitor water and water scarcity, and therefore it can be used as early warning tools for decion makers and leaders to take precautionary measures against water scarcity and drought.this is because it can be modeled to show areas with drought severity.

Conclusion on crop yields

The research carried out has demonstrated that crop yield depends on the sufficiency of rainfall. Decrease in water leads to decrease in yields and vice versa. On the other hand, rainfall amounts of MAM season have effect on the resultant crop yield of that particular year. This is because this is the period where we have long rains

ACKNOWLEDGEMENT

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Ministry of Agriculture, Kenya Meteorological Department and the Nakuru County Government agriculture office.

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GIS MODELING FOR AN OPTIMAL ROAD ROUTE LOCATION: CASE STUDY OF MOIBEN-KAPCHEROP-KITALE ROAD

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Abstract

The choice of a route location is a detailed activity that involves evaluation of different factors in order to attain optimal location. Roads are major projects and therefore need to be located to ensure seamless connectivity, which should be optimal. The objective of this research study was to perform spatial modeling using GIS analysis and weighting criterions using Analytical Hierarchical Process to come up with suitable site for an optimum road. To attain optimal road route location, satellite image of the study area was acquired and the image processed and reclassified to obtain baseline data of the area including the land use land cover map. A Geodatabase was created to allow integration with GIS analysis. GIS database included Shapefiles of soils, existing roads, towns, rivers, and vegetation, noise and dust surveys. Questionnaires administered to various experts were processed to give weights derived using Analytical Hierarchical Process (AHP). The weights from different criterions gave unique normalized Eigen vectors in each category. The weights were applied in the development of a model to obtain an optimum route. From the findings factors that were given high considerations were topographical and physical features, which included slope, vegetation and existing rivers. This was followed by infrastructure, environment and lastly soils according to the weights derived.

Two routes from the analysis were realized which were optimal and differed from the original route proposed for the project. The implications of these findings therefore showed that embracement of GIS with integration of different sources of data and remote sensing and analysis using AHP technique should be adopted as a tool and system for a project of similar approach in Kenya.

Keywords: AHP, GIS, Modeling, Optimal route location

INTRODUCTION

Road transport in Kenya constitutes a key component of Kenya's service sector in both their contribution to the country's employment and income generation and their role in external trade. The Kenya vision 2030 aspires for a country with integrated roads. The Kenya economy is dependent on road transport. Roads constitutes a major transportation channel widely used for carrying goods, passengers and other services (Minna *et al*, 2015). Roads have been significant contributors to national wealth and are vital elements of the social fabric in many nations because they represent a significant component of national infrastructure capital (Dixon *et al*., 2010), therefore there is significant need for these roads to be optimal and reduce costing during construction and at the same time using modern methods to perform routing like GIS and remote sensing techniques. There is need to avoid adverse impacts and to ensure long-term benefits leading to the concept of sustainable development. Evaluation of optimum route is a complex activity since there is need to be a balancing of various factors to come up with optimum route.

GIS functionalities are useful in integrating various datasets, performing analysis and modeling for optimum route location. These functionalities address various hurdles of getting an optimized route basing on the various criteria. Roads in Kenya are under the umbrella of Kenya Roads Board, which its major task is to oversee the road network in Kenya and

coordinate the development, rehabilitation and maintaining of these roads. Improved roads have attracted many investors along the road corridors (Gichaga, 2016).

Traditional routing of roads in the earlier times involved use of bulk paper work, and use of baseline information that was not so precise and conclusive. In most cases, these baseline data lacked precise information on land cover, vegetation pattern, geomorphology, hydrogeology, drainage pattern, air, water, and noise quality, socio-economics, etc.

The adoption of advanced technologies like remote sensing and GIS provides accurate and synoptic spatial and temporal databases on vegetation and land cover, surface hydrology, and aerosols for larger areas in a time- and cost effective way.

This paper presents a method that combines remote sensing, GIS and AHP to create a model that analyses criteria to identify an optimum road route and Eigen vectors that gave weights to the criterions.

METHODOLOGY

Study Area

The road measures approximately 80km and starts at the junction of Eldoret – Legebet road near Moiben and proceeds in a northerly direction to Cheborwa, where it turns westwards to Kapcherop, Kipkeikei, Sibanga where it continuous in westerly direction to Kitale. The road traverses through three counties in Kenya namely UasinGishu, Elgeyo Marakwet and Trans Nzoia.

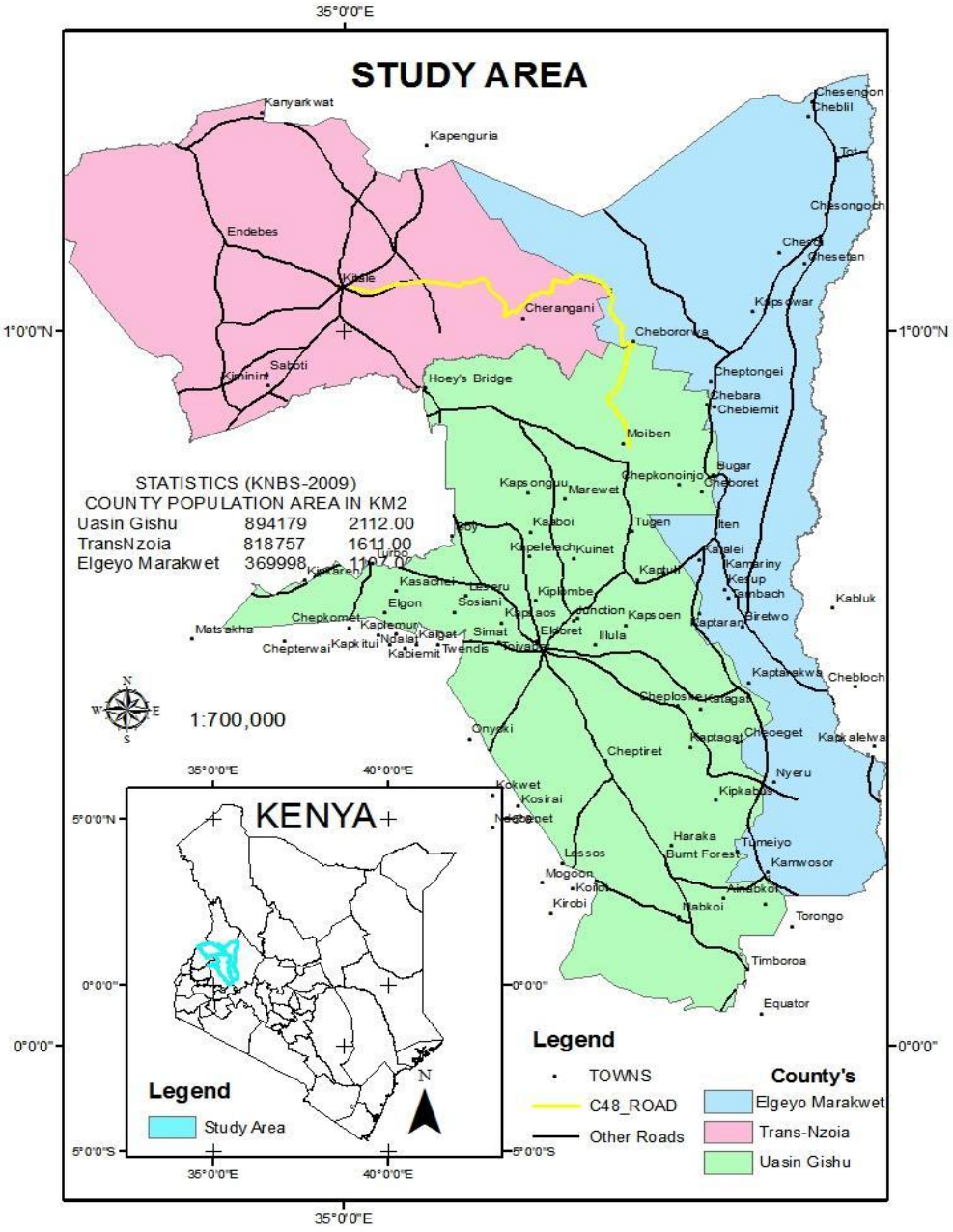

Figure 15: Map of the Study Area

Datasets and materials

For this research, activities involved the integration of primary and secondary data sources, databases and satellite images. GIS datasets used were soils, roads, vegetation, rivers, towns, noise levels, air quality levels, county, schools and settlements data. Other additional data were existing topographical maps of the area. Spatial data also included expert questionnaires that were later analyzed to give weights to various criterions.

Table 2**: Datasets used for modeling for optimal route**

	Data	Source
1	Topographical maps	National Mapping Agency Survey of Kenya
2	Soils	Kenya National Highways Authority
3	Roads	Kenya National Highways Authority Regional office.
4	Vegetation	Kenya National Highways Authority
5	Rivers	Kenya Meteorological Department
6	Towns	Kenya National Highways Authority
7	Schools	Kenya National Highways Authority
8	Noise and air quality Levels	National Environment Management Authority
9	County Shapefiles	National Mapping Agency Survey of Kenya
10	Population	Kenya National Bureau of Statistics
11	Satellite imagery	Regional Centre For Mapping of Resources for Development
12	Questionnaires	Various Road Experts

Research framework

The research framework adopted for this study is summarized in Figure 2. The methodology involved the selection of Spatial and non-spatial factors that would affect the routing of the road. Spatial data used was topographical sheets obtained from national mapping agency Survey of Kenya. Expert questionnaire also formed spatial data. A geodatabase was created in ArcGIS where it housed all the data and parameters for this research. Aster satellite image was used and pre-processed using ERDAS software. Sub setting was done to the mosaicked image and later linked to Google Earth view. Image classification was done using maximum likelihood to extract quantitative information from the image. From the various factors and criteria set of rules were established to minimize the road from crossing rivers, schools, settled areas, wetlands and flood prone areas. Rules to minimize the disruption of sound produced by the heavy machinery and dust emitted from the construction sites, rules to maximize the connectivity with other roads. All data was logically and consistently checked for errors, additions, emissions or gaps. For suitability process to be achieved, the data was converted in raster format and reclassification followed. When reclassification was done each cell was given a value which would tally from the rules set to obtain a suitable and optimum route. Derivation of weights for the road was done using Analytical Hierarchical Process and modeling the road route using them. Upon completion of AHP, the weights relative to each other factor were obtained through an iterative procedure by obtaining the Eigen vectors of the pairwise Comparison Matrix. The weights were adopted for weighted overlay procedure to get the suitability map. It was prudent to reclassify all the input factors in such a way that they can be compared one to one. The variables were compared as per Saatys' scale (Saaty, 2003). The study developed a suitable model for the road, it was done in a way that a criteria was loaded in the Geodatabase with its weighted influence and when validated gave a suitable site. This procedure was done for all the datasets to achieve an overall of a final weight of the model that gave the best route.

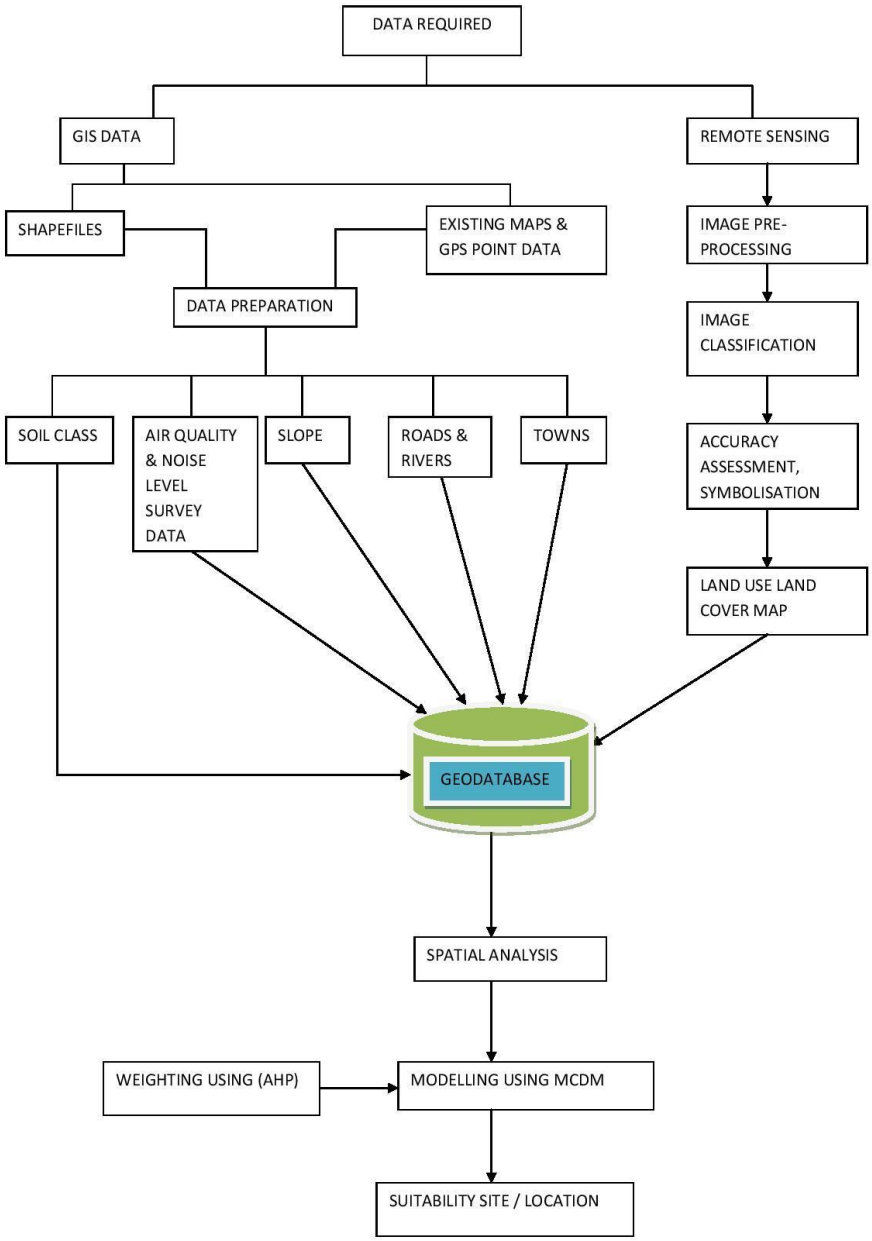

Figure 16: **Research Methodology**

RESULTS AND ANALYSIS

The results for the land cover mapping are presented in Figure 3. The results show the land cover derived from supervised classification. The land cover classes included: forest land, cropland & pasture, agricultural land, built-up/urban and rangeland

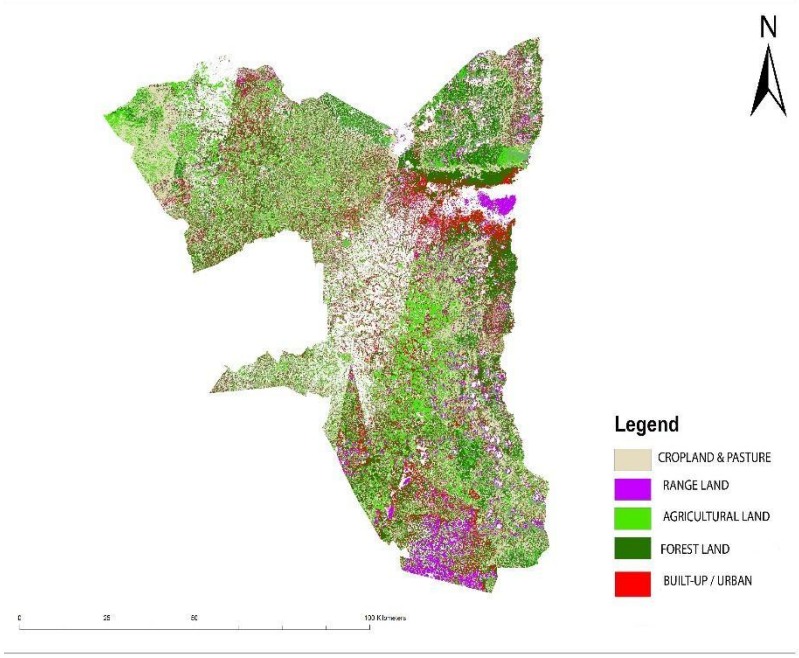

Figure 17**: Classified image of the Area of Study**

Table 3**: Land use Land cover statistics**

Land use land cover	Area in Hectare
Agricultural land	142215.70
Forest land	119313.13
Crop land & pasture	77003.02
Build-up / urban	174753.15
Range lands	20115.13

Results for soil analysis are presented in Figure 4. The results show the soil classes of the area and the original route. The area is generally covered with clayey soils taking more preference followed by loamy, very clayey and sand soil the least.

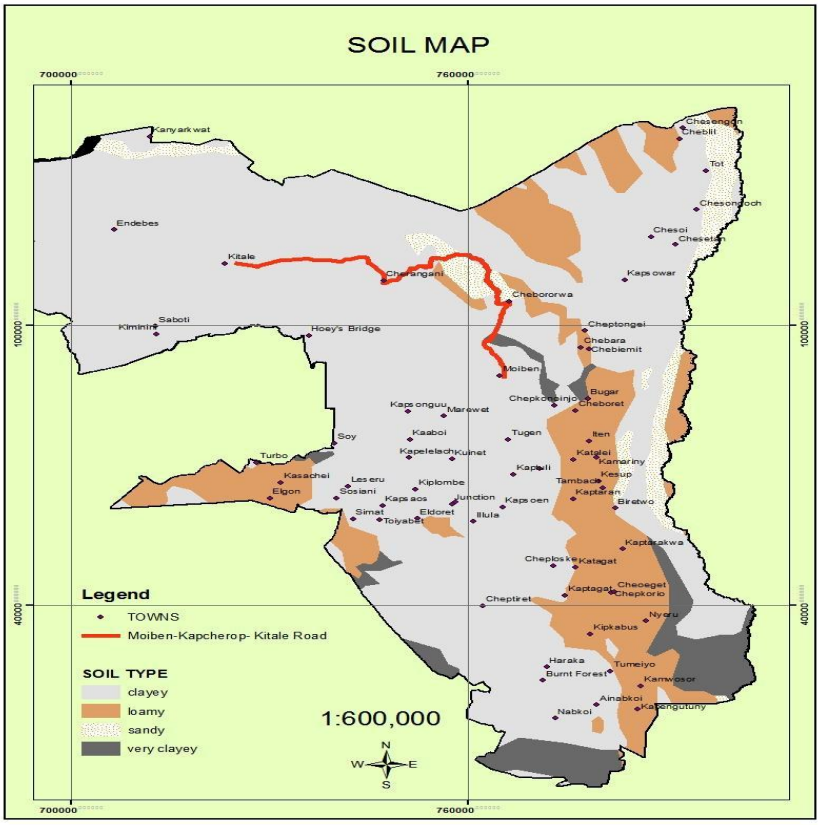

*Figure 18**: Soil Map of the study area***

Results for drainage description are presented in Figure 5. The results show that there were four major types of drainage pattern of this area. The original route traversed from moderately well drainage, through a well-drained and ends onto a poorly drained area.

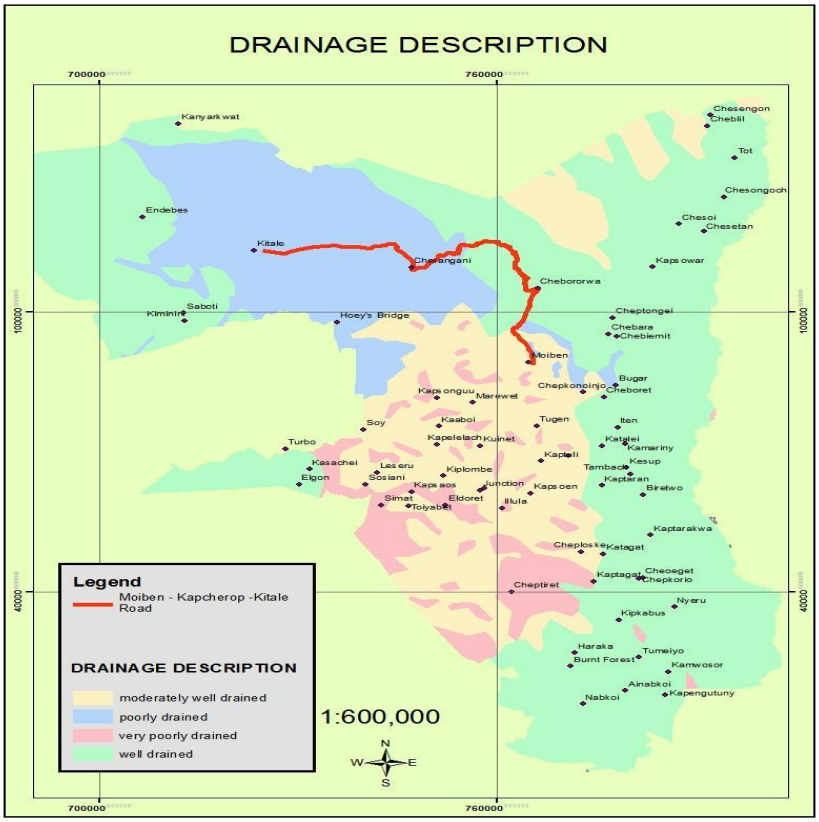

Figure 19**: Drainage Description**

Results for slope analysis are presented in Figure 6. The results show the graduation in dark brown representing the steepest places. This is the mountainous places of the area. The original route showed that it traversed on a gently undulating surface.

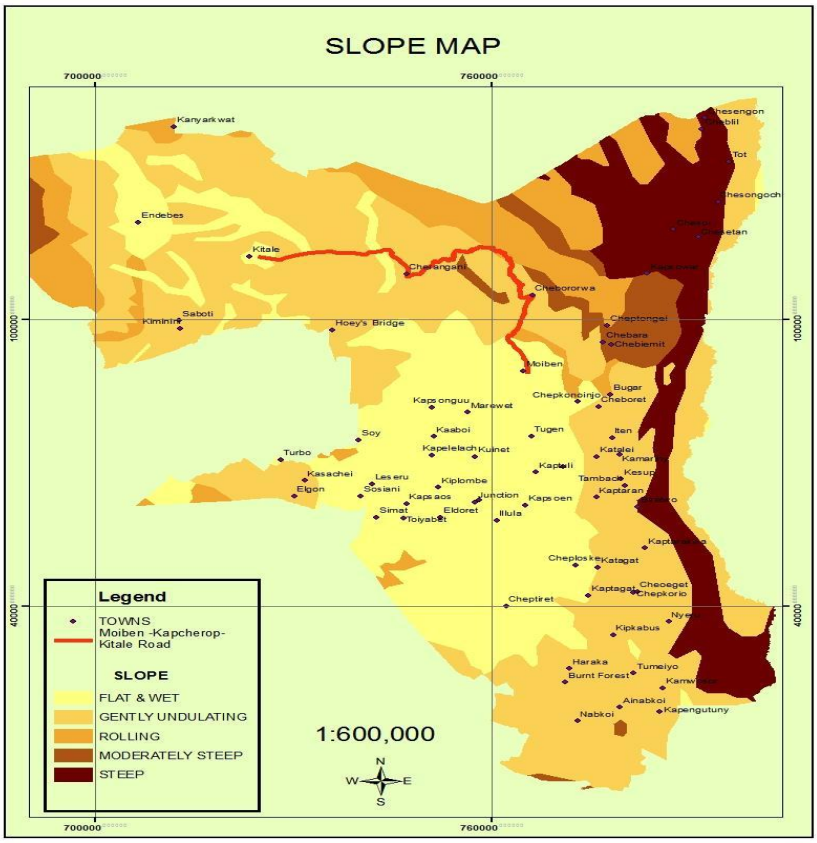

Figure 20**: Slope Map**

Results for river pattern are presented in Figure 7. The results show that the area is widely covered by a pattern of many rivers. These can be attributed by been an area that's hosts some forests and have two rainy seasons with rainfall ranging between 900mm to 1200mm annually. It has a cool and temperate climate, with annual temperatures ranging between 8.4 °C and 27 °C. There is a need to reduce the cost when constructing such a road by avoiding areas where the road shall cut a river due to the construction of bridges and gabions

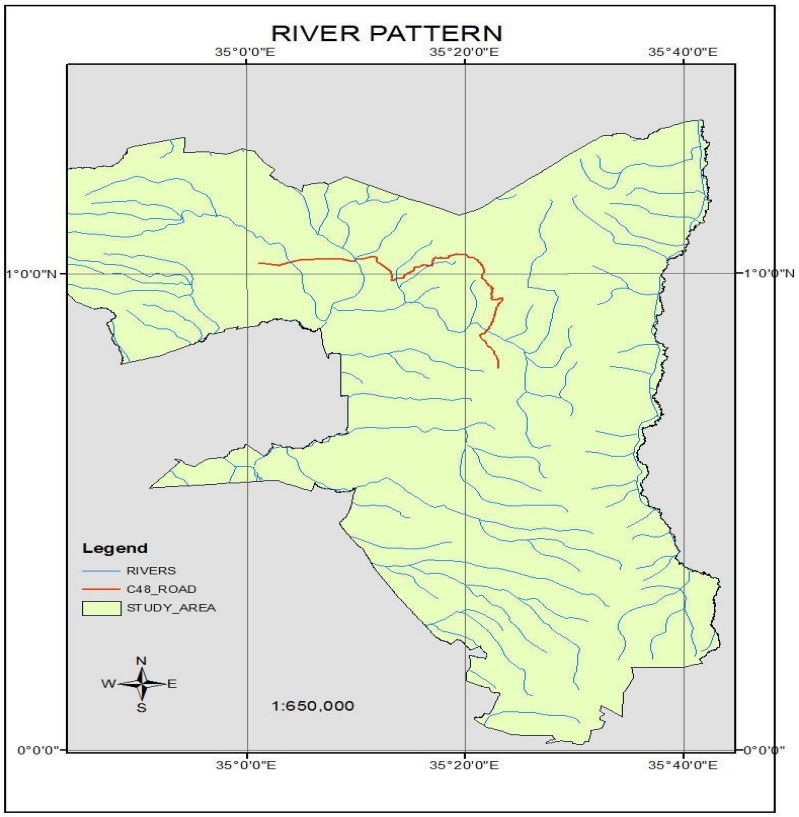

Figure 21**: Map of River Pattern**

Results for roads and towns are presented in Figure 8. The results show that the study area is characterized by several economic activities and industries and therefore there is need for connectivity from one point to another. It has several tourist attractions with scenic beauty, sports tourism, cultural tourism and eco-tourism. The road developed therefore should be of minimum cost and increase connectivity in the area

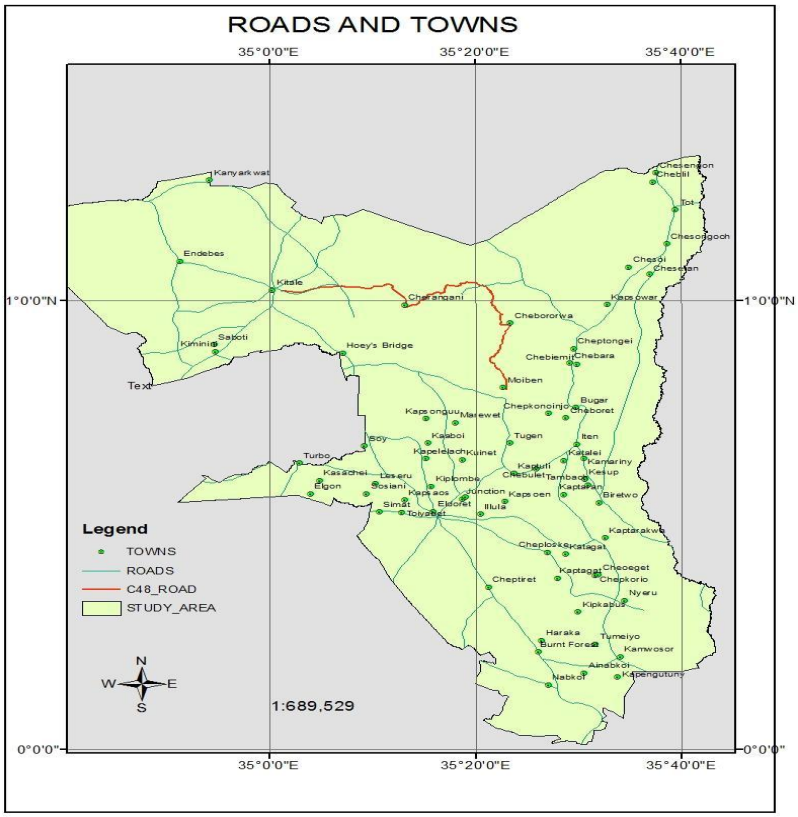

*Figure 22**: Map of road network and towns***

Results for the filtered alternative routes are presented in Figure 9. Based on the overall criterion alternative routes were calculated. The original route was 80,000m. After weighting all the criteria and doing the calculations on the pixels that the original route took, two alternative routes were hence calculated and analyzed as shown by Table 3.

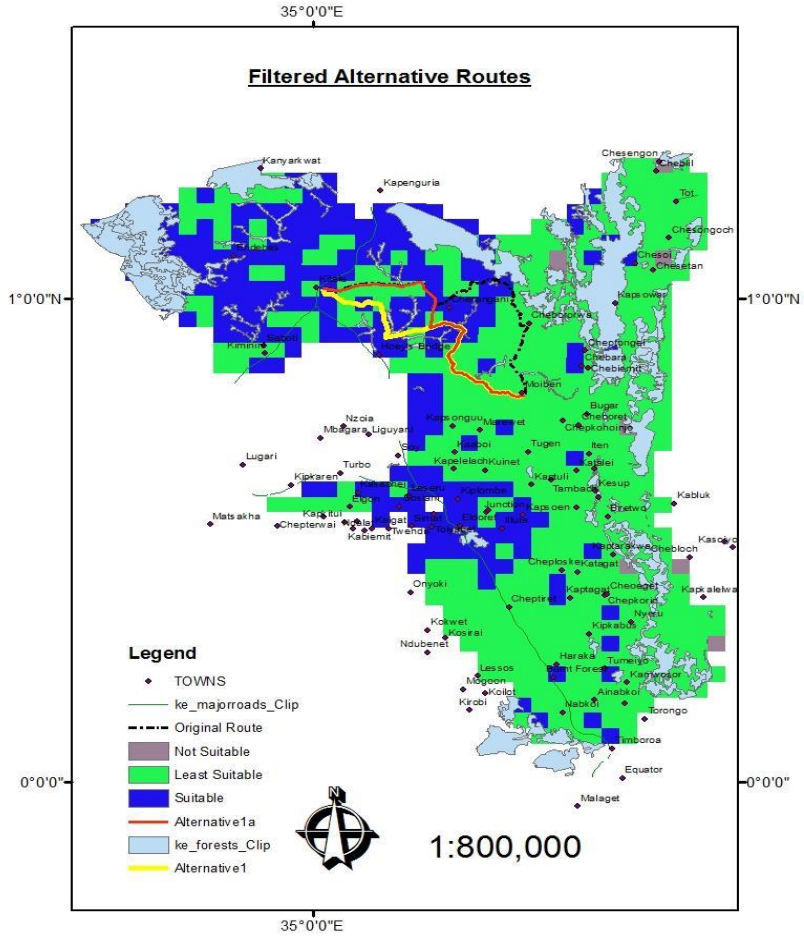

*Figure 23**: Filtered alternative Routes***

*Table 4**: Results for alternative routing***

Route	Total Length (m)	Suitability Polygons		Route Difference
		Least Suitable	Most Suitable	
Original Route	80000	52614	27603	
Alternative 1	66801	31902	34899	13199
Alternative 1a	67769	32028	35741	12231

Therefore, alternative route 1 was shorter by 13,199m while alternative 1a was shorter by 12,231m.

Results for the original elevation profile are presented in Figure 10. The results shows that from the elevation values, this road started at 2126.5176m asl, then it gradually fell to 1958.9407m asl before shooting up to an elevation of 2357.6616m asl. This greatly has shown that some factors of slope and terrain were not given much consideration on its

original design. The minimum elevation was 1800.8461m asl and the maximum was 2405.257m asl.

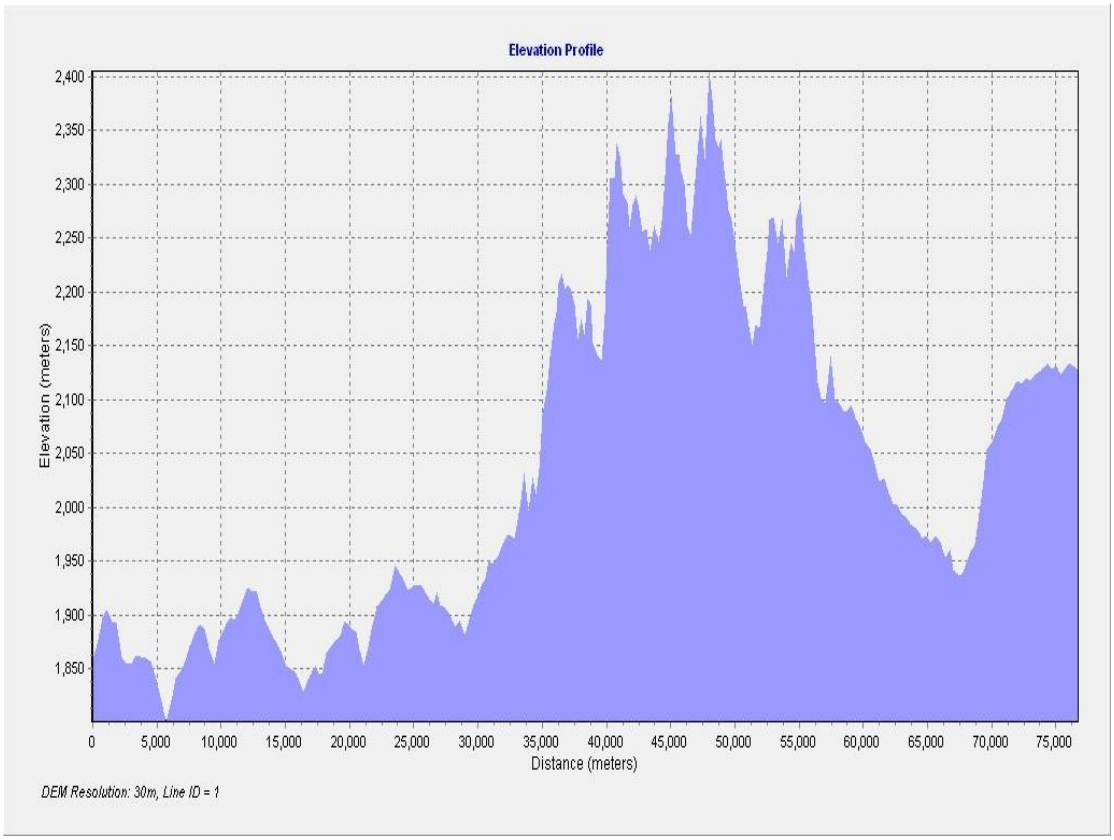

Figure 24: **Elevation Profile for the Original Route**

From the alternative *1a* elevation profile, the elevation started 2127.0667m asl and smoothly fell to 1948.7696m asl at a distance of 35km.This has shown from the criterion of topography and physical features, these factors if considered in the design and construction would give an optimum road. The lowest elevation was 1802.4237m asl and highest was 2128.5815m asl, this shows that there was an incredible drop of the highest elevation with a 276.6755m asl difference. Such an elevation in terms of quantities for design of a road is a huge saving on material cost when implemented.

For the elevation profile for alternative *1* route, the starting nodes coincided with that of alternative route *1a* up to a distance of 35km where there was change of elevation. This route had the lowest elevation of 1794.6304m asl and a highest with 2129.4272m asl. Statistically, and graphically this route demonstrated to be the optimum route.

CONCLUSION

This research objective was to perform spatial modeling using GIS analysis and weighting criterions using Analytical Hierarchical Process to come up with suitable sites for an optimum road. GIS and Remote sensing techniques were integrated in this study. Questionnaires administered to various experts were processed to give weights derived using Analytical Hierarchical Process (AHP). The weights from different criterions gave unique normalized Eigen vectors in each category. The weights were then applied in the development of a model to obtain an optimum route. Eight factors that were considered were slope, existing roads, rivers, air quality, towns, vegetation settlement and schools. Analytical Hierarchical process was used as a way to get relative preference of every factor used in this study.

Information from experts was arranged in a hierarchical tree and using pairwise comparison relative criterion over another was expressed. Topographical and physical factors gained the highest choice. This was followed by infrastructures, Environments and Soils.

From the results on topographical and physical factors, conclusion was drawn that there is much need to conserve the environment by avoiding diverging of rivers, avoiding vegetation clearing and avoiding so much of excavation of the land. Under the category of soils, this study has shown that much of this land was suitable for this road however only a small percentage gave the most suitable site. From the category of Infrastructures, more priority was given to settlements. This implies that for an optimum route to be achieved people can pave way for the road and this has shown that the roads proximity is near the people.

This study has presented the results of an integrated GIS data sources with remote sensing data for a road project. In addition, the research has combined the use of AHP mode of decision making with GIS as an approach to factors that can be addressed for similar road projects in the country Kenya. Elevation profiles that were generated from this route clearly demonstrated that there was a huge change in elevation of this route. This results show the importance of conservation of vegetation, rivers and choice of fair slope for the route. The Model generated in this study was dynamic and other factors that were not considered can be incorporated to achieve results that are more precise. It is recommended that GIS, Remote sensing and AHP techniques can be adopted for obtaining optimum route for a road or any other linear project in Kenya. Policy and decision makers therefore need to welcome the role of using GIS and AHP as a method, which can be used for decision-making. To improve the results obtained from this study, it is recommended that more research need to be carried out whereby more datasets should be incorporated in the final model to give the final criteria.

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ASSESSING THE ENVIRONMENTAL IMPACTS OF POST EATEC WATTLE TREE PLANTATIONS IN ELDORET MUNICIPALITY

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Abstract

The study area which lies within Eldoret Municipality has experienced environmental problems as a result of the sale, land subdivisions for settlement and subsequent clearing of the wattle tree plantations that were owned and managed by EATEC. The extent of environmental consequences due to the clearing of the plantations is not fully understood and the necessary mitigation measures to manage these challenges have not been put in place.

The objective of this research study was to carry out an environmental assessment of the impacts of the clearing of wattle tree plantations that were originally owned by (EATEC) within Eldoret Municipality by the use of remote sensing and GIS techniques. The study sought to characterize the environment before and after the project implementation, assess and quantify the major environmental changes between 1995 and 2015 and identify the major environmental impacts and then propose mitigation measures to address the negative impacts.

Remote sensing together with GIS analyses were used to carry out a Post Environmental Assessment of the study area on the effects caused by the clearing of the plantations. The study used a mixed scale approach involving both primary and secondary sources of data and analyzed using descriptive statistics, GIS techniques and remote sensing. Remote sensing Satellite images for the years 1995, 2000, 2003, 2010 and 2015 were classified and integrated with other data within GIS for assessment of the land use and land cover change.

The results reveal that the study area has experienced significant changes due to the clearing of the wattle tree plantations and increase in human settlement resulting in environmental challenges including decreased wetlands, decreased wattle tree plantations, and increased cropland and bare land. The research findings indicate that human activities have had a profound effect on the natural environment and are the main agent of environmental degradation. This study has proposed mitigation measures which if undertaken could address environmental challenges affecting the study area.

Keywords: Remote Sensing, GIS, wattle tree plantations, environmental assessment.

INTRODUCTION

Wattle trees are fast growing but short-lived, with hard, strong wood useful for fuel, poles, fencing posts and tool handles. Maslin (1980) further described themalso as suitable for bee forage and the bark used in the tanning process and in the production of gum. They are widely cultivated in many parts of the temperate world, as ornamental and agro-forestry trees. Wattle trees were introduced in East Africa for their tannin-rich bark, and for use as fuel wood.

Dharani (2006) in his findings stated that wattle trees, were regarded as a weed in many parts of the world as they out competed other crops for nutrients and light and capable of invading native vegetation from grassland to dense forests he termed them as invaders in many parts of the world, though in South Africa, they are invaders with a commercial use, animal fodder and soil stabilization. Maundu and Tegnas (2005) noted that wattle trees were not listed as a noxious weed by any state or government authorities in Kenya, Tanzania or Uganda.

Wattle tree plantations in Eldoret Municipality were owned and managed by the East African Tanning Extract Company (EATEC). They covered an area of about 35,000 acres within the municipality and with a workforce of over 3,000 employees. Maundu and Tegnas (2005) in their research found out that wattle trees were grown for their bark. The extracted tannin was largely used for tanning leather, as well as in making adhesives, preserving ropes and nets, making dyestuffs, corrosion inhibitors and as pharmaceutical products. They were also used for both fencing and building poles.

The sale of this land and subsequent subdivision into small parcels of land led to an influx of people to the area in search of land for settlement and other socio economic activities. The increased human settlement led to the clearing of the wattle tree plantations that has caused environmental concern and deprived the thousands of people formally employed by the company of their source of income. The parcels have further been subdivided into smaller uneconomical units that have had negative impacts on human health as a result of informal settlements coming up and due to lack of piped water and solid waste disposal mechanisms.

The need for EIA was succinctly expressed in Principle 17 of the 1992 Rio Declaration on Environment and Development which afforded the strongest evidence of international support for EIA in the following terms; “Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant impact on the environment and are subject to a decision of a competent authority. (UNEP.The United Nations Conference on Environment and Development 1992)

Remote sensing, which, in combination with Geographic Information Systems (GIS) and fieldwork, is an effective management tool that is increasingly important in the detection, description, quantification and monitoring environmental changes.Haag, F.Hoagland and Stefan (2002).

Subjecting projects to environmental assessment through spatial information technology involving GIS and remote sensing are crucial for sustainable development. Geospatial technologies willalso play a leading role in monitoring the environment as a result of the clearing of the plantations and the rapid population growth.

This study was therefore undertaken to assess the impact of the clearing of the wattle tree plantations formally owned by (EATEC) within Eldoret Municipality. This would enable the governmentmake informed decisions on the state of the environment and mitigate the negative impacts to ensure sustainable development.

METHOD

Study area

The study area borders Eldoret town to the south and located in the high-agricultural potential highlands of UasinGishu County. It lies at an altitude of 2,085 metres above sea level and traverses latitude 0˚ 31'North and longitude 35˚16' East. It is located about 312km northwest of Nairobi on the main Kenya-Uganda highway. The study area borders Sosiani River and rises southwards from1800m above sea level to about 2120m above sea level in the extreme south east.

The study area receives bimodal rainfall which falls between the months of April and May. The municipality enjoys two rainy seasons with an annual rainfall ranging between 900 to 1200 mm. Sited on a plateau; the municipality has a cool and temperate climate, with annual temperatures ranging between 8.4 °C and 27 °C. The wettest season is experienced between the months of April and May while the driest season comes between January and February. There is a dry spell in June followed by increasing rainfall in July and August and tails off in September and October. A long dry period of 4 to 5 months then follows. The average day temperatures are 24˚C with average night temperatures being 10˚C.

Geologically, Eldoret falls under the tertiary volcanic period. The rocks are mainly of alkaline type including basalts, phonolites, nephelinites, trachytes, alkali rhyolites and their pyroclastial equivalents. The rock formations indicate that the rock slopes, run along the escarpment and most of the volcanic effusion was by way of vents and fissures. The soils are the red to strong brown friable clays with laterite horizon and grey mottled clays.

The study area comprises of Langas location, Kapsoya location and Saroiyot sub location and has had a population increase from 55,387 in 1995 to a projected population of 178,535 people in 2015 (KNBS 2006). However the rate of physical development has superseded the provision of potable water.

Liquid waste disposal in the study area is normally by pit latrines while water wells close by, supplement the sources of water.

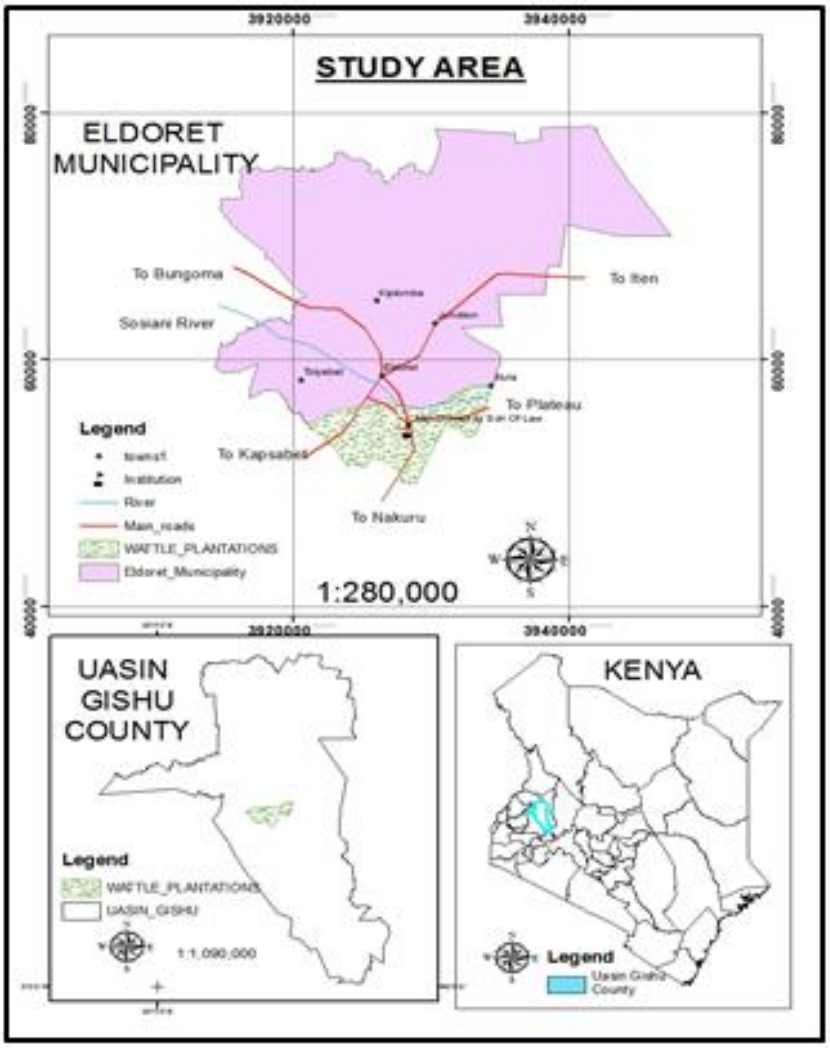

Figure 1: Map of the Study area

Data

The first step was to identify the variables needed to assess the environmental impact of theStudy area on the clearing of the wattle tree plantations. The variables consisted of environmental information, including the amount of Crop land, Human settlement, Wetlands, Forests, Population, rainfall, hydrological data and land subdivision data.

These variables were obtained from secondary sources such as government documents. The Variables obtained covered the period from 1995, 2000, 2003, 2010 and 2015.

The study also relied on datasets from The United States National Aeronautical and Space Administration. The satellite data used consisted of 5 scenes of Satellite images for the separate periods of 1995, 2000, 2003, 2010 and 2015 for the study area.

This paper used a mix scale approach involving the integration of primary and secondary data provided through government sources and data bases from other organizations. The raw spatial data and satellite images that were used in the research came from the United States National Aeronautical and Space Administration.

Table 5:

S/no	Data type	Source	Year
1	Landsat 5 (TM) image	USGS	January 1995
2	Landsat 7 (ETM+) image	USGS	February 2000
3	Landsat 5 (TM) image	USGS	March 2003
4	Landsat 5 (TM) image	USGS	February 2010
5	Landsat 8 (OLI) image	USGS	February 2015
6	Population data	Kenya National Bureau of Statistics	1979, 1989, 1999 and 2009
7	Rainfall data	Kenya Meteorological Department	1995, 2000, 2005, 2010 and 2015
8	Hydrological Data	Water resources Management Authority	1995, 2000, 2005, 2010 and 2015
9	Land subdivision data	Survey of Kenya	2001, 2003, 2010 and 2015

Research approach

The methodology adopted for this study is summarized in Figure 2 and involved Remote sensing data processing, land cover mapping, change detection, environmental assessment and identification of mitigation measures

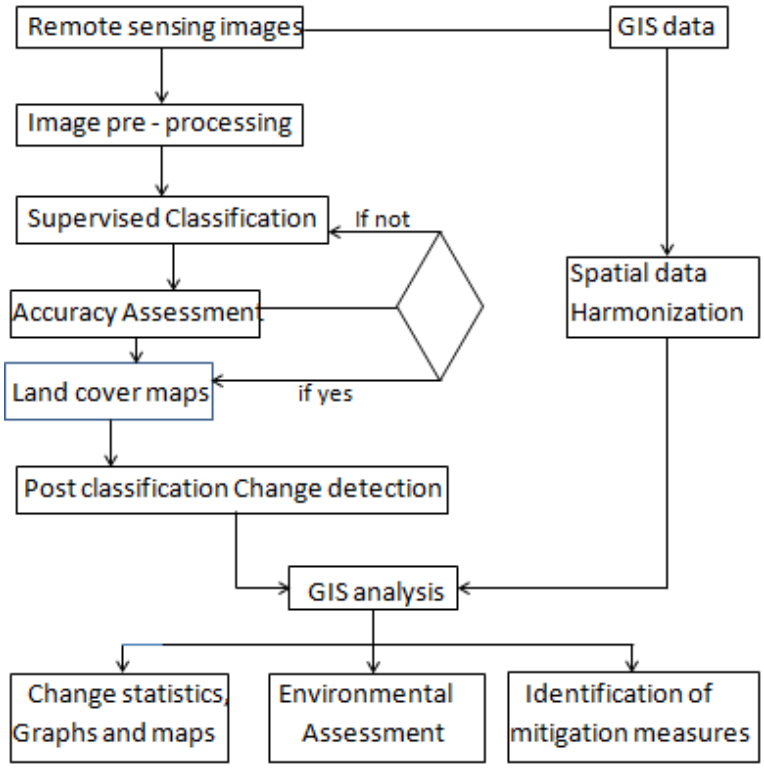

Figure 25: Methodology flow diagram

Land cover mapping

Due to acquisition system and platform movements, remotely-sensed data are generally geometrically distorted. Pre- processing entails, geometric correction, radiometric correction, noise removal and geo referencing.

The satellite images were imported into ERDAS 2010 software in an image format for geometric correction. The images were then geo referenced and subset on the basis of Area of Interest (AOI).

Supervised classification was used in this research and involved the training stage, feature selection, Selection of classification algorithm, Post classification smoothening and Accuracy assessment.

Spectral signatures for the respective land cover types derived from the satellite imagery were recorded by using the pixels enclosed by these polygons. A satisfactory spectral signature is the one ensuring that there is 'minimal confusion' among the land covers to be mapped. Supervised classification was performed by applying maximum likelihood algorithm on the images. Land cover maps with six classes were generated from each satellite image.

Accuracy assessment was essential for individual classifications if the classification data was to be useful in change detection. For the accuracy assessment of land cover maps extracted from satellite images, stratified random method was used to represent different land cover classes of the area. The accuracy was assessed, based on ground truth data and visual interpretation. The comparison of classification results and reference data was carried out statistically using error matrices.

Change detection

Change detection was done by overlay of classified maps. It was done by comparative analysis of map-to-map comparison. This approach required very good accuracy in both classifications because the accuracy of the change map was the product of the accuracies of the individual classifications. It was thus important to do an accuracy assessment of each land cover map.

Change detection in terms of the acreages of the land cover classes were obtained for each classified map and compared. The classes involved were wetland, forestland, cropland, settlement, grassland and bare land.

GIS Analysis

GIS analysis is described by Jones (1997) as a methodological framework that may be applied to a very wide range of spatial analysis problems and projects.

GIS brings to the EA process a new way of analyzing and manipulating spatial objects and an improved way of communicating the results of the analysis, which can be of great importance during the public participation process where the results from the public consultation and social surveys can be imported into a GIS for spatial and non-spatial analysis, and display in a format that is easily understood by all stakeholders. The process of Environmental analysis is described by Erickson (1994) as using either or combination of checklists, overlay, matrices and network methods.

Mitigation measures

They aremeasures put in place to counter the negative impacts on the environment that may arise from the project. Impact may be defined as 'any alteration of environmental conditions or creation of a new set of environmental conditions adverse/beneficial, caused or induced by the action or set of actions under consideration (Bhatt, (2009). In this study, the negative impacts found were mainly due to human actions. They included increased settlements,

decreased forest cover, and increased bare land, decreased wetlands and other environmental challenges.

RESULTS AND DISCUSSION

Population

The population of the study area encompassing Pioneer location, Kapsoya and Saroiyot sub location was obtained from the Kenya Bureau of Statics in their Eldoret office. The census data obtained was for the census years 1989, 1999 and 2009. The data was interpolated to obtain the population for the study years 1995, 2000, 2003, 2010 and 2015 (Table 2). The results showed that the population increased from 55,387 in 1995 to 178,535people in 2015. These figures represented an increase of 222.34%.

Table 2: **Projected population data**

Location/ Sub location	**1995**	**2000**	**2003**	**2010**	**2015**
Pioneer	34,099	43,703	60,281	97,617	118,521
Kapsoya	18,218	22,735	28,302	35,284	44,514
Saroiyot	3,070	3,859	5,794	10,635	15,500
Total Projected Population	**55,387**	**70,297**	**94,377**	**143,536**	**178,535**

Rainfall

Rainfall pattern between the years 1995 and 2015 did not show a predictable trend, Instead of a decrease, there appeared to be a non-uniform increase in the rainfall pattern.

These may beattributed to the existence ofKaptagat and Ainabkoi forests to the East of Eldoret Municipality

Table 3: **Rainfall (Kapsoya gauge station within the study area)**

Year	**1995**	**2000**	**2005**	**2010**	**2015**
Total rainfall (mm)	985.9	855.9	955.3	1348.6	1121.2

Hydrological data

Hydrological pattern agrees well with the rainfall pattern of the study area. The effect on theStudy area was minimal.

Table 4: **Hydrological data (gauge heights on River Sosiani)**

Year	**1995**	**2000**	**2005**	**2010**	**2015**
Mean Gauge Height (m)	0.62	0.55	0.59	1.02	0.97

Land sub divisions

The information obtained from Survey of Kenya County Office indicated that, on first Registration in 2001, there Were 3,537 parcels of land ranging from 0.01ha to 40ha.

Registration as at 28th June, 2015 stood at 14,591 parcels. This is an increase of 11,054 parcels, representing an increase of 312.5% over a period of 15years.

It is worth noting that the increase in subdivision of parcels is not uniformly distributed across the entire study area. The parcels along Eldoret to Nakuru road have been converted to Commercial; Residential and Institutional uses among them are Moi University school of Law. Similarly, informal settlements have cropped up, notably Rehema informal settlement, which is referred to as Block 27 of EATEC registration. (Table 5) shows the number of parcels created after subdivision since 2001 to 2015.

Table 5: **Land Subdivisions**

Year	**1995**	**2001**	**2005**	**2010**	**2015**
No of Parcels	0	3537	5120	8948	14277

Land use/ Land cover Change detection

The results of the land cover maps (Figure 3) of 1995, 2000, 2003, 2010 and 2015 are presented in (Table 6). Settlement areas increased from 144.72 ha in 1995 to 763.29 ha in 2015 representing an overall increase of 427.43%, cropland increased from 7959.33 ha in 1995 to 19257 ha in 2015 representing an increase of 141%, similarly there was an increase in other land from 15311ha in1995 to18695.1 ha in 2015 representing an increase of 22.1%. Forestland posed a decrease from 1467.09ha to 1356.03, grassland from 24675.3ha to 9200.7 ha and wetland decreased from 293.84ha to 82.62 ha representing a decrease of 7.57%, 60.29% and 71.82%.

Table 6: ***Results of the land cover maps 1995, 2000, 2003, 2010 and 2015maps and percentage change between 1995 and 2015***

Classes	**Area (Ha) 1995**	**Area (Ha) 2000**	**Area (Ha) 2003**	**Area (Ha) 2010**	**Area (Ha) 2015**	**% change 1995 - 2015**
Cropland	7959.33	29705.3	18734.4	25269.4	19257	**141.94**
Forestland	1467.09	4441.98	3738.69	2904.75	1356.03	**-7.57**
Settlement	144.72	505.037	557.91	644.13	763.29	**427.43**
Wetland	293.84	156.3553	73.33	49.68	82.62	**-71.82**
Grassland	24675.3	4512.02	15582	9200.7	9798.39	**-60.29**
Bare land	15311.00	10728.4	10382	11883.7	18695.1	**22.10**

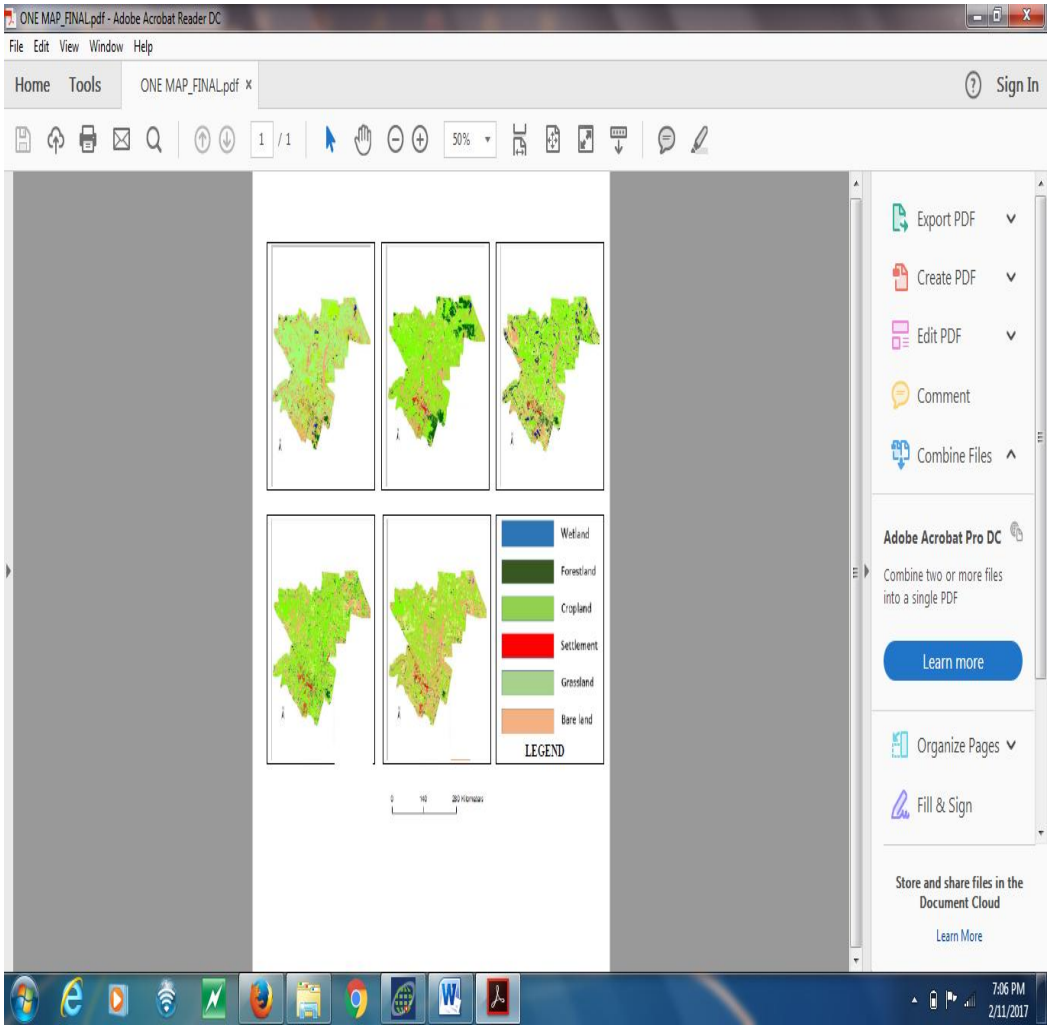

Figure 3: Land Cover maps for the period 1995, 2000, 2003, 2010 and 2015

Dynamics of land cover changes beginning from 1995 to 2015 in terms of areas and percentages were obtained. Six land cover classes of settlement, forestland, wetland, cropland, grassland and bare land were decided upon based on knowledge of the study area.

Harmonization of the spatial data sets composed of decomposing the data sets so as to graphically determine the relationship between them. Since the data sets were in different units of measurement, it was necessary to normalize the data into one unit of measurement.

From the analysis, it was possible to obtain, change statistics, graphs and maps. Similarly, it was possible to do an environmental assessment from the land cover change detection and the harmonized GIS data. The major environmental drivers in the study area were identified from the analysis (Figure 4). This formed the basis of mitigating their effects on the environment.

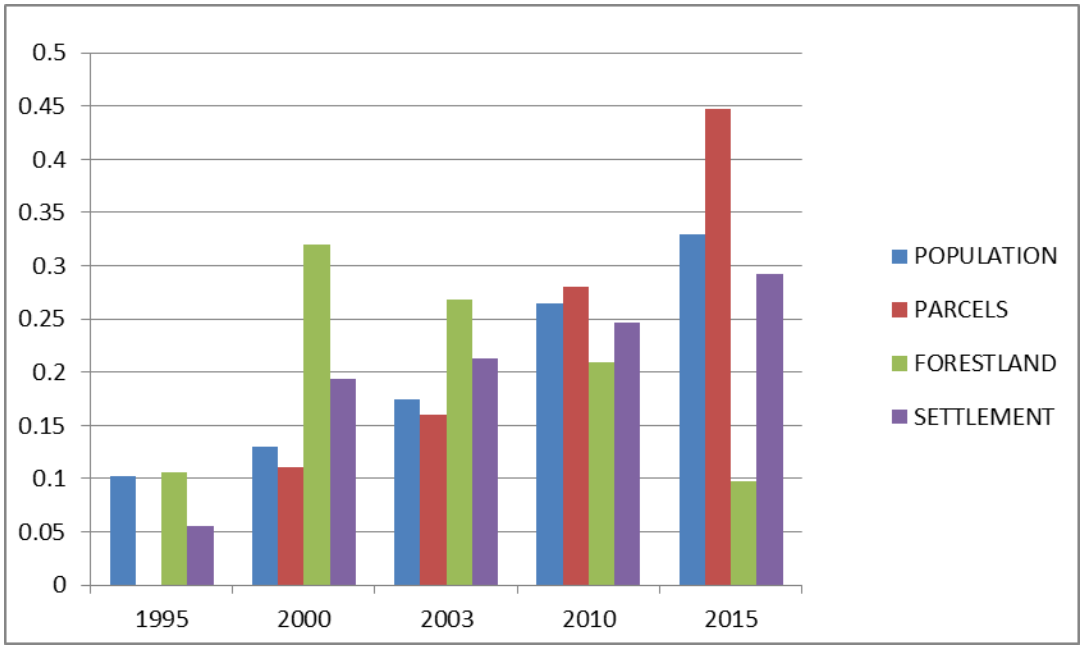

Figure 4: Environmental drivers

Environmental drivers in the study area

The results, analysis and data obtained from government sources showed the following drivers as responsible for environmental Change within the study area, Increase in human Settlements, increase in population, decline in forest cover, increase in Land subdivisions and Environmental policies and regulations that are ineffective and lack the enforcement aspect.

These trends possess challenges to the environment and Policy makers in the local Government and needs urgent confrontation to tackle the impending environmental degradation.

Mitigation measures

Onincrease in human settlements and population, the Government could promote sustainable land use planning and management bymaking provisions for environmental infrastructure such as water, sanitation, drainage, hazardous and solid waste management.

On eradication of poverty, creation of productive employment and social integration, the Government could formulate and implement human settlement policies that ensure equal access to basic services like education, food security and basic health that would include family planning and reduction of the burden of investment on curative health. Similarly,the Government could develop and enforce appropriate norms and laws for land use, buildings and planning standards to reduce any impacts that may arise due to natural and human-made disasters.The Government could also provide adequate financial and legal support for the effective protection, conservation and rehabilitation of the historical and cultural heritage. (UNEP. Human Settlements, 2007)

On decline in forest cover the Local Government could create responsible partnerships, for enhanced private sector participation in forestry developmentand to promote tree planting and agro-forestry activities. Similarly, the Local Government could enact legislation toensure that all sub-divisions of land are tied to land use sizes specified for different ecological zones and

put in place a system to determine economically viable minimum land sizes for various zones, promote conformity of land subdivisions with the set minimum economically viable land sizes (National Land Policy, 2009).

CONCLUSIONS

The clearing of the wattle tree plantations that were being managed by the East African Tanning Extract company (EATEC), subsequent subdivisions and increase in human settlement has had serious environmental challenges on the study area within Eldoret Municipality. The continued population growth has resulted in environmental problems such as decreased wetlands, loss of the wattle tree plantations (forest), increased bare land, increased cropland and many other issues. There was an urgent need to undertake an environmental assessment to determine the extent of the impact of these changes on the environment and mitigation measures to manage these challenges.

The objective of this research study was to carry out an environmental assessment of the impacts of the clearing of wattle tree plantations that were originally owned by (EATEC) within Eldoret Municipality by the use of remote sensing and GIS techniques. The study sought to characterize the environment before and after the project implementation, assess and quantify the major environmental changes between 1995 and 2015 and identify the major environmental impacts and then propose mitigation measures to address the negative impacts

This study used a mix scale approach involving both primary and secondary sources of data and analyzed with descriptive statistics, GIS techniques and remote sensing. The primary sources of data for the study were Landsat 5 imagery for the year 1995, 2003 and 2010, Landsat 7 imagery for the year 2000 together with Landsat 8 imagery for the year 2015 were used for this study. The satellite imageries were processed using ERDAS IMAGINE 10 image processing software. The images were imported into ERDAS using ERDAS native file format GEOTIFF. Since the images were in single bands, they were stacked together using ERDAS layer stack module. The images were then classified using supervised classification technique to identify land cover features within the study area. The secondary data included population, rainfall; hydrological information and land subdivision data. The remaining procedures involved spatial analysis and output (maps-tables-text) covering the study period, using ARCVIEW GIS.

The results of the classified images of 1995, 2000, 2003, 2010 and 2015 were assessed for accuracy and the results showed that Settlement areas increased from 144.72 ha in 1995 to 763.29 ha in 2015 representing an overall increase of 427.43%, cropland increased from 7959.33 ha in 1995 to 19257 ha in 2015 representing an increase of 141%, similarly there was an increase in other land from 15311ha in1995 to18695.1 ha in 2015 representing an increase of 22.1%. Forestland posed a decrease from 1467.09ha to 1356.03, grassland from 24675.3ha to 9200.7 ha and wetland decreased from 293.84ha to 82.62 ha representing a decrease of 7.57%, 60.29% and 71.82%. Similarly, the population of the study area increased from 55387 in 1995 to 178,535 in 2015 and land subdivisions increased from 3537 parcels in 2001 to 14277 in 2015. Rainfall and hydrological information did not have much significance on the study area.

Results reveal that the study area experienced some significant changes in its environment as a result of the clearing of the wattle tree plantations, increased human settlement, decreased wetlands, increased agricultural intensification and other environmental variables. The other factor was the rapid increase in population and its implication on the environment.

To deal with these challenges, the project offers some mitigation measures as part of the conservation strategies for the study area. The mitigation measures consist of participatory approach, periodic assessment, land use management strategies, land subdivision strategies and strengthening the laws and regulations dealing with environmental issues.

In summary, successful implementation, of the mitigation measures highlighted in this project could lead to effective management of the environment in the study area. The project has also demonstrated that GIS and remote sensing techniques can be an effective tool in the assessment of the environmental changes.

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SPATIAL MONITORING OF URBAN GROWTH USING GIS AND REMOTE SENSING: A CASE STUDY OF NAIROBI METROPOLITAN REGION

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Abstract

Metropolitan areas are regions with a large population nucleus. These regions experience rapid urban growth in developing countries. Nairobi city extended its influence beyond its boundaries leading to the formation of the 32,514 km^2 metropolitan area. The Kenyan government had a vision that the region was to grow into a world class African metropolis by the year 2030.

Urban growth has both negative and positive effects on the environment. To ensure coordinated development in the region, the Ministry of Nairobi Metropolitan Development prepared a spatial plan in the year 2008. The spatial plan proposals have never been fully implemented because of rapid urbanization challenges and lack of reliable urban planning data. As a response, monitoring the growth of this phenomenon is essential in understanding the changes.

Remote sensing and GIS technologies are a proper and effective tool to evaluate and analyse temporal spatial information to help understand and present urbanization. The region's urban land cover before and after spatial planning was identified, mapped, quantified and analysed. Three different land cover maps of the study area were produced from Landsat imagery integrated with GIS. Urban growth between1995 and 2015 was evaluated and analysed using Spatial Metrics, the Annual Spatial Expansion index and through visual interpretation. At ten year epochs, the region's, urban land cover increased from 408.99 km^2 to 763.79 km^2 to 2182 km^2 between 1995 and 2015. The growth rates were 8.4% and 17.2% per year respectively The Annual Spatial Expansion Indices were 4.58% and 6.32% per year respectively. The radial-axial expansion was determined by social-economical, political, legal, environmental and technological factors. The trend calls for the government to acquire spatial urban growth information to guide the implementation of plans for sustainable development.

Keywords: GIS, Nairobi Metropolitan Region, Urban growth, Remote Sensing.

INTRODUCTION

Geographic areas with a high density of people over limited space working on non-agricultural activities form urban areas. Metropolitan areas are regions with large population nuclei together with adjacent communities having a high degree of economic and social integration with that core (MoNMD, 2008).They are created when the world population is attempting to satisfy its economic and social needs in an urban context (Paul, Gregoy, & Jeffrey, 1995).

The Kenya Vision 2030, an economic and social development program, proposed flagship projects to spur development across the country one being the creation of six metropolitan areas covering the main cities such as Nairobi, Mombasa, Nakuru-Eldoret, Kisumu-Kakamega, Garisa-Mwingi and Meru-Isiolo. The Nairobi Metropolitan Region (NMR) project was the first be set up (MoNMeD, 2012).

It was earmarked for rapid economic development since it plays an important role locally in the Kenyan economy, regionally as well as globally. The NMR vision was to grow and develop into a world class African metropolis capable of creating sustainable wealth and

offer a high quality of life to its residents, the people of Kenya and investors by the year 2030.

Urbanization is the physical growth and change in the extension or intensiveness of urban areas as a result of local and global changes, including the movement of people from rural to urban areas (Commission 2, 2011). It can be used as a major tool to promote economic development and national welfare. Kenya being one of Africa's fastest urbanizing countries had 215 urban centres twenty four (24) of which are located within the NMR.

Urban growth is a dynamic and complex phenomenon indicating a transformation of the vacant land or natural environment to built-up land cover (Jitendrudu.L.R.B).It is induced by population and economic growth, industrialization, speculation, land hunger attitudes, physical geography, transportation, lack of proper planning policies, living and property costs and demand for more living space (Batta, 2010). It is determined by environmental, political, economic, social, technological, and legal factors.

Comparing the urban land cover with other types of land cover such as agricultural land, it covers a smaller area but its impact to the surrounding environment is higher than any other landuse classes. Although rapid urbanization benefits human civilization in terms of society, economy and culture, it generates a lot of problems and challenges economically, socially and environmentally (Omwenga, 2010). Urbanization when ignored may intimidate sustainable development in regions (Dubovyk.O., 2011). Negative effects of urban growth and sprawl outweigh any positive effects. It is one of the problems and challenges faced in the NMR (MoNMeD, 2009).Understanding the extent of the urban land cover is vital element for efficient planning, managing and decision making activities.

Despite the economic benefits accrued, rapid urbanization rates and unplanned expansion of urban centres have negative consequences economically, socially and environmentally. Urbanization has led to high land prices, low forest cover below the recommended threshold and encroachment on conservation areas (MoNMeD, 2009). Previous studies on land use/cover changes were done within Nairobi city yet its influence is beyond its boundaries.

Due to inefficient implementation systems in Kenya, urban planning, infrastructure and services are generally poor. Urban growth combined with urban sprawl, inadequate infrastructure and land use planning have posed a challenge in the NMR (MoNMeD, 2008). There is need for intensive planning and development efforts in the urban sector.

The Ministry of Nairobi Metropolitan Development (MoNMeD) initiated the development of a Spatial Planning Concept (SPC) for the NMR to come up with a spatial plan for the purpose of guiding and coordinating development of infrastructural facilities and services and for the specific control of land use and development (MoNMeD, 2012). It proposed spatial modeling for the NMR through six new towns as new growth centres to accommodate new activities meant to decongest Nairobi city, and a system of strong urban centres (MoNMeD, 2012).

The selection of the proposed locations for this new towns were based on easy accessibility from the road network, topography, availability of low productivity agricultural land, least interference with ecological sensitive and conservation areas and good potential for landscaping leaving out the crucial urbanization factor. Urbanization determines the implementation of these spatial planning proposals and has an impact on sustainability of urban ecosystems.

Monitoring urban growth in the NMR is necessary for implementing appropriate strategies regarding the urban planning decision making process and in redrawing urban policies to realize sustainable development. In this study, remote sensing and GIS technologies are used since they are a proper and effective tool to understand and present the phenomenon.

Study Objectives

The main objective of this project is to monitor growth in the urban land cover by identifying, mapping, quantifying and analysing the spatial-temporal urban land use/cover changes that occurred in the region before and after the creation of the Ministry of Nairobi Metropolitan Development using GIS and remote sensing techniques.

METHODS

In this study, urban growth was monitored using the region's satellite imagery for years 1995, 2005 and 2015. Urbanized land in the NMR was identified, mapped and analyzed to reveal the changes and patterns over the study period. Analysis involved calculating the changes in the area of urbanized land cover over time, growth rates and expansion indices using urban growth indicators and spatial metrics. Urban growth patterns were drawn out from the resultant urban land cover maps.

The mapping process was divided into two components;

(1). Data identification and acquisition,

(2). Data and digital image processing.

Landsat satellite imagery for the study area was downloaded from the USGS Earth Explorer at the Regional Centre for Mapping Resources and Development (RCMRD). Topographical maps from Survey of Kenya and high resolution Google Earth TM images were used as reference data. GIS datasets from ILRI GIS services were also used in defining the regions urban centre locations and transport network. (Table 1)

Table 6: Datasets

SENSOR	DESCRIPTION(YEAR / PATH / ROW)	SOURCE
Landsat 5 TM	1995, path 167 row 62, path 168 row 61,62& 62, path 169 row 61	USGS
Landsat7ETM+	2005, path 167 row 62, path 168 row 61,62 & 63, path 169 row 61	USGS
Landsat8 OLI/TIRS	2015, path 167 row 62, path 168 row 61,62& 62, path 169 row 61	USGS
GIS Datasets	Shape files	ILRI GIS SERVICES
Topographical & Boundary maps	1:50000	SoK

1995 Landsat 5 TM, 2005 Landsat 7 ETM+ and 2015 Landsat 8 OLI/TIRS imagery covering paths 167, 168 and169, rows61, 62 and 63(figure 1) were used to monitor urban growth in the Nairobi Metropolitan Region between the year 1995 and 2015.

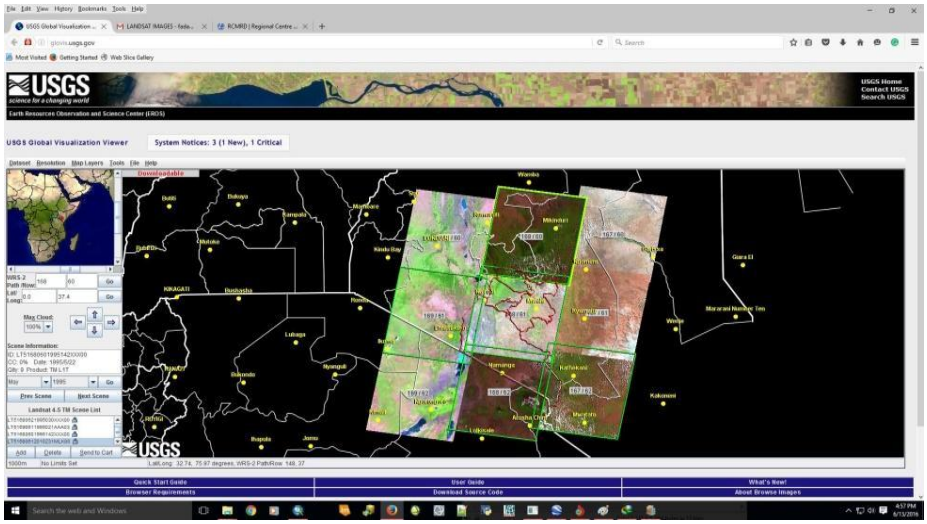

Figure 1: Landsat scenes overlay of the study area

(Courtesy of USGS Global Visualization Viewer)

The 32159.50km^2 region is comprised of four out of the forty seven counties in the country Kenya namely Nairobi, Kiambu, Machakos and Kiambu (Figure 2). The region is a highly urbanizing region with 24 urban centres forming nodes for activity concentration and consumption centres Nairobi city being the core of the metropolis. The Metro Vision 2030 divided the region into four sub regions: Core Nairobi, Northern Metro, Eastern Metro and Southern Metro.

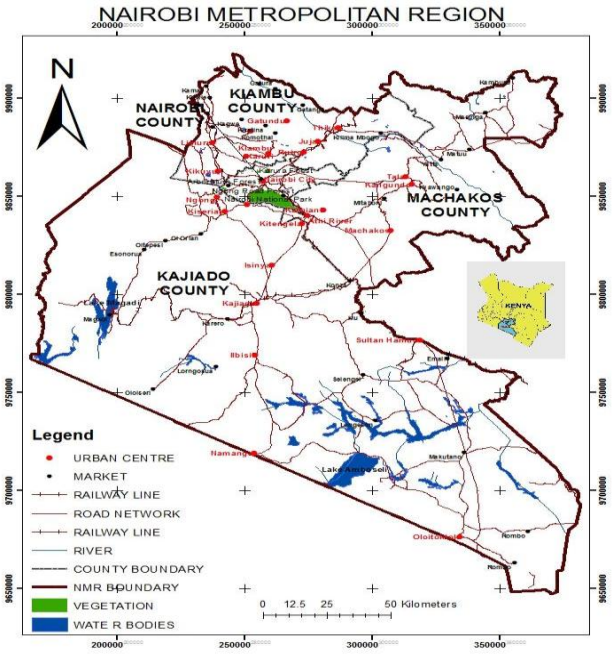

Figure 2; Study area, the Nairobi Metropolitan Region (adopted from the MoNMeD)

The identified and acquired data was processed in readiness to map the region. The processing, mapping, interpretation and analysis of images to capture and reveal urban land cover was done using ERDAS Imagine 2014 and ArcGIS 10.1 software.

The sub set was classified into five classes (built-up, vegetation, water, bare land and other lands) using the supervised maximum likelihood (ML) classification algorithm. The class other lands consisted of areas that did not fall in any of the four classes.

The classes were regrouped into built-up and non-built-up when defining urban areas. The urban areas consisted of vegetation (parks, plantations), open spaces, roads and railway networks, impervious features, airports, dumpsites, sport and leisure facilities, open spaces, parks etc. within selected urban centres (patches).

Three (3) land cover maps of the Nairobi metropolitan area were generated. The built-up class that characterized urban land cover was mapped by curving out the consolidated built-up areas at selected urban centres while disregarding isolated houses, buildings in the surrounding rural areas and stray pixels resulting from misclassification. Stray pixels were differentiated from the urban land cover by examining their proximity to the urban centres under study.

Post classification differencing that involved map to map and image to image comparisons was done to extract meaningful urban land change information from the classified satellite data. The urban areas were quantified and cross tabulation of the resultant areas was used to compare pairs of classified images to determine their change quantities. Analysis of urban built in the years 1995-2005 and 2005-2015 was studied by overlaying the resulting classified images/land cover maps of each year.

Using the captured urban area calculations, quantitative evaluation and urban spatial change analysis was done together with visual assessment by taking a closer look at the physical form of new urban development across the region. The analysis of the urban landscape was further done using the spatial expansion indices and spatial metrics. The annual urban spatial expansion index (AUSEI) and seven spatial metrics i.e the total area(TA), class area (CA) number of patches(NP),patch density(PD),the largest patch(LP), the largest patch index(LPI and the mean patch size(MPS) were used. The urban extent and growth rates over time were determined over the entire region and within the sub-regions.

RESULTS AND DISCUSSION

The resultant five classes are shown in different colour tones (figures 2, 3, 4). Built-up areas in maroon, vegetation in green, water bodies in blue, yellow/cream colour shows bare land and grey showing the class other lands. Surfaces with similar spectral properties presented a challenge in the classification process leading to misclassification of some land covers.

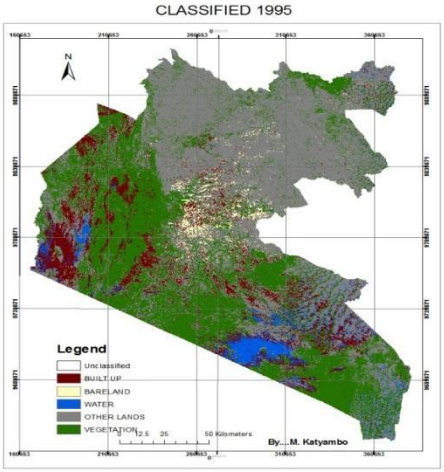

Figure 3; Classification Results 1995

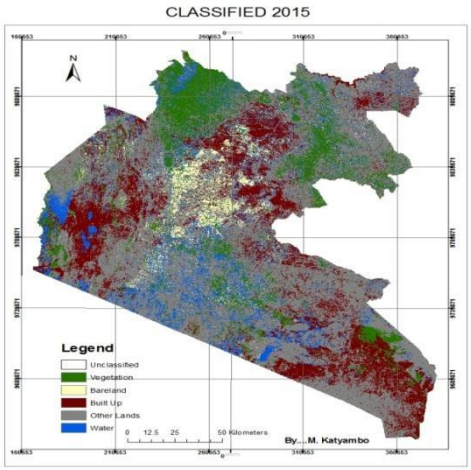

Figure 4; Classification Results 2005

Classified images revealed the changes and growth in urban land cover. Different land cover class areas were then generated (Table 3).

Table 2; Assessment of satellite images classification

YEAR	OVERALL ACCURACY (%)	KAPPA STATISTICS
1995	87.1	0.82
2005	87.62	0.81
2015	87.94	0.85

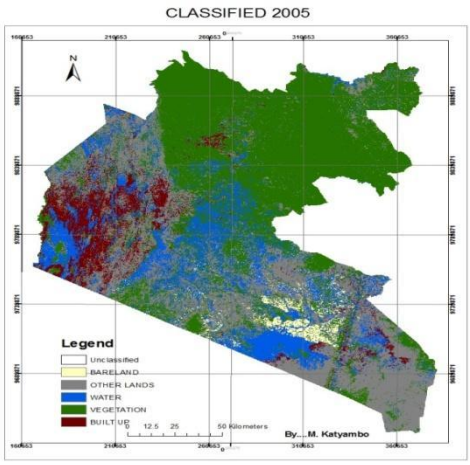

Figure 5; Classification Results 2015

The class areas were generated thereby revealing the coverage of each class in the region(Table 3)

Table 3; NMR Land cover class areas

LANDCOVER / AREA (km^2)	**YEAR**		
	1995	2005	2015
BUILT UP	1,254.30	2,030.05	3,494.62
VEGETATION	14,722.22	14,465.15	13,783.75
BARELAND	4,103.94	3,838.12	3,332.81
WATER	5,421.15	5,398.17	5,350.74
OTHER LANDS	6,657.71	6,427.87	6,197.31
TOTALS	32,159.32	32,159.46	32,159.23

It must be noted that urban areas comprise of built-up, vegetation, bare land and water. The resulting land cover classes (Table 3) were therefore further regrouped into built and non-built-up categories (Table 4) to help analyze changes in urban land cover that occurred. Urban land cover was captured by curving out the built up category within the selected urban centres in the NMR.

Table 4; **Regrouped land cover classes**

CATEGORY	DESCRIPTIONS
BUILT UP	Comprises all buildings, roads and railway networks, impervious features, vegetation, open spaces, Airports and Dump sites, Sport and Leisure facilities, Parks, etc. within selected urban centres.
NON BUILT UP	Comprises buildings, vegetation, water, roads and bare land not within the urban centres (in the rural areas) and the class other lands.

Temporal mapping of urban growth

The built-up land cover category around the twenty four (24) urban centres in the NMR was curved out(Figures 6, 7, 8, 9) and maps used for visual and quantitative assessment of urban growth that had occurred in the study area.

Urban areas and changes over time in the counties were calculated (Table 5) to enable regional analysis of urban expansion. To analyse land cover in the NMR, built-up and non-built-up proportions in the NMR were determined.

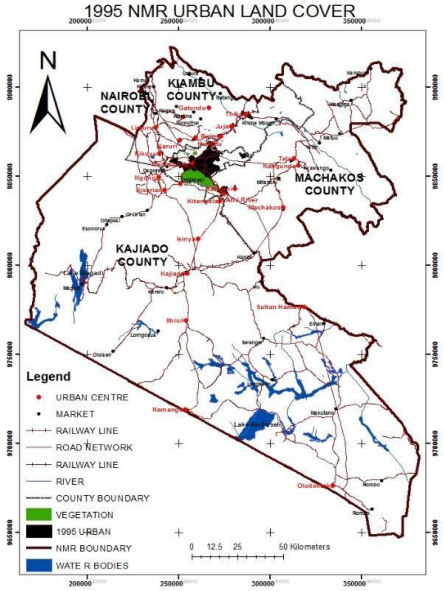

Figure 6; LULC map 1995

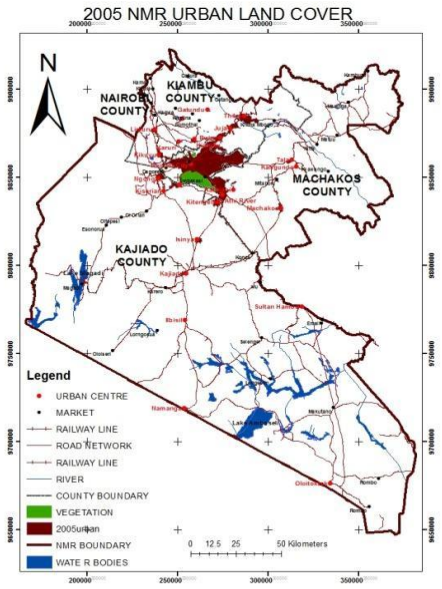

Figure 7; LULC map 2005

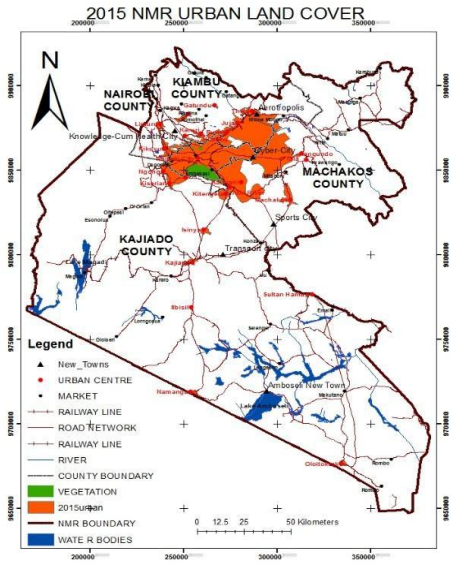

Figure 8: LULC map 2015

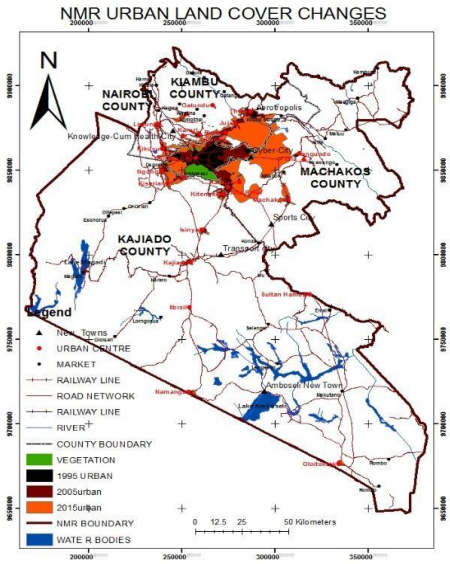

Figure 9; NMR urban land cover changes 1995-2015

Table 5; NMR counties urban are cover and changes

COUNTY	AREA	YEAR / URBAN AREA(km^2)			CHANGE (km^2)	
		1995	2005	2015	1995-2005	2005 - 2015
Nairobi	700.50	302.15	492.62	700.50	172.47	207.88

Kiambu	3,275	29.82	98.30	951.40	68.48	853.10
Machakos	6,281	21.72	97.23	379.17	75.51	281.94
Kajiado	21,903	37.30	75.64	156.75	38.34	81.11
TOTAL	32,159.50	408.99	763.79	2,187.82	354.80	1,424.03

Table 6; Percentage proportions of land use to the total NMR land

Landuse category	**1995**		**2005**		**2015**	
	Area (km^2)	**%**	**Area km^2)**	**%**	**Area (km^2)**	**%**
Built up(urban)	408.99	1.27%	763.79	2.38%	2,187.82	6.80%
Non-built up	31,750.51	98.73%	31,395.71	97.62%	29,971.68	93.20%
Total	32,159.50	100%	32,159.50	100%	32,159.50	100%

Urban mass increased by 354.80 km^2 and 1424.03km^2 between 1995-2005 and 2005-2015 respectively (Table 5). This means 1778.83km^2 non urban land cover was converted to urban land cover within the study period. The urban land mass expanded rapidly between 2005 and 2015(1424.03km^2) compared to between 1995 and 2005(354.80km^2) (Figure 10).

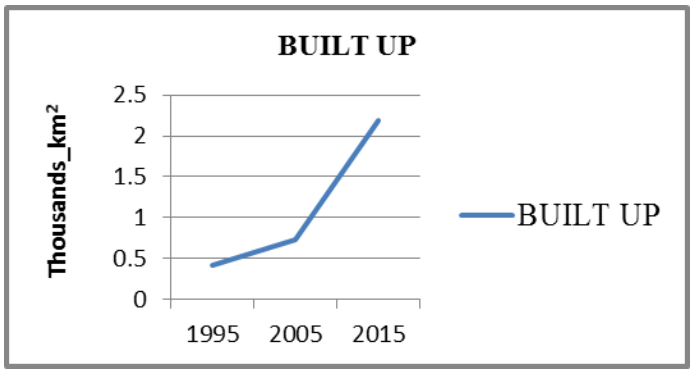

Figure 10: Graph showing the NMR built-up area/urban land mass between 1995 and 2015

With regard to 1995, built-up land cover expanded by encroaching on non built-up land cover by 1.12% and 4.49% in 2005 and 2015 respectively (Table 7).

Table 7: Built-up encroachment on non-built-up land with regard to 1995

Year	**2005**	**2015**
% encroachment on non built up land	1.12%	4.49%

Urban growth indicators and measurement

The AUSEI was 4.65% / year between 1995 and 2005, the urban land cover change was 368.46km^2 at an annual rate of expansion of 35.48km^2 / year. Between 2005 and 2015, it was 6.51% / year with an urban land cover change of 1424.03 km^2 at an annual rate of expansion of 142.40 km^2/ year (Table 8).

Table 8: AUSEI for periods 1995 - 2005 and 2005- 2015

Year	Urban area (km^2)	Spatial expansion(km^2)	AUSEI (%)/UEII
1995	408.99	-------	------
2005	763.79	354.80	4.65
2015	2,187.82	1424.03	6.51

The annual urban spatial expansion index increased from 4.65% / year to 6.51% /year revealing robust urban growth in the NMR between 2005 and 2015.

Spatial metrics were used to describe and quantify changes in urban land cover. They include Total area (TA),class area(CA), number of patches(NP),patch density(PD), largest patch (LP), largest patch index (LPI) and mean patch size (MPS) (Table 9).

Table 9: Description of the NMR using spatial metrics

LULC	ear/Metrics	^{2})	P	PD	^{2})	PI	MPS (km^2)
)		408.99		0.05	320.15	78.3	17.78
)		763.79		0.03	492.62	64.5	31.82
)		,187.82		0.008	700.50	32.0	136.74

Changes in LPI and PD imply a decrease in spatial heterogeneity. A decrease in PD from 0.05 in 1995 to 0.008 in 2015 indicated the expansion of patches as a result of rapid continuous development and a decrease in the number of patches. Continuous urban growth and development in the built-up area led to a reduction in fragmentation and hence a reduction in the number of patches (NP) from 24 to 17. The expansion of urban centres led to a reduction in the NP and PD caused by merging of the patches into larger patches. The NMR MPS increased from 17.78km^2 in 1995 to 31.82km^2 in 2005 to 136.74km^2 in 2015 implying a spatial increase in contiguous/continuous built-up area that led to reduction of patches due to merging of existing patches (Table 9).

By the year 2015, Nairobi County was 100% urbanised with an urban land cover of 700.50km^2. It was followed by the northern metro (Kiambu county) and then the eastern metro (Machakos county) with urban areas of 951.40km2 and 379.17km^2 respectively. The southern metro (Kajiado county) is the least urbanised region in the NMR with 156.75km^2 of urban land cover and a patch density of 4.47(Table 10).

Table 10; Description of the NMR regions using spatial metrics

Spatial Metric	**Metro Region**				
	Nairobi (core)	**Eastern metro(Machakos)**	**Northern metro(Kiambu)**	**Southern metro(Kajiado)**	**Total**
Region Area(km^2)	700.50	6281	3275	21903	32159.50
CA(urban-km^2)					

1995	320.15	21.72	29.82	37.30	408.99
2005	492.62	97.23	98.30	75.64	763.79
2015	700.50	379.17	951.40	156.75	2187.82
NP(n)					
1995	1	5	8	10	24
2005	1	5	8	10	24
2015	1	4	5	7	17
PD(%)					
1995	0.31	23.02	12.23	26.81	
2005	0.2	5.14	5.74	13.22	
2015	0.14	1.05	0.52	4.47	
MPS(km^2)					
1995	320.15	4.34	8.18	3.73	
2005	492.62	19.45	17.42	7.56	
2015	700.50	94.79	190.56	22.39	
LP(km^2)					
1995	320.15	14.83	13.05	14.07	
2005	492.62	76.42	37.47	16.34	
2015	700.50	325.40	805.51	99.21	
LPI(%)					
1995	100	68.3	43.8	37.7	
2005	100	78.6	38.1	25.5	
2015	100	85.8	84.6	63.3	

Urban Growth theories

The concentric zone, axial development and multiple nuclei theories explain urban growth in the NMR. Urban growth occurred in a radial-axial manner along transport routes away from the core Nairobi city towards the urban centres and away from the urban centres towards Nairobi (Figure 9).

CONCLUSIONS

Urban growth in the NMR is a result of social-economic, legal, political and environmental factors. Significant urban growth occurred within the study period especially after formation

of the Ministry of Nairobi Metropolitan Development in the year 2008. The physical planning Act (CAP 286) of 1996, part VI encouraged urban growth. Political manifestos (2002 general elections) and the economic policy in the government encouraged urban growth. The results demonstrate the effect of topography on the urban structure and growth. Kangundo town has not expanded extensively over time as compared to the neighbouring Tala trading centre due to the nature of terrain and topography at its location.

There was radial-axial urban development in the NMR. Growth was dominated by extension developments and sprawl at the Nairobi city periphery onto agricultural land in the rural areas, along transport routes from Nairobi city to other urban centres and from the urban centres to Nairobi city encouraged by the improvement of the country's economy and transport network.

The Southern Metro being the least urbanized region together with part of the Eastern Metro still have space for further urban land cover expansion.

Urban growth in the region does not affect the location of the NMR spatial plan proposed Transport city and Amboseli new town. The Cyber city, Knowledge cum Health City and the Aerotropolis need to be relocated due to urbanization.

Recommendations

The NMR management should think on its urban development strategy. The collapsed government urban development policies should be revived and packaged with adequate funding. They should consider acquiring up-to-date three dimension (3D) thematic urban spatial information using high resolution imagery, 3D in the sense that urbanization considering human settlements expands both horizontally and vertically. Such studies should be carried out when carrying out spatial planning. For them to implement the metro 2030 strategy proposed urban growth management mechanisms like urban growth boundaries and land use delineation, they need to use temporal urban growth spatial information (4D) generated from high resolution satellite imagery as a guiding tool .

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A WEB BASED AUTOMATION OF CADASTRAL SURVEY WORKFLOW AND FILE TRACKING SYSTEM. (A CASE STUDY OF CADASTRAL DIVISION-SURVEY OF KENYA)

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Abstract
Survey of Kenya is the National Mapping Agency in the country headed by a Director who is charged with responsibility of providing safe custody of maintaining, updating, retrieving, dissemination and managing cadastral information in Kenya. Currently, the checking of survey cadastral files at the Survey of Kenya cadastral checking section is analogue. This has led the section to have challenges in handling the ever increasing cadastral survey jobs submitted by the surveyors for quality checking and processing. Modern survey techniques for carrying out the field survey pose another challenge as the section is not adequately equipped to handle the ever evolving technological advancement of the post-colonial times. The proposed automation of the cadastral file tracking system is capable of handling the above quoted challenges. The main goal of this study is to develop a web based cadastral survey workflow and file tracking system at Survey of Kenya and if implemented, will support all cadastral survey workflows hence address the delays experienced in the land survey division and reduce the interaction between the clients and the officers. It will make use of information technology by use of internet and mobile technologies in disseminating the information to the end users.

Keywords: Automation, Cadastral survey, Cadastre, File tracking, Workflow, Ministry of Lands and Physical Planning, Survey of Kenya

INTRODUCTION

The Department of Surveys under the Ministry of Lands and Physical Planning is the official Government Agency for land surveying and mapping. The role of the department is to survey land, collect data for research and production of topographical and thematic maps, plans, charts and aerial photographs. These functions are carried out within the provisions of the Survey Act (Cap 299) of the Laws of Kenya, under which the department drives its legal mandate and the title Survey of Kenya (Lands, 2010). Cadastral survey division is one of the branches at Survey of Kenya which is the government mapping agency in the country. It is headed by a Director who is charged with responsibility of providing safe custody of maintaining, updating, retrieving, dissemination and managing cadastral information in Kenya. The Cadastral system in Kenya was established in 1903 to support land alienation for the white settlers who had come into the country in the early part of the 20th Century (Wayumba, 2013).

The aim of this project is to develop a web based system that can assist the surveyors spread all over the Kenyan territory to track their submitted cadastral field survey files at Survey of Kenya. With a unique identifier code(surveyor's reference number) for each fixed cadastral survey work submitted by licensed/ government surveyors at Survey of Kenya, surveyors will access the web portal any time anywhere in their android devices or on a desktop at the comfort of their offices. The system will aid in tracking stage the survey file stage and at

what status, approved or not approved. When approved, one can download an authentication slip and pay the checking fee online using a pay bill number and when not approved the interface should provide a link for enquiring the possible cause of disapproval. A surveyor will therefore not need to physically visit the Survey of Kenya premises moving from one office to the other tracking the cadastral survey file manually as it is today. A local area computer network at Survey of Kenya with regular updates through the office interfaces will help in updating the database server which will be managed by a database administrator. Meanwhile the ministry is training officers on file tracking system that aims at solving the problem of missing files and improve efficiency in service delivery. However, the lodging of cadastral surveys for approval by the Director of Surveys is still required to be done in analogue form despite the use of digital land surveying equipment when capturing data in the field. To be suitable for modern technology-based land administration, the cadastre together with the land register have to be automated, taking into account common standards and data models (David N.S., 2005).

STUDY AREA

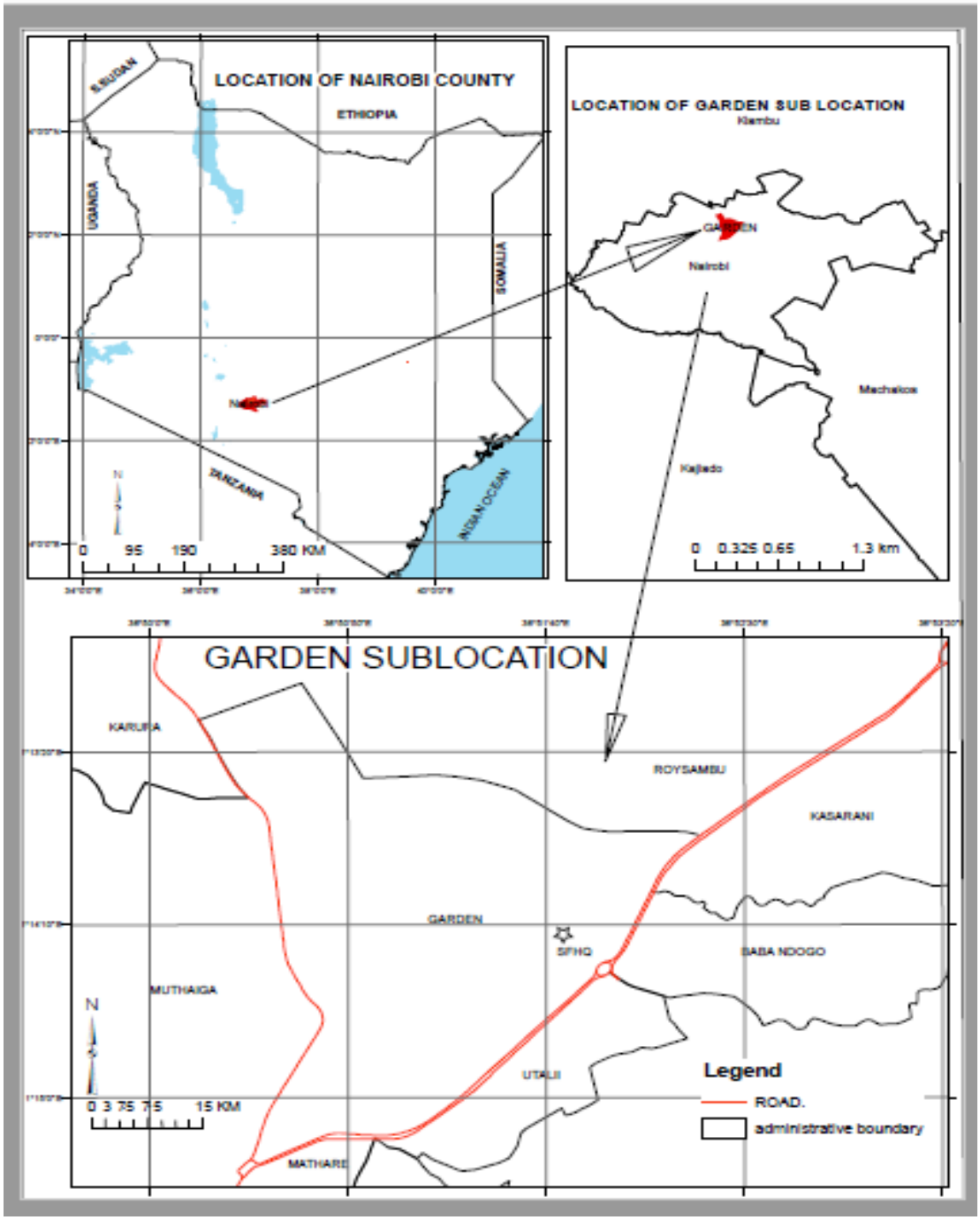

Figure 1: Survey of Kenya, Ruaraka offices

Cadastral survey section which is under land survey division at Survey of Kenya is located at Nairobi County off Thika super highway approximately five kilometers from the Nairobi city center in the Republic of Kenya.

Survey of Kenya serves as the survey field headquarters for the Ministry of Lands and Physical Planning. All fixed survey files are submitted, checked for quality control and authenticated for further actions under this division.

Data Sets

The study involved various activities including data acquisition, data processing and data analysis and interpretation. Two categories of datasets are generally stored in geo database.

First is the cadastral data which is directly connected with land ownership and the second category is the supporting data such as geodetic reference points, administrative boundaries and topography, which assures basic cadastral data(legal cadastral objects) of accurate referencing in relation to physical objects and to the earth, as well as allowing integration with other types of spatial data. Data from the submitted cadastral survey files details will be acquired from cadastral division at Survey of Kenya. The primary data to be collected for this study will provide the possibility to examine the opinion relating to the information sharing in the cadastral survey division. Two methods will be used to obtain the information questionnaires, and observations. An explanation of how the two will be put to use is given hereunder.

Questionnaire

The Questionnaires were hand delivered to potential respondents. The two sets of questionnaires were meant to address inter-related issues with a bearing on the development of an effective web based cadastral survey system.

In particular, the government/ private Surveyors questionnaire dealt with the following: data storage; updating records; access of information; security of cadastral survey file information; and linkage between the departments.

The questionnaires were both closed and open type where possible answers were given. Closed ended have been seen to inhibit the free thinking of the respondent but the open type gave a room to give their views that is by use of commenting more on the question. Observation method is largely employed in areas where the methodology of interviews and questionnaires is unlikely to yield results. A number of factors favor the use of questionnaires. First, it is particularly appropriate due to its anonymous nature. Second, it curbed the cost and time constraints that would hinder the prospect of reaching respondents scattered all over the country. Finally, it allowed respondents adequate time to respond which enabled the procurement of in-depth information. Even then, questionnaires pose some challenges, the problem of low response rate. This was resolved by allowing adequate time and constant reminders to the respondents.

Secondary sources

Apart from primary data mentioned above, secondary data was gathered in the course of this study. These were the collected and analyzed historical data from both published and unpublished materials. Secondary sources included the field survey, books, journals, newspapers, magazines and previous theses. The field data was captured through the various interfaces in every office avoiding redundancy in the database. Data captured was the cadastral survey file submission date, name of the licensed surveyor who signed the file, registry entry number, records officer, folio register number, computation number and the current officer carrying out the task.

METHODOLOGY

Figure 2: **Flow Diagram** (diagram is empty)

Two questionnaire samples were prepared, one for the officers who interacts with the manual system daily and another for the users to identify the problem as it exists. The users considered were the private and government surveyors who are in the field and submits their cadastral survey files at Survey of Kenya for quality checks and title processing. This was the data collection method adopted in this study. The Questionnaires were hand delivered to potential respondents. The two sets of questionnaires were meant to address inter-related issues with a bearing on the development of an effective web based cadastral survey system.

Secondary data was the collected and analyzed historical data from both published and unpublished materials. This includes field survey, books, journals, newspapers, magazines and previous theses. Database design were done which involved the process of identifying the data that will go into the geo database and how it will be represented. The database were designed using the post GIS and postgre SQL software. PhpAdmin which is a postgre SQL graphical interface was used to connect the database so as it can handle the SQL queries. The database in this project is surveyplan application. Application Development were done with the use of mapserver and Php scripts. Apache Web Server was used to serve both static content and dynamic web pages on the local host. Mapserver for windows (ms4W) was installed on a local host server together with Apache. PHP script was used to create web

pages, tools and functionalities. Mapserver then was used to link the data stored in post GIS database and thus web mapping application was developed. Geomoose software was used to display the map which shows the spatial location of various parcels of land.

Website Development was done using the Dream weaver software which is a software program for designing web pages. It offers login section so as to control the accessibility of the system and also introduces the user segmentation which means that some of the information related to the cadastral survey file being tracked will only be accessed to authorize Survey of Kenya officials while what the public should access will be availed to them. Once the database, application and website were developed, all were integrated to form the web based cadastral survey workflow and file tracking system. HTML was used to embed the application on the website. System implementation was done by testing the system on a local host. The test was successful as it was running and one would track a cadastral survey file.

RESULTS AND DISCUSSION

The outcome of the questionnaires administered to different government and private surveyors at the Ministry of Land and Physical Planning is as shown in figure 3 and4.

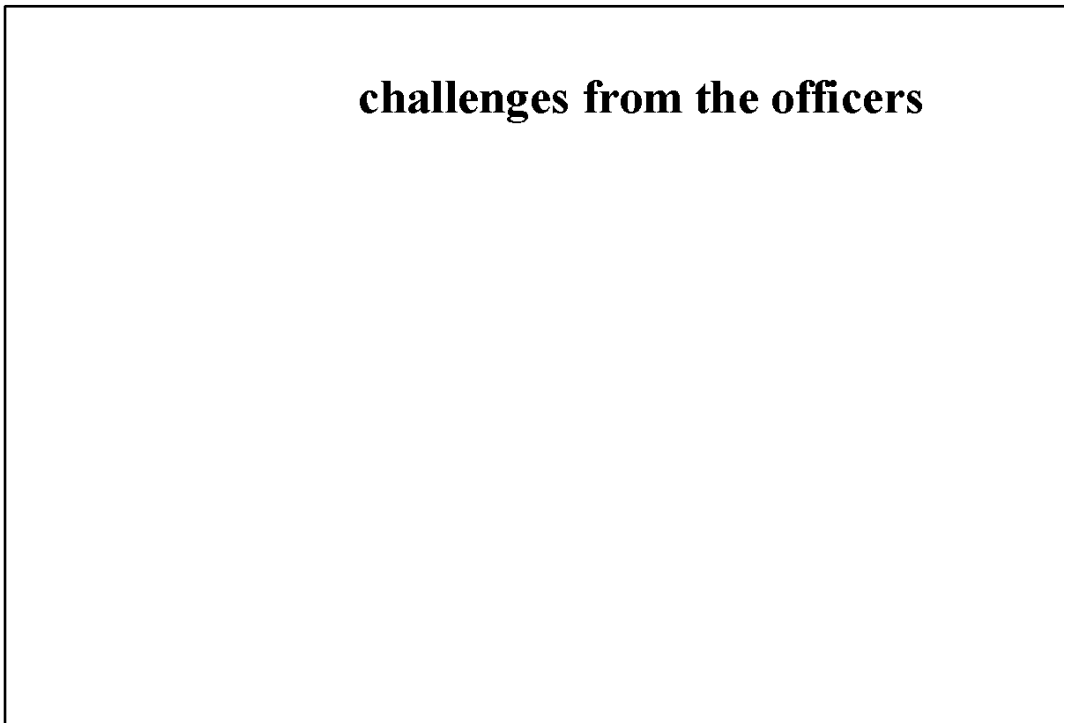

Figure3: Challenges from Survey of Kenya officers

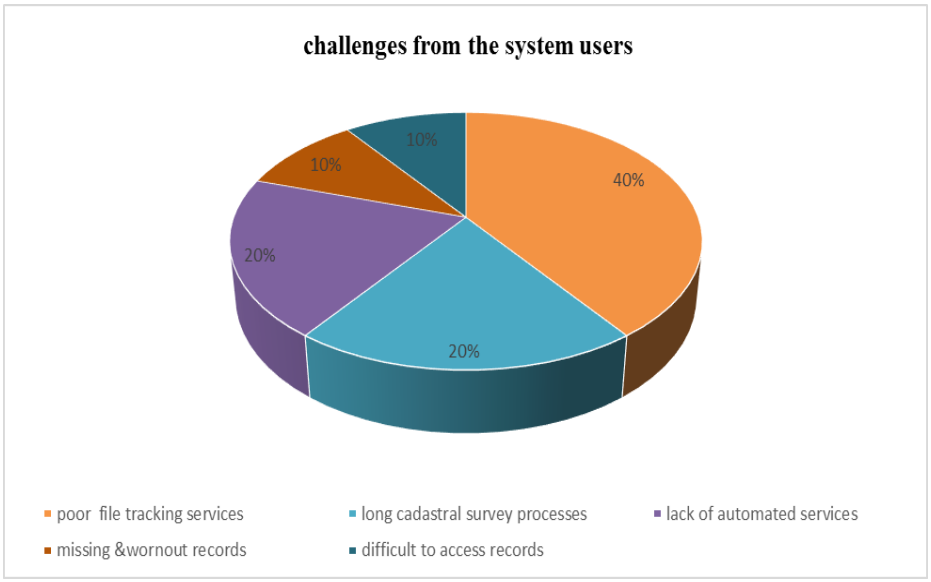

Figure 4: Challenges from the system users

The overall results indicated that at present state, the cadastral division at Survey of Kenya has not kept pace with new technology. The research inquired on the problems that, in the opinion of the officers, hindered their timely delivery of services. 45% pointed out lack of soft wares and hardware, 15% blamed it on low level of computer literate staff, 15% blamed it on lack of ICT skills among the staff, another 10% on faster changing emergency of technology, and 5% was not a priority to them. In the opinion of the system users, 40% pointed out that there exists the problem of modern file tracking services. 20% blamed the system on long cadastral survey processes that a file must go through, 20% blamed it on lack of automated services at Survey of Kenya for tracking a cadastral survey file. 10% said they also face difficulties in accessing the records since some go missing and others are torn out.

To access the application, a web link gene.webfactional.com/survey/ will be used to log in as shown in the interface below:

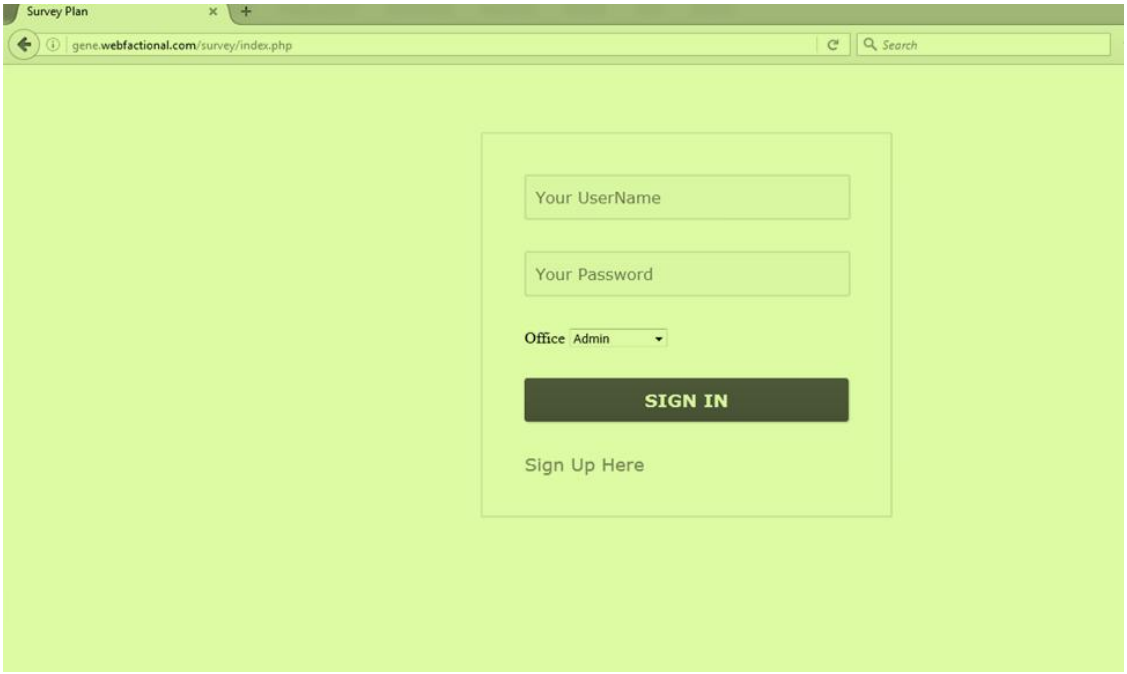

Figure 5: Sign up window for Survey of Kenya officers

This will be used by the officers interacting with the system on daily basis. For the users to access the information, they would need to register for access rights and this will enable them to access only the required information while the information for the users will be hidden.

A job scheduler which is a special system software whose main task is to select the jobs to be submitted into the system and decide which process to run will be operated by the database administrator. A job scheduler selects processes from the queue and loads them into memory for execution. This will help the administrator to know which cadastral file is delaying and can identify the officer in charge of it and take an action. It will also help in fair distribution of cadastral survey files especially in the quality control offices.

It is as illustrated below:

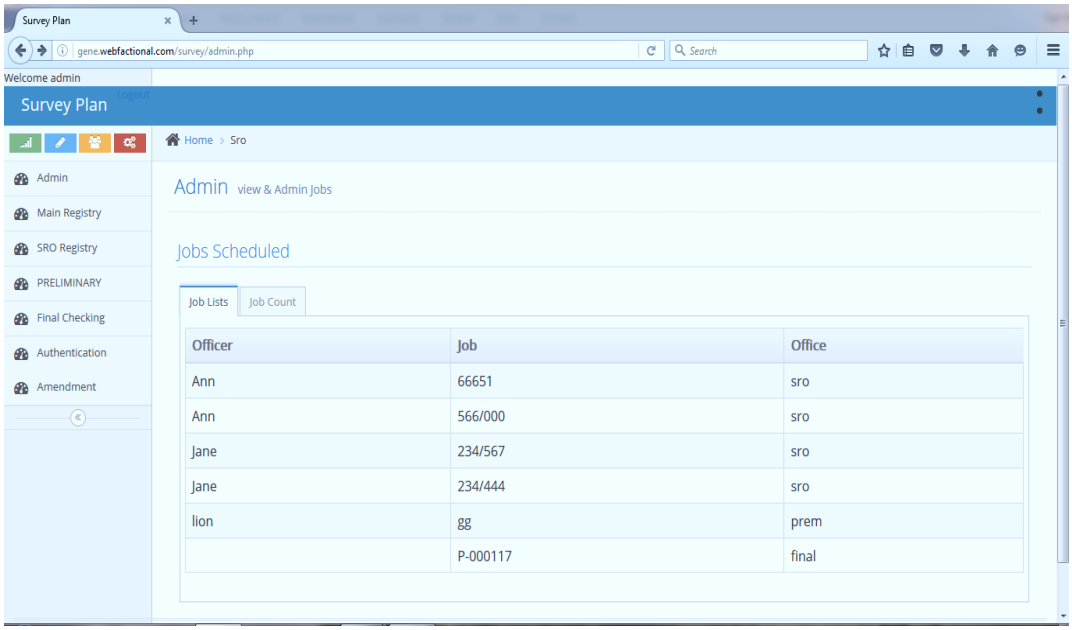

Figure 6: Job scheduler interface

To track for the cadastral survey file, the user types the link gene.webfactional.com/survey/search/search.php, with the unique identifier for tracking a cadastral survey file been the surveyor's ref no. The resulting interface is as below;

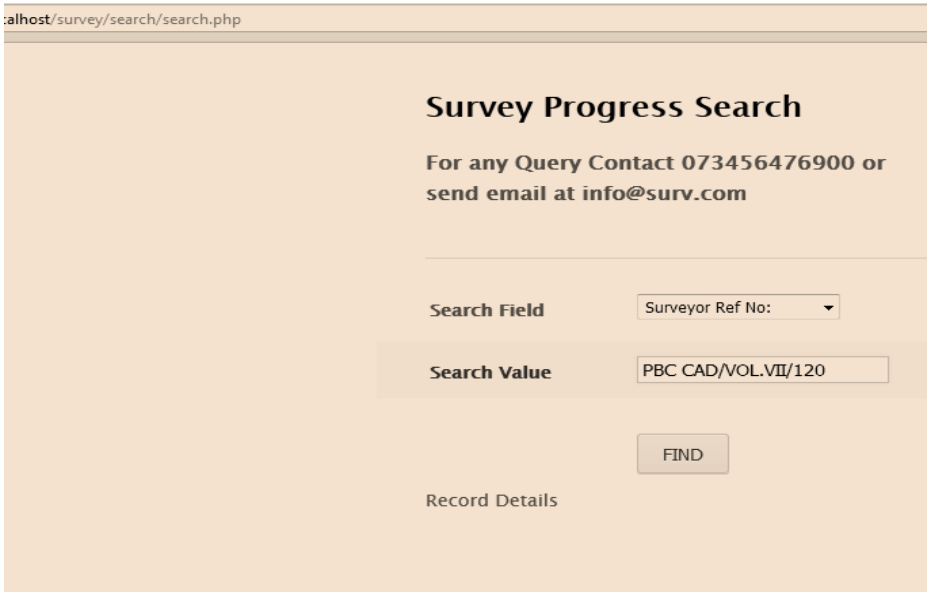

Figure7: File tracking interface

The results are displayed as in the figure below;

Figure 8: **Search Results window**

The final results of this web based automated cadastral survey workflow and file tracking system is the cadastral survey file details showing the office, status (approved, rejected or pending) folio registry number, date received and computation number online using the hosted web sites.

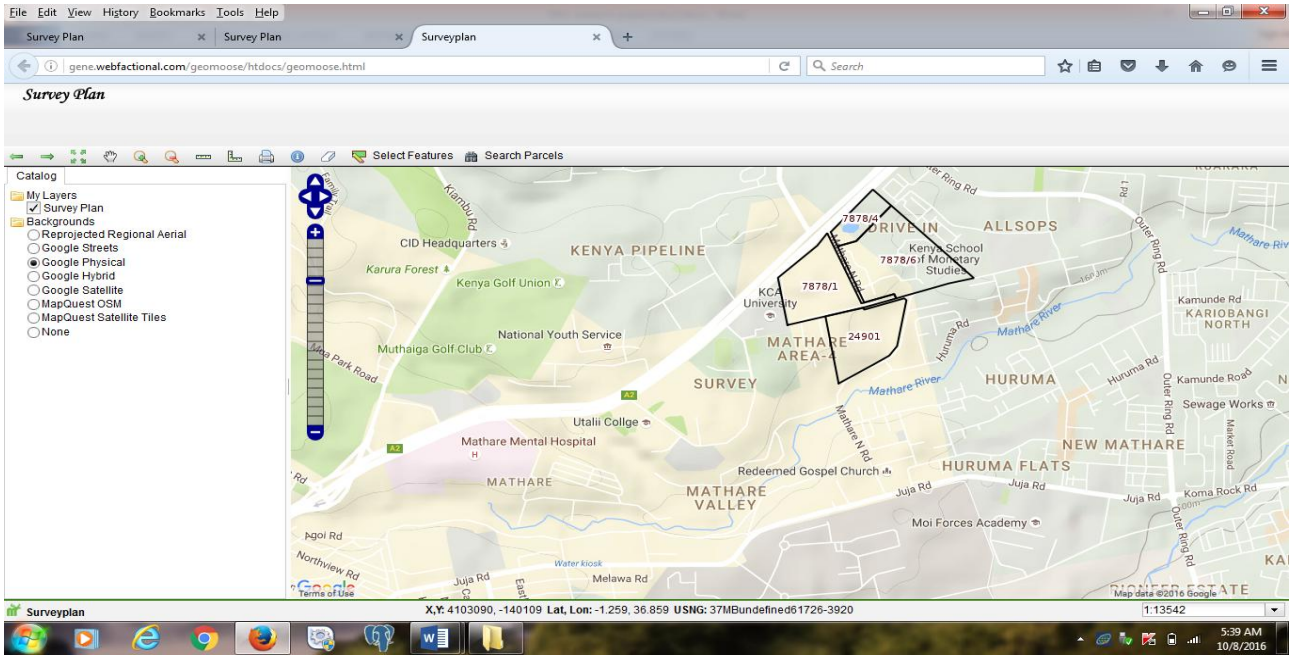

Figure 9: Visualizing spatial location of a land parcel

This cadastral survey and file tracking system could be used to visualise the physical location of a parcel of land in question. The above Geomoose software can be used to measure acreage of a parcel of land, bearing and distance of lines and also the x and y coordinates (spatial location).From the results it was clear that if this system is implemented at the Survey

of Kenya cadastral survey offices, the surveyors will enjoy tracking their files progress at the comfort of their offices anywhere in the Republic of Kenya.

On analysing the system it was found that, for one to track the cadastral survey file at Survey of Kenya, one have to follow around seven stages which takes hours if not days. It's tedious, time consuming and frustrating when one's survey file is misplaced and no one is accountable for it.However,for one to track a cadastral survey file at Survey of Kenya using the web based automated cadastral survey workflow and file tracking system, one will be required to visit the web links where the cadastral file details will be provided.

CONCLUSION

In this study, the existing problems were identified using the questionnaires administered to both the officers interacting with the system on daily basis and other users which includes the government and the licensed surveyors. The main deliverable was the prototype web based cadastral survey workflow and file tracking system which was successfully achieved. This system is a representative of how all the workflows in the Ministry of Land and Physical Planning can be implemented. Its importance is in addressing the automation of the cadastral survey workflow and file tracking at Survey of Kenya.

It is important to stress that the current manual cadastral file workflow and file tracking system scenario is time consuming due to the long processes that one has to undergo to track a cadastral survey file at Survey of Kenya, tedious because of moving from one office to another tracking a file, expensive in terms of time and money and insecure due to non-accountability among the members of the staff.

The main deliverable was the prototype web based cadastral survey workflow and file tracking system which was successfully achieved. This system is a representative of how all the workflows in the Ministry of Land can be implemented. Its importance is in addressing the automation of the cadastral survey workflow and file tracking at Survey of Kenya. The prototype system designed provides a quicker means of tracking a cadastral survey file at Survey of Kenya. This system is expected to make cadastral survey services accessible to all surveyors in the Republic of Kenya from the comfort of their homes and offices without having to visit the public agencies through the online and mobile platforms. One of the achievement of this system once implemented is that it will be easier to view and track tasks. The database administrator will be able to tell who is responsible for what and whether tasks were accomplished on time as required or not.

This system can be modulated to serve other private and public sectors with workflow and file tracking services. Survey of Kenya should embrace going digital in all sections and automating services to the public and also be improved to support data sharing in land registration section. Therefore, the Ministry of Lands and Physical Planning should adopt the new technology of a web based system of file tracking and cadastral survey workflow in the cadastral division. The Survey Act Cap 299 should be amended to allow the submission of cadastral survey files in soft copy online. This system can be extended to the 48 county governments in Kenya to provide services to the land stakeholders at the county levels who might be in need of tracking their cadastral survey files at Survey of Kenya.

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ADOPTION OF BIOMASS ENERGY CONSERVATION TECHNOLOGIES IN SELECTED AREAS IN KITUI COUNTY, KENYA

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Abstract

Access to clean and sustainable energy is a key indicator of an improved social-economic life and environmental sustainability of any community. Globally, about 3 billion people rely on biomass energy for cooking and heating. Over dependence on biomass energy by households and cottage industries has contributed to environmental consequences such as deforestation and land degradation. It has also negative health impacts. Development and promotion of biomass energy conservation technologies has been undertaken widely. However, adoption rates still remain low. Therefore, the main objective of this study was to assess factors influencing adoption of biomass energy conservation technologies in four selected areas of Kitui County, Kenya. The sites included Kabati, Chuluni, Kitui West and Central. Data was collected using a structured questionnaire and thematic guidelines for institutional and focus group discussions. Sampling was done through purposive and stratified random sampling. The study employed descriptive and inferential data analyses. Results revealed three categories of available biomass energy conservation technologies: energy saving stoves (46%), woodlots (9%) and improved charcoal conversion kilns (2%). The mean percentage adoption rate in the four study areas stood at 48 % with Chuluni having the highest (51%) and Kitui West the least (46%). Ministry of Agriculture (28%), Kenya Forest Service (26%) and NGOs/CBOs (23 %) were indicated as the main sources of information. Field days (35%), community trainings (30%) and demonstrations sites (22%) were the most preferred dissemination channels. High cost of technologies, lack of community inputs in technology development, lack of awareness of the community's cultural needs, lack of follow up programmes and inadequate capacity to enforce implementation of existing energy policies and regulations, financial constraints and cultural preferences were indicated as the major constraints to adoption of technologies. The study recommends development of a joint implementation strategy and follow up programme on biomass energy that will look at the cost of technologies, dissemination channels and involvement of all stakeholders' in development and dissemination of technologies.

Key words: Biomass energy, Conservation, Technologies, Dissemination

INTRODUCTION

Biomass energy includes fuel wood, charcoal, bio-fuel and briquettes, and accounts for nearly 80% of the total renewable energy supply worldwide (FAO, 2010a). Wood fuel (fuel wood and charcoal) is the most important single source of renewable energy, providing more than 9 percent of the global total primary energy supply (FAO, 2012). Over one third of the world's population, about 2.7 billion people, rely on traditional biomass energy in form of wood fuel, agricultural residues and animal wastes for their basic energy needs *(*FAO, 2012, WBA, 2016). In Sub-Sahara Africa (SSA), 90% of the inhabitants use biomass energy for domestic purposes. The remaining 10% uses either petroleum based fuels such as kerosene and gas and the least use biogas, electricity or solar energy (IEA 2010). In SSA, the number of biomass energy consumers is projected to reach almost one billion by 2030 (WEO) (UNDP/ WHO, 2009). The high number of biomass energy consumers and increased demand is associated with rapidly increasing populations, urbanization, high poverty levels and relatively high prices of alternative energy sources. The increasing population has also seen increased use of agricultural residues for energy purposes thus contributing to low soil fertility a major factor in food security (FAO, 2010b).

In SSA, most of the wood fuels resources are obtained unsustainably from dry forest and wood lands. The traditional way of producing and utilizing biomass energy is also unsustainable as the technologies used are inefficient and has significantly contributed to increased overexploitation of tree resources. With increased awareness on climate change and energy security, wood energy has become far more important and visible as a global issue. Unsustainable harvesting of tree resources and use of inefficient technologies has led increased emission of green house gases thus contributing to climate change (GIZ & GEBP, 2013).

In Kenya, wood based energy provides 70% of the national energy needs with about 90% of Kenyan's rural households depending on fuel wood as basic source for cooking and heating while it is estimated that 83% of Kenyan urban households depend on charcoal for cooking. Apart from being an important domestic energy source, Wood fuel is an important source of energy for rural based small and medium enterprises (SMEs) such as agro-processing industries, confectioneries and mineral-based industries such as brick making and ceramics (Githiomi *at el.,* 2012) and institutions such as schools, hospitals and prisons. It is estimated that in Kenya, the national demand of charcoal is over 16 million m^3 while supply is estimated at about 13.5 million m^3 (MEWNR, 2013). The current deficit is estimated at over 60% (SOE, 2014). This state of affairs has major implications on the environment and the people as most of the energy is produced and utilized in traditional and inefficient kilns which have low efficiency rates of between 12-15 % (Oduor *et.al*, 2006) and utilized in inefficient stoves leading to overexploitation of tree resources.

Problem statement and justification

Overexploitation of wood resources to meet domestic and commercial energy in Kitui County has led increased environmental degradation, threatened tree species, wood scarcity and food insecurity. The proximity of Kitui County to major towns has made charcoal production a big business even for outsiders and this has led to increased impacts on the environment and the people. To curb the negative impacts, a number of organizations have developed and disseminated biomass energy conservation technologies to local communities and institutions within the county. The technologies includes energy saving cook stoves, improved charcoal conversion technologies and establishment of wood fuel plantations Information on available technologies has been disseminated to local communities through trainings, demonstrations sites, field days, exchange programmes and development and provision of extension

materials. Despite the high number of organizations involved in development and promotion of sustainable energy technologies, adoption and continued use of the technologies remains low. This was observed in the Socio-economic study undertaken in the County (Muok *et al.*, 1997). The study indicated low level of adoption of energy conservation technologies thus contributing to wood fuel scarcity and environmental degradation. However, no studies have been undertaken to establish factors influencing the adoption of the technologies. This study therefore sought to assess factors influencing the adoption of energy conservation technologies in four selected areas of Kitui County.

Overall Objective

To assess factors influencing adoption of biomass energy conservation technologies in four selected areas of Kitui County.

Specific objectives

i. To document energy conservation technologies used by the local community and small scale commercial enterprises in the study area.
ii. To determine how various information dissemination pathways by organizations has influence adoption of the technologies by the community.
iii. To establish the influence of environmental and socio- economic related factors on the adoption of the technologies.

RESEARCH METHODS

Study area

The study was undertaken in four selected areas of Kitui County namely: - Central, Chuluni, Matinyani and Mutonguni. The total area of the County is 30,496.4 km2 (KNBS, 2015). The estimated population in 2013 stands at 1,065,829 with 86% of the population estimated to be living in rural areas and 14% living in urban areas (KNBS, 2015)

Sampling

Sampling was done through purposive and stratified random sampling**.** The four study areas were identified and stratified into locations and then sub-locations. A total number of 1,920 households in the selected Sub-locations formed the population sample. Through random sampling, 10% of the total household's in each sub-location was selected for individual household interviews and according to (Gay, 2011) a sample of at least 10% of the household population per sampling unit was adequate. A total of 192 households and eight organizations identified through focus group discussions were interviewed.

Data Collection and Analysis

Data was collected using structured questionnaires for individual households and institutional interviews and questionnaire guidelines for focus group discussions (FGDs). The study employed Microsoft excel and statistical package for social scientists (SPSS) computer packages for descriptive and inferential statistics.

RESULTS AND DISCUSSIONS

Socio-economic and demographic factors of the population.

The result shows that 77% of the respondents were women and 23% being men, Head of the households were mainly men at 61.9% while women were 39.1% mainly widows and single parents. Most families are large with a mean of seven members. Literacy level high, however women make 75% of people with little or no education at all. Most farms were privately registered (72.9%) mostly under the name of the head of household, majority whom were men except where land was jointly bought.

Sources of energy of the respondents

The results showed that firewood (97%) followed by charcoal (86%) were the main sources of energy for cooking and heating in all the four study areas. Other sources of energy for cooking, heating and lighting included crop residues, kerosene, gas, solar and electricity at 62%, 53%, 28%, 12% and 7 %, respectively indicated in Figure 1.

The high percentage of usage of biomass based fuels i.e. firewood, charcoal and crop residues confirms the information that biomass energy is a major source of energy for a big percentage of the population in the study area. This is due to its availability, affordability and ease of use as indicated by over 90% of the respondents. The high prices of the alternative energy sources such as liquefied petroleum gas (LPG) and electricity were indicated by (75%) of the respondents as one of the major constraint to use of alternative energy sources. They also lacked accessories and devices such cylinders and cookers to use energy. Brick making, liner and pottery firing and tobacco curing enterprises were also observed to use large amounts of fuel wood.

Energy conservation technologies by the local community and SMEs

Three categories of biomass energy conservation technologies used by the communities and the SMEs were identified in the four study areas. The technologies included; Improved energy saving stoves (46%) establishment of wood fuel plantations (9 %) and improved charcoal conversion kilns (2%). The technologies varied within the study areas as illustrated in **Figure 2.**

Figure 2: Proportion of respondents who have adopted technologies in the four study areas

Adopted energy saving cook stoves and reasons for adoption

The adoption of biomass energy conservation technologies in the areas was noted to be improving given the variety of stoves and devices available within the community and the high number of organizations involved in their promotion. Adopted stoves and devices included "Kuni mbili", Kenya ceramic jiko (KCJ), "Maendeleo" liner, the "Enzaro",, modified simple brick, Rocket and "Jiko poa" stoves. The "Jiko Poa"stove was being provided through a credit facility by K-REP micro-finance.
Respondents had varied reasons for the adoption of the stoves as indicated in **table 2**.

Table 2 – Reasons for adoption of energy saving stoves

Study sites	Low consumption of fuel	Cleaner cooking environment	Less cutting of trees	Less smoky and polluting	Saves time and labor	Improved health	Saves on money
Mutonguni	10	15	10	18	20	14	13
Central	23	17	8	14	13	14	20
Matinyani	15	10	16	12	18	16	13
Chuluni	22	18	6	14	14	10	16
Means	17.5	15	10	14.5	16.25	13.5	15.5

Increased awareness, availability of stoves and availability of local materials used for construction of some the stoves were indicated as some of the factors contributing to increased use of the devices. However, despite the well known beneficial aspects associated with use of improved stoves and information availed by the various organizations, overall, only 47% of the respondents had adopted the devices. However this was an improvement from 33% recorded in an earlier study (Muok *et al.,* 1997*).*

The traditional stoves continue to enjoy cultural preference despite its associated health and environmental related issues. In a related study undertaken in Peru, Kenya and Nepal on behavioural altitudes and preferences in cooking (Evelyn *et al.,2014*) traditional cooking stoves were still preferred cultural preference, perceived to yield tasty staple food, faster in cooking, food more pleasing to the people when associated with traditional stoves, uses locally available materials, can be used for other cultural activities and is part of the culture of the people as people share information and stories around the open fire. In all households where the improved stoves were observed, the traditional stoves were still in use. This is despite the low efficiency levels. Their ease of mobility and installation anywhere within the homestead and community makes the traditional stoves and the traditional metal stoves highly preferred for large families and social activities such as wedding and funerals. The cultural preference for the three stone stoves especially by the elderly in the community is due to its multiple uses such as heating, cooking, lighting, performing cultural activities. The smoke from the traditional stoves is also associated with food security as observed in the study area, where cereals are stored in structures below the roof of the kitchen just above the traditional stoves and the smoke from the fire repel pests, this saves them the use of chemical pesticides.

Charcoal conversion technologies

According to the results, over 97% of the respondents involved in charcoal production in the four study areas used the traditional earth kilns while only about 2% used improved charcoal. Improved charcoal production technologies available in Kenya are in three categories: earth, metal and brick kilns. The earth kilns includes the improved earth and the Casamance kilns. These kilns have recovery rates of up to 30% (Oduor *et al,* 2006). Other includes the metal kiln (portable metal, the *Mekko* and the drum kilns) and lastly, the masonry kilns. The masonry brick kilns include the half orange and the retorts. With recovery rates ranging between 25% to 38% (Oduor *et al,* 2006), the metal and masonry kilns don't require any vegetation material to cover the wood in the process of carbonization. The production capacities of these kilns range between 5 - 120 bags depending on size.

Use of traditional kilns for charcoal production is an old art and has been used for charcoal production until the beginning of the twentieth century (Amanor *et al.*, 2002). The use of the technology still persists because it's cheap, easy to handle, skills learnt on job and information passed on through generation. It can be operated at the source of wood thus saves the producers extra costs of transporting the wood to the kiln site.

The traditional kilns are known to be inefficient, with efficiency levels ranging between 12% to 15 % according to studies undertaken by KEFRI on efficiency of different types of kilns (Oduor *et al,* 2006), however, charcoal producers still prefer them. The kilns are known to produce low and inconsistent quality of charcoal products and also contribute to environmental pollution through release of tar and green house gases to the environment (FAO, 2006).

According to the study, only about 2% of the respondents indicated to have used improved kilns. Two types of improved kilns observed in the areas were the brick kiln (half Orange") and the metal "*Mekko*" Kiln. These were observed in Musengo and Miambani Locations in Mutonguni and Kitui Central respectively. However, the adoption and usage of the improved kilns by the community was noted to be very low due to a number of factors chief among them lack of skills and information, high cost of the technology, ignorance of the benefits of using improved kilns and high extra costs of transporting the wood materials to the kilns sites.

The producers are also very wary of any extra cost that would increase their production costs and make their products less competitive in the market. Despite being depended on charcoal

as source energy and income, the community are also ignorant of the benefits accrued from using the improved kilns.

Establishment of woodlots

Tree planting or wood fuel plantations have the potential to make biomass energy sustainable and also mitigate climate change. The practice of establishing woodlots as source of wood fuel saves enormous amount of time and money which would have otherwise is used to procure wood fuel from outside.

In the study areas, respondents with small farms were more likely to engage in tree planting unlike respondents with big farms who could access tree resources from their land. Matinyani area led in the number of respondents with woodlots. This is because of small sizes of the farms and the increasing populations leading to more fragmentations of the farm. The households indicated preference of integrating trees on farm as boundary, shade, or scattered trees on the compound. In a related study in Central Kenya (Githiomi *et al.*, 2012), trees planted either as scattered trees on farm or as border planting plays a major role in supplementing wood fuel production for house hold use.

Correlation analysis between income sources, education level and adoption of the technologies

In reference to costs of technologies which was higher than the traditional technologies, there is a significant correlation between income sources/levels and energy conservation methods, p=0.000.

Table 2: Correlation analysis between income sources, education level and adoption of technologies

		Source of income	Education level	Energy conservation methods
Source of income	Pearson Correlation	1	.070	.433**
	Sig. (2-tailed)		.338	.000
	N	441	188	231
Education level	Pearson Correlation	.070	1	-.009
	Sig. (2-tailed)	.338		.915
	N	188	189	159
Energy conservation methods	Pearson Correlation	.433**	-.009	1
	Sig. (2-tailed)	.000	.915	
	N	231	159	249

**. Correlation is significant at the 0.01 level (2-tailed).

From the results, households with higher levels of income had higher levels of adoption of the energy conservation technologies. This relationship also applies to other clean energy conservation technologies such as use of electricity, gas and solar energy.

Information dissemination on energy conservation technologies

The results showed that a number of organizations were involved in promotion of biomass energy conservation technologies**.** They included Ministry of Agriculture and Livestock Development (28.5%), Kenya Forest Service (KFS) (23.3%), NGOs/CBOs such as Kenya Energy Non-governmental Organization (KENGO), MUSEVECO and Trees for energy project (16.8%), Ministry of Energy (12 %), KEFRI (11%), others (radio/Church and schools) (8.5%) and Micro-finance institutions (K-REP) (4%). Information was disseminated

through training, demonstrations, study tours and provision of extension materials. In all study areas, MoA, KFS, and NGOs/CBOs were ranked as the major sources of information, while others (radio, churches and schools) and Micro-finance (K-Rep) were ranked the least as sources of information. The Ministry of Energy was least mentioned as source of information on biomass energy conservation technologies despite the docket of renewable energy falling under that ministry and the presence of a Renewable Energy Centre in the County. Inadequate human and financial resources were indicated as the major constraints to information dissemination by the Ministry. Presence of well trained personnel in the Ministry of Agriculture up to the Ward level was indicated as one of the reasons for being indicated as main source of information on energy conservation despite its mandate being agriculture.

Information dissemination channels used

Information acquisition and dissemination channels refer to the transfer or exchange of information from person to person or from one place to another (Ifukor *et al.,* 2013). The purpose of any information dissemination pathway is to increase the level of uptake of a technology or product.

The results showed, a number of information dissemination channels were used by the various organizations to transfer information to the communities. They included; field days, community trainings, demonstrations site, home visits, study tours, group meetings and use of extension materials). The dissemination channels indicated were common across the board given the commonality of organizations working in the area. The three most preferred dissemination pathways across the four study areas included field days (59.5%), demonstrations (50.5%) and group trainings (44.5%). The three depicts practical demonstration of the technology and an interactive discussion of how the technology works. Other included group meetings 31.5%), use of extension materials 29.75% (leaflets pamphlets, posters, and documentaries) and home visits (28%) in that order.

Barrier to effective information dissemination in the study areas

Despite the various channels used for information dissemination, there were barriers to effective communication for increased awareness and uptake of the technologies. While there was no significant differnce in the types of dissemination channels used within the four study areas (P=0.05). In Chuluni, the respondents felt the field days were too few, while in Kitui Central, respondents felt the extension materials were too technical given the low literacy levels of most of the participants. The repondents felt the materials meant for the local community could be simplified and be relevant to their interests and needs. In Kitui Central and Matinyani the respondents felt the demonstration sites were inadequate to effectively pass the information to the community.

The use of various dissemination pathways by various organizations in the community has however not translated to actual increased adoption and continued use of the energy conservation technologies disseminated. The community noted that there was a knowledge gap between the information available with organizations and the information needs of the community. There was also lack of cooperation among the information dissemination agents thus creating a feeling of repetition, barrier to information flow and community fatigue.

The community proposed various improvements for increased positive impact to the community. This included increasing the number and frequency of field days held, conduct more community/group trainings, set up more demonstration sites, and use of public forum.

Socio-economic and technical constraints to adoption of the technologies

The results show a number of socio-economic, technical and environmental constraints to adoption of energy conservation technologies. They include resistance to change due to

cultural preference of traditional technologies/ stoves, lack of finances or credit facilities to procure the devices. Others include lack of follow-up programmes to ensure implementation of action plans after trainings and to ensure installation, use and maintenance of the devices /technologies disseminated, limited fuel wood resources planted on farm, lack of expertise (technical capacity), inadequate information on installation of the technologies, lack of knowledge sharing within the local community after training and lastly, ignorance of the beneficial aspects associated with the improved energy technologies.

Socio-economic

Improved energy saving stoves has financial implications and thus the cost of devices is major hindrance to the technology adoption according to 76% of the respondents. Installation of improved energy saving stoves requires procurement of construction materials and masonry expertise which all have financial costs. Purchasing of readymade improved stoves such as the Kenya Ceramic stove (KCJ), the 'Jiko Poa', from local dealers require more finances than traditional metal stoves as they cost in the range of Kenya shillings (KES) 600-4,000 per piece depending on the type and size of the devices..

The cost charcoal conversion kilns such as the Metal kilns and the "half orange" kilns are also costly and require a high capital investment in the range of KES 50,000 – 250,000 depending on the size. This high cost of the devices is a discouraging factor especially for communities with low income sources. Most improved kilns observed during the study, were either procured using donor or government funds. Being free issues, the community was not obliged to take care of them, thus there was lack of sense of ownership. In most cases the devices were never repaired for lack of finances and skills as the cost of repair and maintenance of the stoves/kilns is high. Financial investment in improved cook stoves/ kilns to most financially constrained families with more pressing family needs is considered. Lack of organized supply chain system and credit facility from financial institutions with support from the government and the donor's community was noted to be lacking by 67% of the respondents. Existence of such credit facility could open up an avenue to provide the stoves/devices cheaply to the local communities on credit basis. K-REP, a Micro finance institution was the only one indicated by the community as providing improved stoves on credit basis in Kitui Central. The respondents felt there is need to link trained organized groups with organizations / micro finance instituions working in the area for follow up and financial assistance though credit facilities.

Technical and Environmental

On the technical aspects, information disseminated to the community through use of extension materials was considered to be very technical (58%) for the local community especially were majority of the targeted audience were women whose literacy level were low. Respondents also indicated they lacked technical capacity to install and operate the kilns (65%) as most of the technologies had technical designs from outside the community that never addresses the cultural needs of the community. Respondents noted that there is need to train artisan including women who will be available to provide the services.

Indigenous trees growing naturally in the woodlands were indicated as the most preferred (67%) for woodfuel production. Despite the decreasing trends in existence of indigenous woodlands, the community in the study area was not planting the indigenous tree woodfuel production. About 35% indicated they lacked technical knowledge on how to propagate indigenous species. Overexploitation of preferred indigenous trees to meet increasing fuel wood demands without any conservation measure was noted to contribute to increased deforestation and loss of biodiversity.

Small land sizes ranging between two to three acres for the majority of respondents (54.2%) was noted hinder establishment of woodlots for fuel wood production. Due to increased competition for crop and livestock production, most respondents preferred to plant multipurpose trees scattered or along the boundaries. Major decisions on tree planting and choice of species rests with head of household whose preferences are for multipurpose trees for other forest products like, timber, poles and posts overshadows the need to plant trees for wood fuel and fuel wood is only obtained as a by product after the trees have been harvested for other purposes, this affects adoption of the technologies for energy production.

CONCLUSION

The study concludes that even with increased information by various state and development organizations on various biomass energy conservation technologies and the benefits of using them, existence of the various socio-economic, technical and environmental factors such as high cost of the improved technologies, cultural preferences, financial constraints due to low incomes and high poverty levels, lack of sense of ownership of the local community due to non involvement in the development of the technologies and lastly, lack of follow up programmes to monitor implementation of the programmes, adoption and continued use of the technologies will remain low.

The study therefore recommends collaborative efforts to promote efficient biomass energy production and utilization technologies. Provision of credit facilities by government in collaboration with financial and development partners with longer repayment periods to community's members to procure preferred technologies rather than free issues of technologies whose designs the communities had no inputs in their development. Promote use of available local materials such bricks, mud, sand and skills to make modified versions of the biomass energy technologies for increased adoption. Government and development partners to provide more funding for research and outreach programmes for development and transfer of appropriate technologies that will incorporate the positive cultural aspects of the traditional technologies in the development of improved technologies to be more acceptable to the target community and also ensure developed technologies reach and meet the need of end user for increased adoption.

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