



## Impacts of Climate Variability in Agricultural Production in Kakamega County, Kenya

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**Abstract** – Climate fluctuates naturally on all time scales from days, seasons, years and few decades to many decades. The short-medium term fluctuations around mean state on climate scales, is referred to as climate variability. Climate variability is manifested in the: increase in extreme weather conditions; land degradation, changes in rainfall patterns; diminishing natural resource productivity; and in some areas, irreversible loss of biodiversity. Agricultural sector is sensitive to climatic conditions and hence vulnerable to climate fluctuations which often result in negative impacts. This study assessed impacts of climate variability in agricultural production in Kakamega county, Kenya. The study adopted the descriptive survey design. Multistage sampling strategy was used to obtain the geographical areas from where four hundred (400) farmers were randomly sampled. Key Informants were purposively sampled. Semi structured questionnaires, Focus Group Discussions (FGDs), Key Informant Interviews (KIIs) and observation check lists were used to collect data. Data were analyzed both inferentially and descriptively using SPSS statistical data package version 17. Respondents observed the following impacts of climate variability in crop and livestock production: Reduction in the quality and quantity of farm produce as a result of emergency of pests, diseases and vectors (98.2%); increased erosion (92.4%); deterioration of soil fertility (89.6%); seasonal uncertainties and change in the time of sowing (51.1%). Regarding livestock, there was a general reduction in size, diversity and quality of genetic breeds of livestock (78.3%). The study concluded that climate variability had impacted negatively on livestock and crop production. This study recommended that farmers adapt their agricultural practices in line with the climatical fluctuations as adaptation increases resilience of the vulnerable communities.

**Keywords** – Agricultural Sector, Climate, Impacts, Variability.

### I. INTRODUCTION

Climate fluctuates naturally on all time scales from days, seasons, years and few decades to many decades. The short-medium term fluctuations around some mean state on climate scales, is referred to as climate variability (IPCC, 2004; IPCC, 2007). Studies suggest that impacts of climate variability vary in different locations depending on the complex bio-physical interactions, changing socio-economic conditions and the unique features that may exist in these regions (Li *et al.*, 2011; Gosh *et al.*, 2011). Nonetheless, IPCC (2007) observes that globally, the air temperature near the earth surface rose by 0.74° between 1906 and 2005 and scientists estimate that it could be

increased as much as 6.4 °C on average during the 21st century. Existing literature document that an increase in atmospheric concentrations of greenhouse gasses equivalent to a doubling of carbon dioxide (CO<sub>2</sub>) will force a rise in global average surface temperature of 1.0 to 3.5 degrees Celsius by 2100 (UNFCCC, 1998; IPCC 2007). The IPCC further observes that an average precipitation will rise as much as 10% to 15% because a warmer atmosphere holds more water (IPCC 2007).

In Kenya, records indicate that the mean annual temperatures have increased by 1<sup>o</sup> C since the 1960s with a consequent increase in the number of hot days and nights (Mutimba *et al.*, 2010; NCCRS, 2010). Total annual precipitation projection in the country suggest an increase by approximately 0.2- 0.4 per cent per year (NCCRS, 2010). The country experiences major droughts every decade and minor ones every three to four years (Mutimba, 2010; NCCRS, 2010; KMD, 2012). Since 1993, Kenya has declared over six national disasters attributable to droughts and floods (DFID, 2010; KMD, 2012; NADMA 2011).

The change in climate has mainly adversarial impacts upon agricultural production because the sector depends on climate factors such as temperature and precipitation (Valerie *et al.*, 2010; Gwadys, 2009; Kakubo *et al.*, 2007; Muchemi 2010). Climate variability impacts in agriculture can be divided into bio and physical types (Maddison, 2007). It is therefore crucial for the farmers to acknowledge and perceive these impacts which should in turn inform their adaptation strategies. This study on the Impacts of climate variability in agricultural production in Kakamega County, Kenya purposed to establish this.

### II. MATERIALS AND METHODS

#### 1: Study Site

The study site was Kakamega county, Kenya. The county comprises of twelve (12) sub-counties and detailed on Fig. 1. The county lies between longitude 34<sup>o</sup> and 35<sup>o</sup> E and latitudes 0<sup>o</sup> and 1<sup>o</sup> N of the Equator and within altitude 1,250-2000m. It has an area of about 3,224.9 square kilometers (GoK, 2009). The site was purposively identified because according to the latest census report of 2010, the county's population stood at 1,660,651, being the second most populous county in Kenya (GoK, 2009). This county has one of the highest population densities in Kenya averaging to 544 persons per km<sup>2</sup>. In some locations, one thousand (1000) people live on the

agricultural output of 1km<sup>2</sup> (Jaetzold *et al.*, 2011). It is ranked at 29<sup>th</sup> position poverty level, out of the forty seven counties in the country (GoK, 2008b). Fifty one percent of the county's population live below poverty line of about

one dollar per day and heavily depend on subsistence farming for their food supplies and livelihoods (GoK, 2009). To a large extent, this food supply is inadequate hence it is food insecure (KARI, 2012; GoK, 2008b).

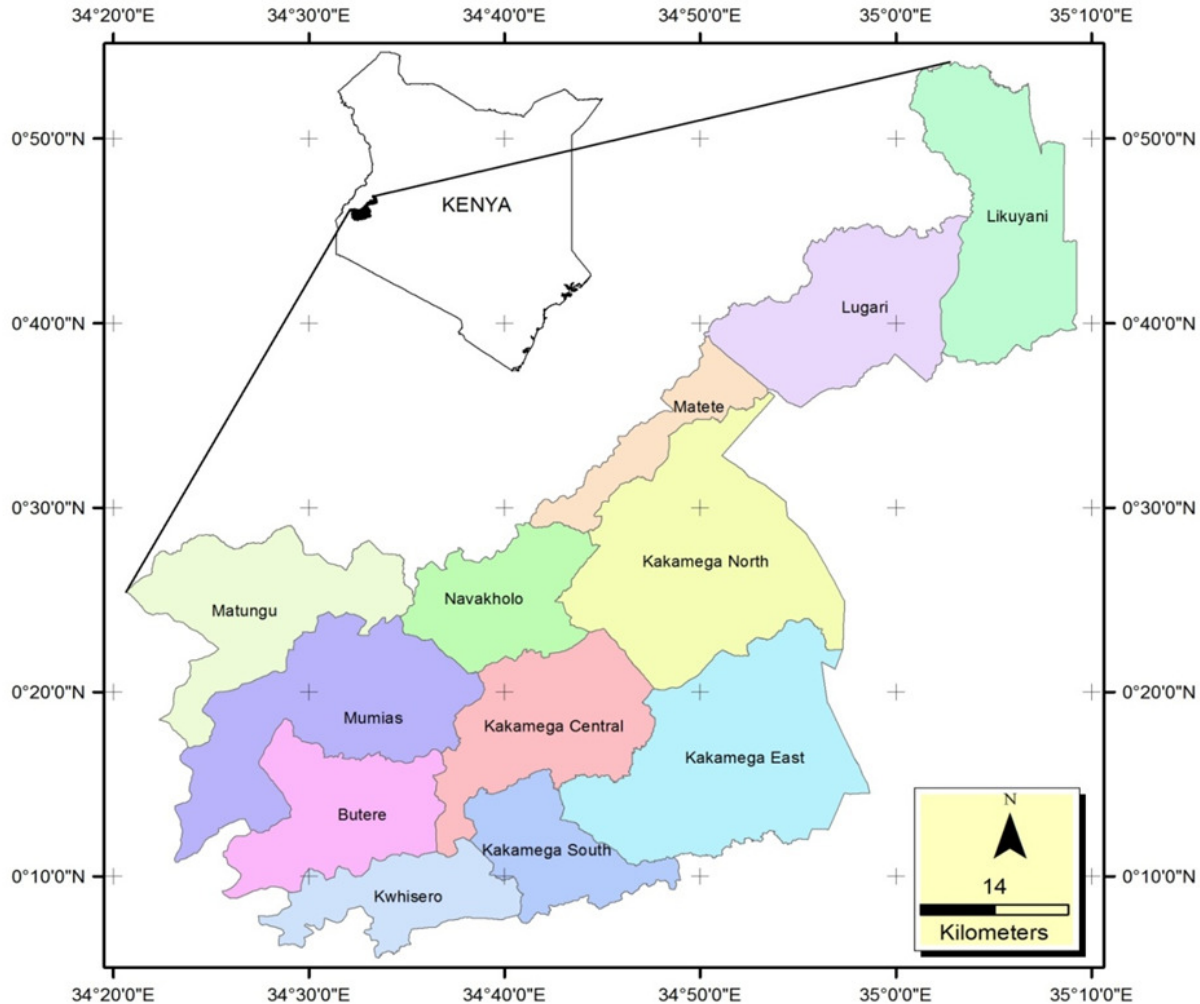


Fig.1. Kakamega County; Study Location

Source: GIS Laboratory, MMUST, 2014

## 2.2: Significance

The population in Kakamega county is comprised of people who heavily rely on subsistence farming for food and their livelihoods (Otolu and Wakhungu, 2013; GoK, 2013b). Climate variability has occasioned very serious vulnerabilities to this population as it has created unfavourable conditions for farming, impacting negatively on their food security. Findings of this study will expand the existing knowledge base and stimulate new developments and research on how to respond to the challenges.

## 2.3: Sampling Procedure and Sample Selection

The study area, Kakamega county was purposively sampled due to reasons given under section. Multistage sampling strategy was used to obtain the three geographical zones from where four hundred farmers were

randomly sampled. There were also key informants who were sampled purposively from stakeholder organizations.

## 2.4: Study Population and Data Collection Instruments

A questionnaire was administered to the 400 farmers. A total of 396 were returned and analysed appropriately. Focus Group Discussions (FGDs) and Key Informant Interviews (KIs) enabled the researcher to source information from other stakeholders in the agricultural sector. Direct observations were recorded in a checklist. The findings were triangulated to establish coherent or divergent responses.

## 2.5: Data Processing, Analysis and Presentation

Data were analyzed both descriptively and inferentially by use of the Statistical Package of Social Sciences (SPSS) version 17. Chi-square test was used to determine if there

were significant differences among the responses regarding how they perceived the impacts of climate variability from the categorical variables. Outcomes of analysed data were presented in tables, graphs and other graphical presentations.

### III. RESULTS AND DISCUSSIONS

#### 3.1: Losses of Crops Due to Climate Related Factors

Eighty six point four percent (86.4%) said they had experienced high losses of crops through climate related factors, and 13.6% indicated they losses were low. Such climate related factors cited comprised high infestation by diseases; (i) infertility of soils due to leaching; (ii) extended dry spells; (iii) diseases and; (iv) floods that impacted negatively on soils. Losses were experienced in the dominant crops grown in the county which comprised; maize, beans and horticultural produce. Fodder crop grown in the county where farmers experienced great loss was napier grass. Fig. 2 summarises the findings.

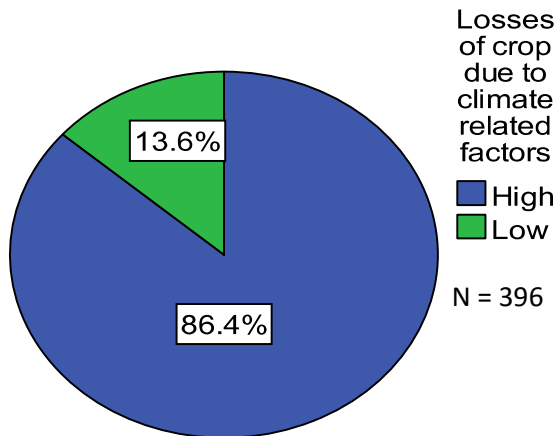


Fig.2. Losses of Crops Due to Climate Related Factors in Kakamega County, Kenya

A Chi Square test conducted on the data showed that there was a highly significant ( $P < 0.01$ ) variation in the distribution of responses on losses of crops during dry spells ( $\chi^2_{1,0.01} = 198.74$ ). This showed that there was a significant difference in the number of respondents who perceived that losses were high and those who perceived the losses as being low.

Farmers attributed the losses in maize to Maize Lethal Necrosis (MLN) disease, potatoes to potato blight, cassava Cassava Mosaic (CMD) and fodder grass napier grass to the stunting and smut disease caused by *165r +1group phytoplasma*. Respondents also observed an emergence of new strains of weeds, pests and more virulent strains of disease causal agents which negatively affected the yields. In some AEZ, like Lugari, this resulted in drastic reduction in the size of herds. Respondents' experiences are best captured by the verbatim expressions hereunder: From a KII respondent in Kakamega East; 'These days, if you plant tomatoes you have to spray with herbicides many times, unlike in the past when you would only spray once in a while.' From yet another FGD participant from Kakamega East that 'I feed my animals on banana leaves

and sweet potato vines because I lost all the nappier grass (fodder) to a disease'

Other climate related factors mentioned by the farmers were drought and floods. Drought exacerbated wind which enhanced evapo-transpiration resulting in loss of water by crops at higher rate. Findings from some studies indicated that during drought, there was increased demand for water which resulted in increased abstraction from the ground hence depleting it. (FAO, 2008b; Ziervogel *et al.*, 2008). This study established that drought occasioned stress in plants which dried up or gave rise to low quality produce. Regarding floods, the respondents observed that they caused soil erosion and leaching which resulted in nutrients loss. Overall, studies have shown that droughts and floods have the highest impact on crop and livestock losses in the climate variability scenarios (Okonya *et al.*, 2013; Ziervogel *et al.*, 2008).

#### 3.2. Losses of Livestock due to Climate Related Factors

The main climate related factors that farmers cited as having resulted in the loss of livestock were increased infestation by diseases and lack of pastures/fodder. Details of the findings are as indicated in Fig.3.

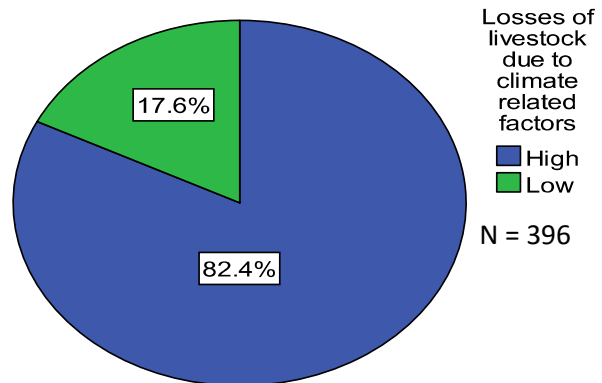


Fig.3. Losses of Livestock due Climate Related Factors in Kakamega County, Kenya

Eighty two (82 %) of the respondents observed that there were high losses of livestock that were climate related while 17.6 % said the losses were low. A Chi Square test conducted on the data showed that there was a highly significant ( $P < 0.01$ ) variation in the distribution responses on losses of livestock due to diseases ( $\chi^2_{1,0.01} = 166.37$ ). This shows that there was a significant difference in the number of respondents who perceived that losses were high and those who perceived the losses as being low.

Farmers attributed the losses of livestock to diseases such as new cattle and fowl typhoid for chicken; anthrax, East Coast Fever (ECF), foot and mouth disease for cattle; and other helminthological disease like those caused by the liver fluke. At the FGD, a farmer in Navakholo sub-county said that he had lost sheep in 2009 to a sickness which was not hitherto known in this region.' They also cited scarcity of pasture or fodder during the extreme weather conditions. The main fodder crop, napier grass had been decimated by the smut and stunting diseases. The

respondents observed that these diseases became more common during the humid conditions. They further cited an increase in the population of the vectors and poor nutritional status of livestock as additional causes. The latter was as a result of livestock not being able to access sufficient fodder or pasture. The observations compare well with the findings of studies that established that livestock that are unhealthy due to various reasons such as lack of pasture or forage succumb easily to illnesses (Archambault, 2012; KARI, 2013). According to Oteng'i (2009) pasture and forage are the two most important inputs in livestock production.

### 3.4. Impact of Climate Variability on Quantities of Farm Yields

The study considered quantity of farm yields as amount of produce as measured by conventional methods in the county. In this study the yields of maize and beans that dominated the agricultural landscape were conventionally measured in kilograms per acreage. Fig.4 show that 93.0% expressed that there was a decrease in the quantity of yields while 7.0% said there was an increase.

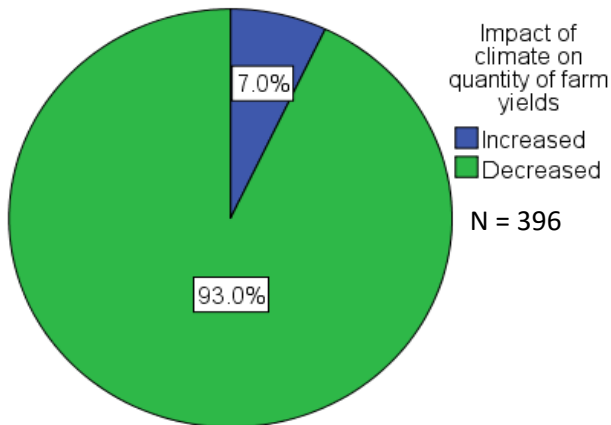


Fig.4. Impact on Quantity of Farm Yields in Kakamega County, Kenya

A Chi Square test conducted on the data showed that there was a highly significant ( $P < 0.01$ ) variation in the distribution responses on the impact of climate variability on quantity of farm yields ( $\chi^2_{1,0.01} = 227.70$ ). This shows that there was a great difference in the number of respondents who perceived that climate variability greatly affected the quantity of farm yields and those with a contrary opinion. These findings implied that a majority of the respondents experienced this impact. At the FGD sessions in the sampled zones, one farmer expressed that while he was growing up; a lot of maize was harvested from the farms while traditional vegetables grew wildly without being planted. The farmers said it was difficult to harvest high produce unless fertilizer and pesticides were used to ward off pests in the unfolding climate variability scenarios. Another respondent indicated that 'when he arrived in Lugari sub-county in 1999, he used to harvest an average of twenty five (25), 90kg bags of maize per acre with less farm inputs. This situation had changed as he could only harvest an average of Fifteen (15) of the 90 kg bags per acre with more farm inputs.

Climate variability greatly lowered the quantity of farm yields. Farmers attributed this to; (i) soil infertility and erosion; (ii) droughts, (iii) floods, (iv) infestation by diseases, (v) poor crop husbandry, and (vi) emerging varieties of weeds and pests. During the KIIs and the FGD sessions, the diseases infecting crops were identified as; (i) Cassava Mosaic Disease (CMD), (ii) Cassava Brown Streak Disease (CBSD), (iii) Maize Lethal Necrosis (MLN), (iv) Maize Streak Disease (MSD), (v) Napier Grass Stunting and Smut Disease, (vi) Cassava Spot Disease and (vii) the Cigar Disease in bananas.

### 3.5. Impact of Climate Variability on Quality of Farm Yields

During the KIIs and FGDs, the respondents observed the following as indicators of the drop in quality of farm yields; (i) small grains size of the dominant cereals, maize and beans; (ii) lack of hybrid vigor especially on subsequent planting and (iii) inability to last long during storage amongst others. Farmers observed that size of grain such as maize and beans in relation to weight of the equivalent had steadily gone down as determined from the records of their supplies to the cereals and produce board. The respondents' views on the impact of climate variability on the quality of farm yields are summarised in Fig.5.

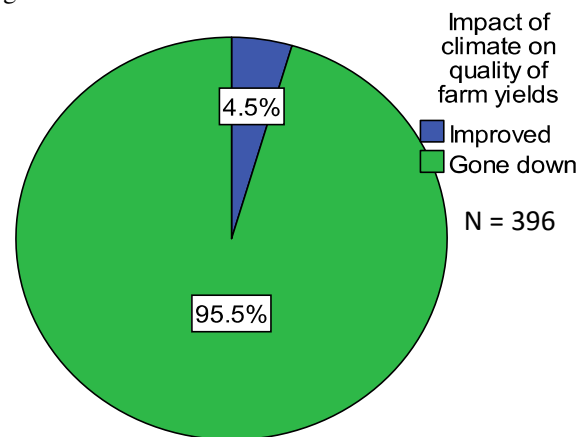


Fig.5. Impact of Climate Variability on Quality of Farm Yields in Kakamega County, Kenya

Ninety five point five percent (95.5%) of the respondents agreed that the quality of farm yields had gone down while only 4.5% indicated it had improved. A Chi Square test conducted on the data showed that there was a highly significant ( $P < 0.01$ ) variation in the distribution responses on the impact of climate variability on quality of farm yields ( $\chi^2_{1,0.01} = 329.26$ ). This showed that there was a significant difference in the number of respondents who perceived that climate variability greatly affected the quality of farm yields and those with a contrary opinion.

Other crops whose quality was cited by farmers to have gone down over time comprised; (i) cash crops such as sugarcane and tea and; and (ii) horticultural crops like tomatoes and vegetables. According to South worth *et al.*, 2000, individual crop growth processes are affected differently by variability in temperature and rainfall. For instance a seasonal rise in temperature resulted in an

accelerated developmental rate of a crop resulting in earlier harvest of poor quality crop. In addition, this caused pre-mature aging of crops as a result of changes in the photoperiods which contributed to low quality crops. Overall, climate related factors such as drought, floods and storms that had negative impacts on the quality of soil; increased infestation of diseases and reduced availability of pasture or fodder for livestock, amongst others.

### 3.6. Impact of Climate Variability on Time of Sowing

The respondents' views on the impact on time of sowing are summarized in Fig.6. Fifty one point one (51.1%) of farmers responded that the sowing/planting time had become unpredictable. A proportion of 41% of the farmers in this category observed that climate variability has resulted in shortened growing seasons.

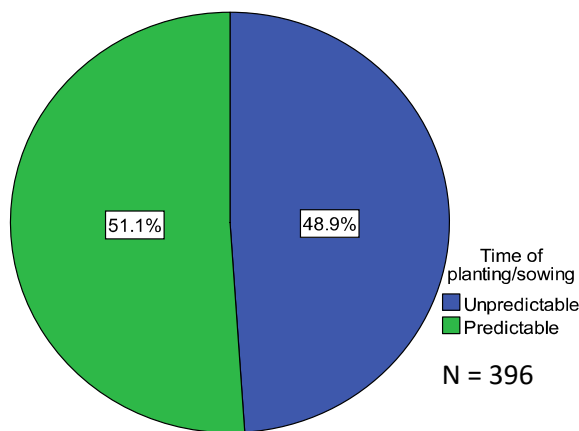


Fig.6. Impact on Time of Sowing in Kakamega County, Kenya

About 75% of the respondents at the KIIs expressed that 'the time of sowing had become very unpredictable as it was a farming activity that relied on the onset of the rainfall'. A stockiest at the FGD expressed that 'these days, you find farmers buying maize seeds even in May, a month when they are expected to be weeding the crop. 'All these manifest the variation in the sowing time that has come about as a result in changes in rainfall occurrence.

A Chi Square test conducted on the data showed that there was no significant ( $P > 0.05$ ) variation in the distribution responses on the impact climate variability on time of planting and harvesting ( $\chi^2_{1,0.05} = 0.17$ ). This showed that there was almost equal distribution of responses on how climate variability affected the time of sowing. Those who said the sowing times had changed indicated at the FGD that they received rainfall late into the growing season and experience extended dry spells. This interfered with the starting of farm operations for the subsequent cropping season which resulted in great losses.

### 3.7. Size of Livestock Herds

Impacts of climate variability on the size of herds as perceived by the farmers are summarized in Fig.7.

Ninety seven point nine (97.9%) of the respondents indicated that the size of livestock had gone down over time while a paltry 2.1% said it increased. On average, farmers in Lugari kept five (6) Cows and very few kept

Sheep and Goats. In Kakamega East, the number went down to an average of only two (2) cows and only 2% of sampled farmers in the sub-county kept sheep or goats. A Chi Square test conducted on the data showed that there was a highly significant ( $P < 0.01$ ) variation in responses on the sizes of herds of livestock kept ( $\chi^2_{1,0.01} = 198.74$ ). This showed that there was a very significant difference in percentage between the responses on whether the size of herds of cattle and other livestock kept were large or small.

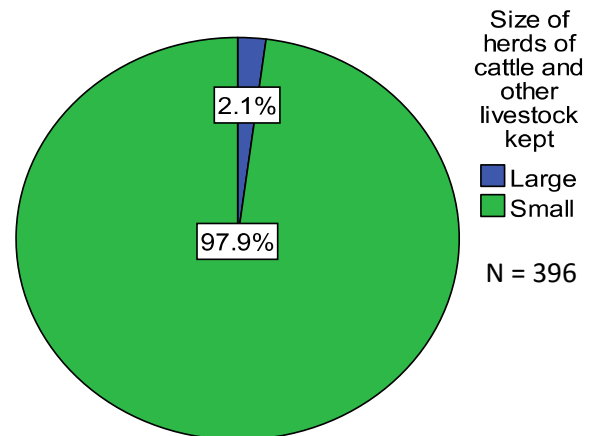


Fig.7. Size of Herds of Cattle and other Livestock Kept in Kakamega County, Kenya.

Of the 97.9% who indicated that size of herds had gone down, 87.3% attributed it to the reduction to extended periods of dry spells which made it difficult to access pasture or fodder. About 12.7% attributed it to; (i) increased disease infestation; (ii) fragmentation of parcels of land which made it difficult to get adequate grazing lands and; (iii) livestock production being an expensive venture. Similar sentiments were expressed at the FGDs and KIIs. For instance, a participant at the FGD from Navakholo said that in 1998, his herd comprised of over ten heads of cattle and 16 sheep. This had gone down to only three heads of cattle and no sheep because he did not have grazing pastures. On average, farmer households kept four (4) cows and about 5% of sampled farmers kept Sheep or Goats in Navakholo sub-county. At an FGD session in Lugari, sub-county, a prominent farmer expressed that as a young farmer in 1985, he had over fifty (50) heads of Friesian cattle which had dropped to only ten (10) because of expenses involved in maintaining their health and none availability of grazing pasture.

The results are consistent with those of Nyandiko (2008), that established that pasture forage and water being the largest input in livestock production were also key limiting factors in Kenya. Jaetzold, *et al.*, 2011, further established that pasture forage and water formed the largest inputs in livestock production and were thus limiting factors that impacted negatively if in short supply.

### 3.8. Genetic Quality of Breeds

The findings on the impacts on quality of genetic breeds are summarized in Fig.8.

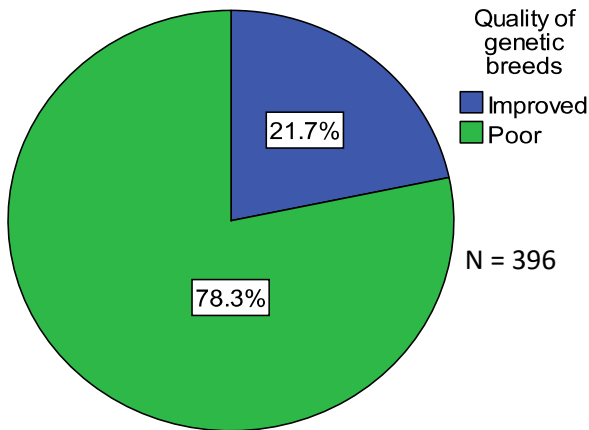


Fig.8. Impact on the Genetic Quality of Breeds Kakamega in County, Kenya

It was observed that 78.3% said that the genetic breeds were of poor quality and a paltry 21.75% expressed that they had improved. This showed that there was a wide variation of responses on whether breeds were poor or improved, with more respondents still having poor breeds. A Chi Square test conducted on the data showed that there was a highly significant ( $P < 0.01$ ) variation in responses on the quality of genetic breeds ( $\chi^2_{1,0.01} = 123.93$ ). Those who reared indigenous breeds cited the exorbitant cost of rearing the high quality breeds and lack of Artificial Insemination (AI) services in their specific localities. These results were supported by existing literature that observed that the inability of the farmers to access Artificial Insemination (AI) services was amongst the factors that had brought down the quality of cattle in the Kakamega county (KARI, 2007).

### 3.9. Extent of Infestation by Weeds, Diseases and Pests in Kakamega County

Fig.9 summarizes the findings. A total of ninety eight point two (98.2%) of the respondents observed that there had been an increase in the extent of infections by diseases (48.8%), infestations by weeds (42.5%), and pests (6.9%) as an impact of climate variability.

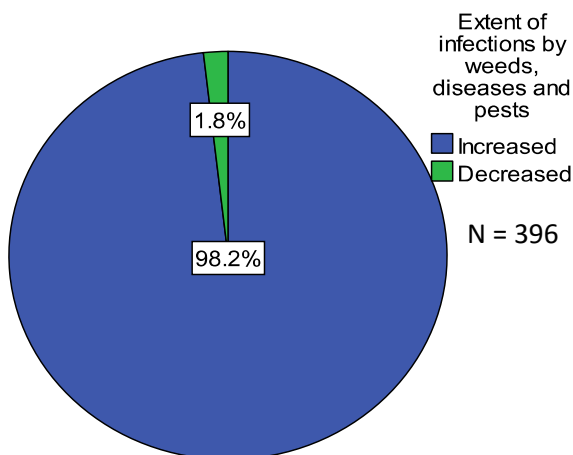


Fig.9. Extent of Prevalence of Diseases, Weeds and Pests Kakamega in County, Kenya

There was equally overwhelming support for this position by the KIIs where the agricultural experts expressed that amongst other reasons for the increased pests was farmers did not practice crop rotation. A Chi Square test conducted on the data showed that there was a highly significant ( $P < 0.01$ ) variation in responses on the sizes of herds of livestock kept ( $\chi^2_{1,0.01} = 198.74$ ). This shows that there was obvious difference between the number of respondents who indicated that the prevalence had increased and those that indicated otherwise.

At the FGD and also during KIIs it was established that the prevalent diseases affecting livestock were Anthrax, Fowl typhoid, ECF and New castle. Those that affected crops were Cassava Mosaic Disease (CMD), MLN, Sugarcane Mosaic Disease (SMD), napier grass stunting disease and the cigar disease in bananas. In some sub-counties there was high infestation of the parasitic striga weed (*Striga asiatica*). Pest menace by stalk borer (*Busseola fusca*), armyworms (*Spodoptera litura*) and the moth (*Lepidoptera*) were reported. The later, a new pest hitherto unknown in Kenya and indigenous to Ethiopia was reported to have caused serious reduction in tomato yields in the county.

Weeds are unwanted plants and often fill many spaces not used by the desired crop. Climate variability has resulted in the increase of new species and bigger populations of weeds. These species are better adapted to sub-optimum conditions than the crops. Consequently, they interfere with crop development impacting negatively on the yields (KARI, 2013). Studies by KARI (2013), recommended that crops must be free of weeds to avoid losses and enhance yields.

Regarding pests, Oteng'i (2009), intimated that the effects of pests varied amongst crops resulting in the lowering of yield levels. Literatures indicate that pests have either multiple interest cycle or one infection cycle during their multiplication. The later require developing a level which affects crop production through repetitive life cycles. This development depends on the characteristics and the course of crop development. Such pests include the Aphids which are considered as vectors of the MLN. The former include the smuts that require only one infective host during its development. The foregoing were crucial in determining the mode of controlling or eradicating the pests in question. That is why an expert from the Ministry of Agriculture at the FGD observed that amongst the reasons why there was an increase in pests, weeds and diseases was because farmers did not practice crop rotation.

### 3.10. Intensity of Soil Erosion

Respondents' views on the intensity of rainfall are summarized in Fig.10. An overwhelming majority (92.4%) of respondents said the intensity of soil erosion was a very high as a result of climate variability while only 7.6% indicated it was low.

A Chi Square test conducted on the data showed that there was a highly significant ( $P < 0.01$ ) variation in responses on the intensity of soil erosion ( $\chi^2_{1,0.01} = 282.16$ ). This implies that there was a very large difference in the percentage of respondents who indicated

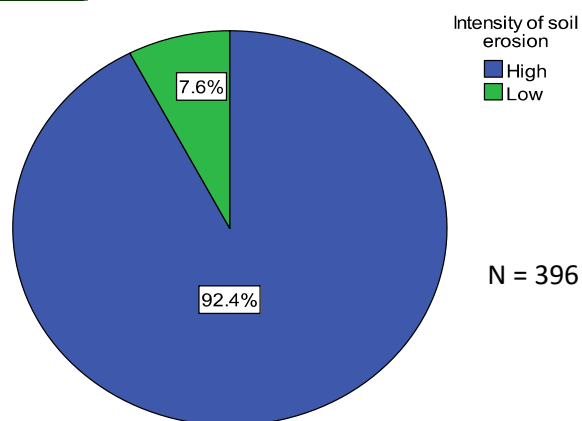


Fig.10. Intensity of Soil Erosion in Kakamega County, Kenya

the rate of soil erosion was high and those that indicated that it was low. According to Oteng'i (2009), rainfall intensity is the most important factor in soil erosion. The higher the rainfall intensity, the greater the volume of runoff water per unit time. Land forms such as the elevated steep slopes or gentle slopes and length of the gentle slope influenced the kind of soil erosion experienced. Soil erosion was a serious impact of climatic variability as cited by a majority of the respondents and measures of control were considered. It deprived farmers of a crucial resource and rendered their farms infertile. Over 80% of the KIIs consented to the fact that soil infertility was amongst the main causes of poor crop production. One key informant from the Ministry of Agriculture succinctly observed that year after year of farming the same crops, nutrients sink either deep into the soils or are washed away downstream resulting in soil infertility.'

### 3.11. Impact on Soil Fertility

The status of soil fertility as perceived by the respondents is summarized in Fig.11. Eighty nine point six percent (89.6%) of the farmer respondents said that the soils fertility had gone down over time while 10.4% indicated it had improved.

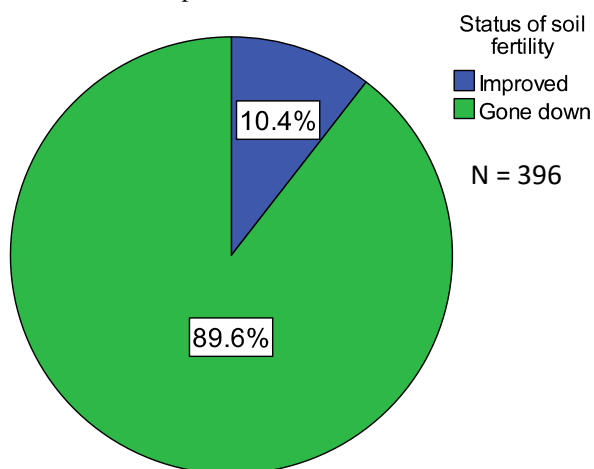


Fig.11. Impact on Soil Fertility Kakamega in County, Kenya

A Chi Square test conducted on the data showed that there was a highly significant ( $P < 0.01$ ) variation in responses on the sizes of herds of livestock kept ( $\chi^2_{1,0.01} = 198.74$ ). This showed that there was a significant difference in the number of respondents who perceived a decline in soil fertility and those with a contrary opinion. This showed that the responses were similar, with most respondents indicating that soil fertility had gone down.

The soil infertility is attributable to various reasons amongst which comprise; (i) leaching due to the intense and severe floods; (ii) overuse of chemical fertilizers such as urea and DAP; (iii) failure to embrace soil conservation measures such as use of organic manure, mulching, crop rotation and agro-forest. The findings corroborate existing literature that observes that higher temperature speeded the natural decomposition of organic matter and increased the rate of other soil processes that influenced fertility (Rosenzweig and Parry, 2004). High temperatures result in warm soils which support both root growth and bacterial decomposition of organic matter. This makes the soils infertile and vulnerable to wind erosion.

### 3.12. Impact on Quantity of Farm In-puts

Respondents' views on the quantity of farm in-puts used in the climate variability scenarios are summarized in Fig.12. Ninety point eight (90.8%) respondents said the quantity of farm inputs had increased over time while 9.2% indicated it had gone down.

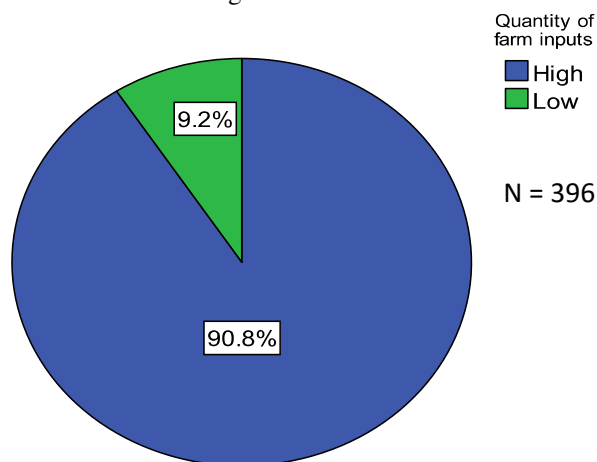


Fig.12. Quantity of Farm Inputs Kakamega in County, Kenya

This showed that there was a large difference between the number of respondents who indicated that the quantity of inputs was high and those that indicated otherwise. A Chi Square test conducted on the data showed that there was a highly significant ( $P < 0.01$ ) variation in responses on the quantity of farm inputs ( $\chi^2_{1,0.01} = 262.19$ ). This showed that there was a great difference in the number of respondents who perceived that there had been an increase in the quantity of farm inputs and those with a contrary opinion.

Studies indicate that changes in optimal temperature result in decreased biomass which translated into low crop yields (Kabubo, *et al.*, 2007; Valerie *et al.*, 2010; WBDR, 2007a). From the KIIs and FGD it was established that expenses related to the following farm inputs had

increased; seeds for planting, herbicides, pesticides, fungicides, animal feed, fuel, fertilizer and labor.

Efficient use of farm inputs is critical to ensuring continued productivity and production. According to GoK, (2013c) report, there exists a sizeable gap between what farmers are producing and what is the potentially possible due to amongst other factors, quantity and quality of farm inputs. The GoK 2013c report further observes that the use of agricultural inputs is constrained by climate variability and change and their ramifying effects.

#### IV. CONCLUSION AND RECOMMENDATIONS

The study concluded that climate variability had impacted negatively on livestock and crop production in Kakamega county. This was manifested by increased incidences of diseases, weeds and pests; floods and droughts; soil erosion and infertility; and seasonal uncertainties. Soil erosion removed fertile top soil resulting in soil fertility decline. The foregoing explained the declining in the quantity and quality of crops. Regarding impacts in livestock production, there was a general decline in the genetic quality, diversity and size of herds. This was attributable to the drastic reduction in pasture or grazing grounds, increased diseases, lack of; a vibrant extension service by the relevant farm experts and Artificial Insemination (AI) services for improvement of genetic breeds; and fragmentation of land that was occasioned by the increased population. This study recommended that farmers adapt their agricultural practices in line with the climatical fluctuations as adaptation increases resilience of the vulnerable communities.

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## AUTHOR'S PROFILE



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A Kenyan national with education background as hereby summarised: 2011-date PhD scholar, Masinde Muliro University of Science & Technology, (MMUST); 2010: MSc in Environmental Science Education at MMUST; 1984 Bachelor in Science Education, Upper Second Class honors Degree, University of Nairobi in Kenya.

Her teaching career spans decades. As a teacher her responsibilities comprises amongst others; Teaching Biology and Environmental Science, Head of Biology Department, In charge of Curriculum Implementation by teaching staff. She has been involved in research works amongst which form the basis for the current article for publication on 'Impacts of climate variability in agricultural production in Kakamega County, Kenya' Other publications include:

- **M. O. Barasa, W. W. Toili, S.S. China.** *Assessment of University Students' Vulnerability to Environmental Health Risks: Sacha Journal of Environmental Studies Vol. 1 No. 2 (2011) pp-92-102,*
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- **M. Barasa., Z.W. Ng'ang'a, G.A. Sowayil, J.M. Okoth, M.O. Barasa, F.B.M. Namulanda, E.A. Kagasi, M.M. Gicheru and S.H. Ozwara** *Cytokine expression in Malaria infected non-human primate placenta in the Open Veterinary Journal, Vol. 2: pp. 58-64 2012; ISSN: 2218-6050.* All publications can be accessed on line.

Mrs. Barasa is currently in her final stage of her PhD studies at MMUST which has enabled her to be absorbed on part time teaching basis at the Jomo Kenyatta University of science and Technology, Kakamega campus, Kenya. She is also a Senior Assistant Registrar in charge of programmes. Mrs. Barasa's other experiences include:

- Quality auditor ISO 9001 – 2008 of the quality management system.
- Member of the committee working on the university programme on attainment of ISO certification.
- Member of the quality assurance committee working in liaison with the ISO team
- Member of the Curriculum Writing panels for Post-Secondary Institutions at the Kenya Institute of Education (KIE).
- Member of several Community Based Organizations and a women leader in my community where I have played pivotal role in matters of Education. Mrs. Barasa is a member of the disaster management and conflict resolution of Kenya.

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### Prof. Silvery Beddar Buluma Oteng'i, Ph.D.

A Kenyan national born on 6<sup>th</sup> June, 1946 with an Educational background as summarized:  
**1996:** Ph.D. (University of Nairobi) in Applied Meteorology; **1980:** M. Sc. (University of Nairobi) in Applied Meteorology; **1976:** Bachelor of Science (B.Sc.) in Meteorology, 2nd Class Upper Division, University of Nairobi, all in Kenya.

He is currently employed as, full Professor of Applied Meteorology at Masinde Muliro University of Science and Technology (MMUST), Kenya. Previously he was the Dean of the Centre for Disaster Management and humanitarian Assistance (CDMHA), MMUST, and Chairman of Research and Technical Committee of Kenya Agricultural Research Institute (KARI) Management Board. His field of specialization is Applied Meteorology. He has reviewed research articles in a number of journals both locally and internationally such as African Journal of Agricultural Research ([www.academicjournals.org/ajar](http://www.academicjournals.org/ajar)). He is affiliated to various organizations amongst which are listed: 2009-date: Member, Institute of Directors of Kenya; 2008-date: Board of KARI Management Board and the chairman of Research and Technical Committee of the board; 2007- date: Member of International Society for Agricultural Meteorology (INSAM); 2007- date: Executive member of Kenya Meteorological Society (KMS); 2002-2005: Member of the research in applied climatology at ICPAC- IGAD, Nairobi. His research interests span various fields such as **2007 - Date:** Documenting and validating efficacy of mushroom production techniques & utilization to enhance food security in Kenya.; 2009: Principal researcher in a Project, Environmental impact of brickmaking in Lake Victoria Basin of Kenya"; 2009; 2007: Principal researcher in Commission for Higher Education (CHE) funded research project "Expanding access to small holder agricultural information through media strategies for sustainable productivity: Toward achieving food security in Kakamega district; 2007-2009: Principal researcher in Research Project, "Environmental impact of brickmaking in Lake Victoria Basin of Kenya Professor Oteng'i has published extensively as manifested in a few of his book titles and publications:

#### Books

- **Oteng'i, S.B.B., 2014.** Teach Yourself Weather Instruments and methods of Use: Land Surface platforms- Volume One; Utafiti Foundation (ISBN: 978-9966-26-024-6); xix+ 188 pp.
- **Oteng'i, S.B.B., 2009.** *Application of Climatology in Sustainable Tropical Farming Systems*, MMUST Library with Scholarly Open Press (ISBN: 9966-779-01-9); viii + 220 pp.
- **Oteng'i, S.B.B. and China, S. S., 2007.** Guidelines on writing research proposals and theses; Scholarly Open Press (ISBN: 9966-779-00-0); vi+ 30 pp.

• **Oteng'i, S.B.B. (still in print),** Teach Yourself Weather Instruments and methods of Use: Marine and Upper Air & space platforms- Volume Two.

#### Publications

- **Oteng'i, S.B.B., and Khabamba, L.** (2013). Environmental assessment of potential measures for balancing natural resources use and integrity of Nzoia River Basin. *J. Meteorology. Rel. Sci.* (ISSN 1995-9834), 4: 7-11.
- **Oteng'i, S.B.B., 2009.** Understanding Meteorological Aspects of Environmental Fires in Kenya. In: E.M. Neyole, G.W. Waswa and K. Onkware, eds. *Environmental Fires Risk Reduction* (ISBN 9966-779-09-4). Proc. Workshop on Environmental Fires 26<sup>th</sup> June, 2009, MMUST: 18-28.
- **Oteng'i, S.B.B., Sigot, A.J., Kisiangani, P.M. and Mudavadi, L., 2008.** Mushroom production techniques and utilizations for enhanced food security in the Lake Victoria Basin. *International Journal of disaster management and risk reduction* (Int. j. disaster manag. risk reduct.) (ISSN: 1992-2744); 1(2): 53-59
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Professor Oteng'i has over 50 peer reviewed articles and has participated in many conferences and was awarded the international award "the **First Honorary Mention**" on the best examples of agro-meteorological services in the 2006 INSAM contest" by the International Society for Agricultural Meteorology, INSAM, headquartered in Bologna, Italy.  
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Professor J. W. Wakhungu was born in Kenya on 23rd March, 1957. His educational background is summarised as: 1997-2001: Doctor of Philosophy (PhD). Animal Production, (Animal Genetics and Breeding) at the University of Nairobi, Kenya. This study was geared towards development of breeding policy for Kenyan small scale dairy cattle farms by productivity modeling approach. In 1986-1988: M.Sc., in Animal Production (Animal Genetics and Breeding), University of Nairobi Kenya. In 1984-1984, Post graduate Diploma (Animal Breeding) University of Edinburgh, United Kingdom. In 1978-1981, B.Sc., Agriculture (Upper Second Class Honors), University of Nairobi, Kenya. He is currently the DEAN at the Center for Disaster Management and Humanitarian Assistance at the Masinde Muliro University of Science and Technology, Kenya. Having worked at the University of Nairobi as a senior lecturer specialized in research and development in Animal Genetics/Breeding and Production Systems Analysis. He has been lecturing for over 20 years. He has published over 40 Journal Papers several chapters in books and a book titled An evaluation of dairy cattle breeding policy for Kenyan smallholders: Based on stationary state productivity model, Publisher: LAP LAMBERT Academic Publishing, 2012 (ISBN 10: 3659133442 ISBN 13: 9783659133442). Some of the journal articles include; Wakhungu J.W and Baptist .R.(1992). Reproductive wastage and mortality as productivity components in dairying: An impact analysis method for sustainable production system. Journal of the Zimbabwe society for Animal Production IV:45-50: Wakhungu J.W and Baptist .R. (1992). Kenya Artificial insemination: policy issues beyond rehabilitation and breeding programmes consideration in The Kenya Veterinarian 16:33-37: Wakhungu, J.W. (2008) Book manuscript titled: Basic concepts for livestock breeding policy design: National and International perspectives (2007), University of Nairobi Press. His paper outputs can be accessed under his name on the internet. He has been previously a research officer in Kenya Agricultural Research Institute (KARI), now referred to as Kenya Agricultural and Livestock Research organization (KALRO) in the period 1981-1988. He has been involved in various aspects of Agricultural Research and Development linked to livestock sub-sector in Kenya and Eastern Africa Region. He is also a consultant geneticist to the Central Artificial Insemination Station (CAIS), Nairobi, Sire Selection and Breeding Committee and CAIS Strategic Planning Committee. In addition, he is the consultant geneticist to Animal Embryo-Transfer Biotechnology Secretariat of the Ministry of Livestock Development in Kenya.

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