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Farmer Awareness of Climate Variability in Kakamega County, Kenya

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Abstract:
Climate fluctuates naturally on all time scales diurnally, seasonally, annually and decadally. The short-medium term fluctuations around mean state on climate scales, is referred to as cli mate variability. Climate variability has negative impacts in most sectors of the economy such as in agricultural production. The severity of these impacts depends on the extent of adaptation as this has the potential to substantially reduce many of the adverse impacts. Studies indicate that people who perceive climate variability adapt better. This paper presents findings of a study conducted in Kakamega county, Kenya. The study assessed farmer awareness of the indicators of climate variability through analyzing trends of recorded data of two climate variables, rainfall and temperature from 2001 to 2013 and triangulating with actual farmer perceptions. Four hundred (400) farmer respondents were used. The study adopted three designs; descriptive survey, correlational and evaluative. Semi structured questionnaires, Focus Group Discussions (FGD), Key Informants Interviews (KIIs) and observation check lists were used to collect data. Analyses of rainfall and temperature records revealed seasonal variabilities in these climatic parameters. Regarding farmer perceptions, 79.1% and 61.1% respondents indicated they had observed an increase in rainfall (amount and intensity) and temperature respectively. They further cited the following derivative impacts (indicators) of variability in rainfall and Temperature: (i) prolonged dry spells and droughts; (ii) frequent and intense episodes of wet spells; (iii) increased frequency of storms and floods (iv) delayed or seasonal rainfall uncertainties (v) earlier onsets or cessation of seasonal rains and; (v) shifts in seasonal patterns especially in short rains 'spilling' into the ordinarily dry periods. This implied a high level of awareness of climate variability amongst the farmers. The study concluded that farmers' perceptions of climate variability corresponded with the analysed climatic data. Whereas a majority of the farmers had perceived climate variability, a minority seemed not to have perceived these changes. This study thus proposed a further study to determine factors that influence the awareness. The study recommended policy options that promote an increased awareness through information dissemination as being crucial as this would inform adaptation strategies.

Keywords: *Indicators of climate variability, Farmer awareness, Anomalies*

1. Introduction

Climate fluctuates naturally on all time scales diurnally, seasonally, annually and decadally. The short-medium term fluctuations around mean state on climate scales, is referred to as climate variability. Meteorological elements that vary in this context comprise; (i) air temperature; (ii) precipitation (e.g., rain, sleet, snow and hail); (iii) atmospheric pressure; (iv) atmospheric humidity; (v) duration of sunshine; (vi) solar and terrestrial radiations; (vii) wind speed and direction; and (viii) evaporation and cloud cover (KMS, 2012; IPCC, 2007; IPCC, 1996). Literature indicates that the two most important meteorological elements are precipitation and temperature (Gabi, 2013; Oteng'i, 2009).

According to the IPCC (2007), global air temperature near the earth surface rose by 0.74°C during the period 1906 – 2005. The report further indicates that this could increase by an average of 6.4 °C during this 21st century. Likewise there is evidence that climate change and variability is altering precipitation patterns worldwide (Gabi, 2013 and Paige, 2013).

Regional manifestation of changes in the climatic elements is evident. For instance, in 2003-2004, Europe suffered very low rainfall throughout spring and summer, and a record of heat waves (Parry *et al.,* 2010; IPCC, 2007). In America, the frequency of hurricanes and tornados attributable to climate variability and change has been on the increase (Goslin*et al.,* 2011; IPCC, 2007; IPCC, 2006). Recent climate behavoiur in China showed a progressive warming and complex patterns of precipitation variability and frequency of extreme events (IPCC, 2007; IPCC, 2006). Existing literature indicate that for Africa, rainfall in the Sahel has dropped by 20-30 %

and the world's most severe long term drought was experienced in the 20^{th} century (Mario *et al.,* 2010; IPCC, 2007). Climate model simulations suggest that a median temperature increase for Africa is 3-4^0C by the end of the 21^{st} century, which is about 1.5 times the global mean response (Mario *et al.,* 2010; IPCC, 2007). The East African region has also experienced changes in climate as manifested by more frequent and intense floods and droughts (KMS, 2012; Mario *et al.,* 2010; IPCC, 2007). Literature indicate that in Kenya, the mean annual temperatures have increased by 1^0 C since the 1960s with a corresponding increase in the number of hot days and nights (Mutimba *et al.,* 2010; GoK, 2010). Total annual precipitation projection in the country suggest an increase by approximately 0.2- 0.4 % per year (GoK, 2010). The literature further shows that the country experiences major droughts every decade and minor ones every three to four years (KMS, 2012; 2010; Mutimba *et al.,* 2010; GoK, 2010). Since 1993, Kenya has declared over six national disasters attributable to droughts and floods (KMS, 2012; NADMA; 2011; DFID, 2010).

Overall, the variability in climate has mainly negative impacts upon agricultural production because the sector depends on climate factors such as temperature and precipitation (Valerie *et al*., 2010; Glwadys, 2009; Kabubo*et al*., 2007; Otolo and Wakhungu, 2013). Since existing literature indicate that the climate change and variability are likely to persist, it is imperative that farmers awareness is enhanced to enable them make informed decisions when adapting.

1.1. Justification

According to GoK (2010), temperatures have risen throughout the Kenya; rainfalls have become irregular, unpredictable and more intense resulting in extreme harsh weather situation. The foregoing trend has been observed more specifically since the early 1960s. The variation in climatic patterns has had adverse impacts in the agricultural sector which is linked directly or indirectly to the livelihoods of a majority of Kenyans (GoK, 2008a).

The population in Kakamega county comprises of people who heavily rely on subsistence farming for food and their livelihoods (Otolo and Wakhungu, 2013; GoK, 2013b). Such a population is very vulnerable to the impacts of climate variability as the changes create unfavourable conditions for farming, impacting negatively on their food security. Projections indicate that the impacts of climate change and variability will worsen if adaptation measures are not embraced (IPCC, 2014; Voleizo and Wakhungu, 2011; GoK, 2010; GoK, 2008a; Maddison, 2007; Rosenzweig and Hillel, 1995). A study to determine whether farmers' perceived the changes entailed in climate variability was therefore justified. Maddiso*et al*(2007) observe that farmers who perceive the changes in climate adapt copping strategies better than those who don't.

1.2. Scope

The study analysed the variability in climate parameters of rainfall and temperature from records of data for Kakamega county over the period 2001 to 2013. This time line was considered important because 1983-2013 was the warmest 30-year period for 1400 years (IPCC, 2014). The variations in these two parameters have derivative effects which manifested as indicators of climate variability. Consequently, farmers' perceptions of the indicators of climate variability were assessed.

2. Materials and Methods

Kakamega County is located in Western Kenya. It comprises 12 sub-counties, namely; Kakamega North, Kakamega Central, Kakamega East, Kakamega South, Matete, Lugari, Likuyani, Navakholo, Mumias, MatunguButere and Khwisero (GoK, 2008b).The county lies between longitude 34^0 and 35^0 E and latitudes 0^0 and 1^0 N of the Equator and within altitude 1,250-2000m. It has an area of about 3,224.9 square kilometers (GoK, 2009).

Climatic characteristics, Kakamega county depicts mainly hot and wet conditions most of the year with mean annual rainfall between 1,800- 2,000 mm. The mean monthly trend of rainfall represents two maxima and minima over the year. The first and second maxima occur in April to June and August to November respectively (GoK, 2013d; GoK, 2010). Generally, there are two main cropping seasons in most parts of the county that coincides with the long rains and short rains. The average temperature in the county is 22.5 ^{0}C. January and February are generally considered as dry months.

2.1. Agro Ecological Zones (AEZ)

Climate, vegetation and land-use potential have been used to assess land suitability for different applications. The major parameters of climate that affect plant growth are threefold: (i) the intensity and duration of rainfall; (ii) the relationship between annual rainfall and potential evapo-transpiration; and (iii) the year-to-year variation in rainfall and temperature. Based on the foregoing, Kenya is divided into seven AEZ using a moisture index based on annual rainfall expressed as a percentage of potential evaporation (Kabubo*et al.* 2007, Jaetzold*et al.,* 2011). Kakamega county comprises of the following AEZ: (i) the Upper Midland (UM) zones, lying between 1500-2000m; and (ii) Lower Midland (LM) zones at 1200-1500m (Jaetzold*et al.,*2011). In the centre of the county, the rainfall is too high leading to leaching of soils. This provides suitable environment for fungal diseases. Therefore, this area is classified as UM 0 and is considered in agricultural planning as a forest zone. The UM zone is further subdivided into subzones; UM 1, UM 2, UM3 and UM4. These are the northeastern parts of the county where Lugari sub-county is located, with humid climate interrupted by four months of dry spell (November-February) restricting cultivation of perennial crops like bananas and sugarcane. There is therefore one main growing season. The dominant crop, Maize is grown on large scale in the Lugari and Likuyani sub-counties. Sunflower is grown as cash crop.

The LM zone has two subzones; the LM 1 and LM 2. These are the sugarcane and the marginal sugarcane (*Sacharin sp.*) growing zone respectively. The sub-counties Malava and Navakholo form the marginal sugarcane growing zones while Mumias is in the LM1 zone where sugarcane is the dominant crop. Other crops such as beans (*Phaseolus Vulgaris L*), sorghum (*Sorhumvulgare*), millet (E*leusinecoracana*) and horticultural crops are grown.

Normally, there are two cropping seasons in the county that coincide with bimodal rainfall regimes in which long rains fall between March and May and the short rains between October and December (GoK, 2010; GoK, 2008c). The main cash crops are sugarcane, tea (*Camellinasinensis*), and sunflower (*Helianthus annus*) while soya (*glycine max*), beans maize (*Zea mays*), potatoes (*Solanumtuberosum*) and bananas (*Musa paradisiaca*) cultivars are planted as food crops (GoK, 2008c). They also produce some fruits namely avocado (*Perseaamericana*), pawpaw (*Asiminatriloba*), bananas and pineapples (*Ananascomosus*). Guavas (*Psidiumguajava*) grow wildly in some parts of Kakamega central and Navakholo and compliment other fruits (GoK, 2008c).

The aforementioned is a pointer to the differences in the micro-climatic conditions that exist in the respective AEZ which in turn influence perceptions by farmers.

2.2. Sampling Procedure and Sample Selection

The study used combination sampling strategies. The study area, Kakamega county was purposively sampled due to reasons given under justification. To get to the location where the farmer households were sourced from, a multistage random sampling was adopted. A total of 400farmer households were randomly selected from the locations using sample frame from the divisional agricultural office.

2.3. Data Collection Instruments

Primary data was sourced through questionnaires FGD, KIIs and observation checklists. A questionnaire was administered to the 400 farmers and 396 were returned. The direct observation assisted the researcher to ascertain and authenticate the information gathered through questionnaires. Two FGD sessions were held, one in Kakamega town and the other in Lugari sub-county as shown in the Figures 1 and 2. According to Mukhovi (2009), FGDs help to gather information that is overlooked by the questionnaires and allows respondents who are shy to communicate their concerns. The FGDs were comprised of 8-12 farmers. Each FGD sourced qualitative data regarding their experiences, awareness on climate variability and confirmed findings from the questionnaires. Mbakaya, (2009) acknowledges that FGDs help to gather information that is overlooked by the questionnaires and other instruments of data collection.

Figure 1: FGD Session at Sun Star Hotel Kakamega Town

Figure 2: FGD Session in Lugari Sub-county

2.4. Data Analysis

Data was analyzed both descriptively and inferentially by use of the Statistical Package of Social Sciences (SPSS). Records of the rainfall and temperature data obtained from the Kenya Meteorological Services (KMS) were exposed to calculations of regression analysis establish the trends. Analysis of Variance (ANOVA) technique was used to establish the significance of the variation. This was plotted on figurative presentations. Likewise, data of rainfall were exposed to similar analytical procedure. As for farmer perceptions, means were used to determine their responses. Finally, Chi test was further done to establish if these responses per sub-county were significantly varying or related.

3. Results and Discussions

3.1. Variability in Climate Parameters of Temperature and Rainfall over the Period 2001-2013

3.1.1. Variability in Temperature

The mean monthly variability in temperature over the period 2001-2013 during hot dry season was calculated and findings summarized in Figure 1.

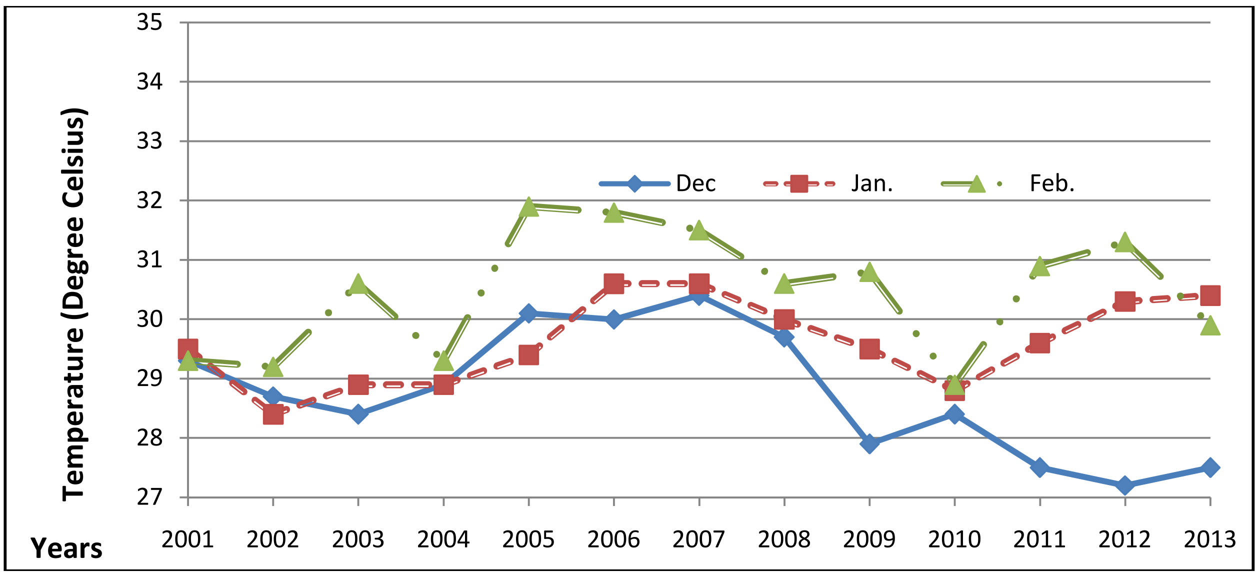

Figure 3: Monthly Variability in Temperature during the Dry Season

Source: KMS Records

Figure 3 shows February was the hottest month with highest temperature of 31.8^{o}c. The lowest temperature was recorded in January 2012 at 27.2^{o}c. The temperatures were relatively higher at this time because this is generally considered as the dry season in the county. In the farming scenarios, it was during this period that farmers prepared their farms for the main planting season just before the long rains. However, the extremes evident in February and December presented challenges to the farmers that demand adaptation.

The mean monthly variability in temperature over the period 2001-2013 during the long rain season was calculated and findings summarized in Figure 4.

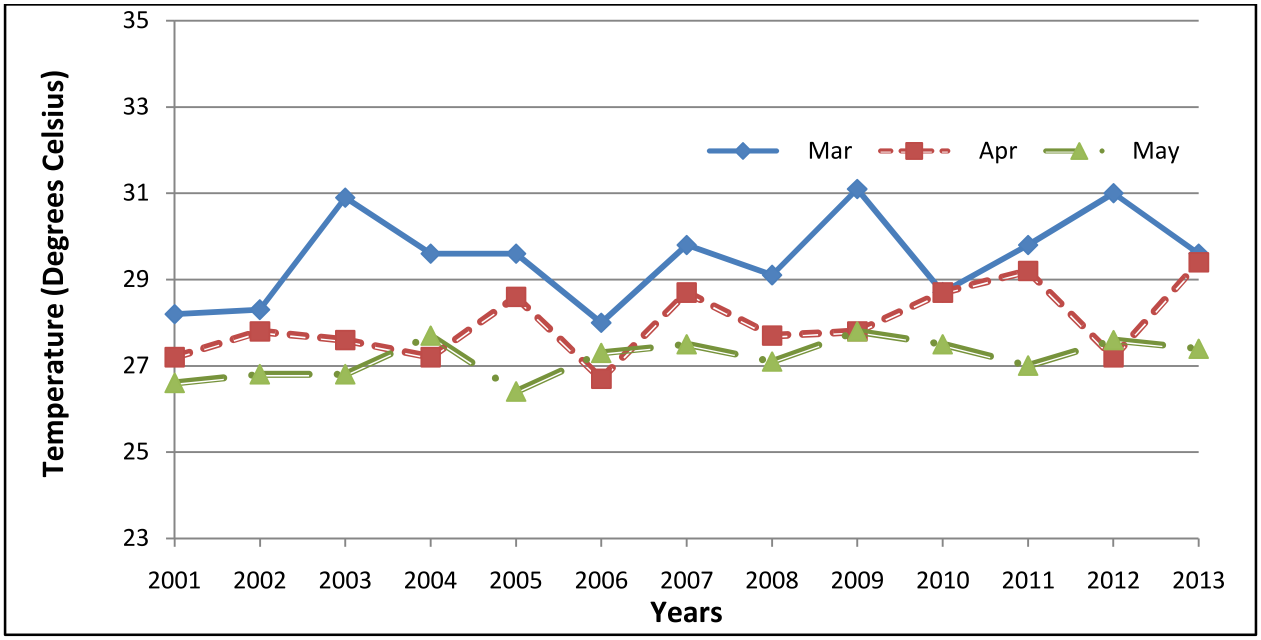

Figure 4: Monthly Variability in Temperature during the Long Rains
Source: KMS Records

During the long rain season, the highest temperatures were recorded in March 2009 (31.1^{0}c). This corroborates the observations by the IPCC (2014) that the years 2009-2012 were the warmest in recorded history. Lowest temperatures were recorded in May 2005. It is also important to note that the month of March comes immediately after the dry season and temperatures would normally be still high. It also marks the beginning of the main cropping season. Temperatures in March remained high throughout the years as compared to April and May which are closer to the cold season that commences in July.
The mean monthly variability in temperature over the period 2001-2013 during the cold season was calculated and findings summarized in Figure 5.

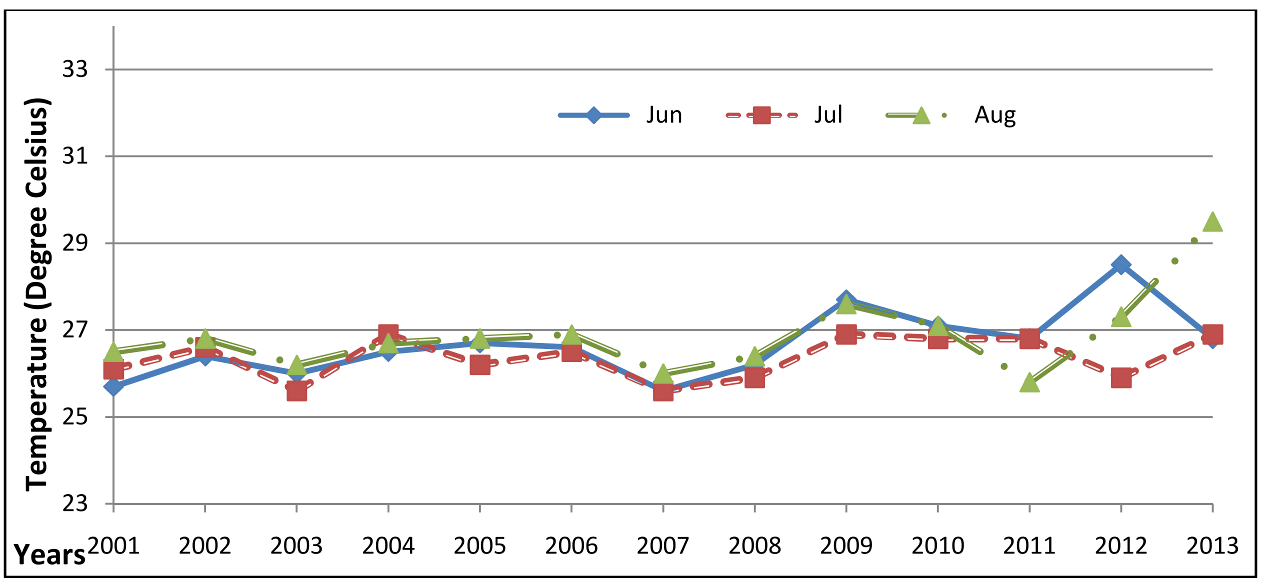

Figure 5: Monthly Variability in Temperature during the Cold Season
Source: KMS Records

June, July and August are normally considered as the cold months. Lowest temperatures were recorded in July 2003 (25.8^{0}c) while highest temperatures (29.4^{o}c) were recorded in August 2013. In agricultural context, the farming activities were relatively low, with most farmers preparing to harvest crops grown in March. During the KIIs and FGDs, farmers expressed that they had experienced losses in crops ready for harvesting as a result of unexpected rains at that point in time.
The mean monthly variability in temperature over the period 2001-2013 during the short rain season was calculated and findings summarized in Figure 6.

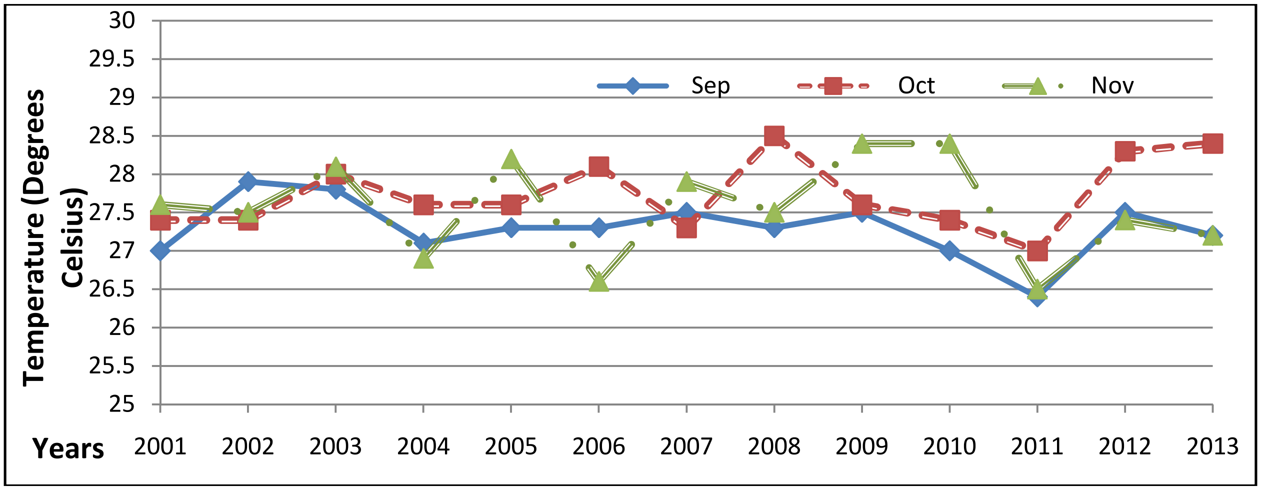

Figure 6: Monthly Variability in Temperature during the Short Rain Season
Source: KMS Records

During the short rains, anomalies in temperature were not very acute as the range varied from 28.5^0c (October 2008) to 26^{o4}c (September 2011). However, the inter-monthly anomalies were evident as shown in Figure 6 with October having high average means and September with relatively lower average. In agricultural scenarios, these anomalies presented challenges for which farmers were expected to perceive and adapt appropriately.

3.1.2. Annual Anomalies

After consideration of the monthly variability in temperature, the anomalies in the annual mean were considered and findings presented graphically as hereunder.
The annual mean minimum temperatures in the county from 2001 to 2013 were plotted as indicated in Figure 7.

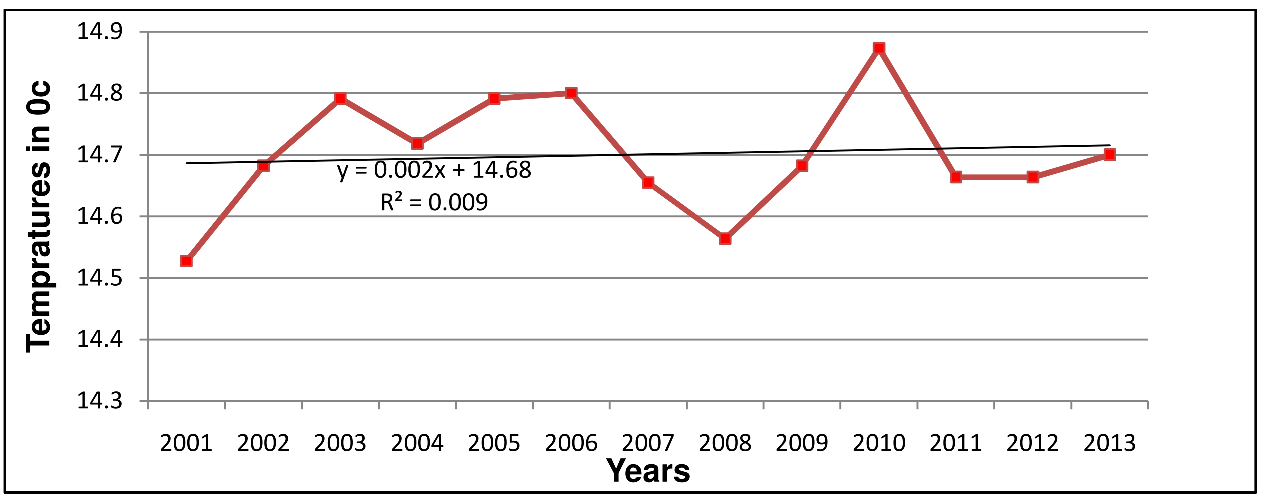

Figure 7: Anomaly in Inter Annual Mean Minimum Temperatures from 2001 to 2013
Source: KMS Records

There was a variability in the annual mean minimum temperatures over the period with an increasing tendency (y=0.0024x+14.684). Analysis of Variance (ANOVA) technique was used to establish the significance of the variation. The results are summarized in Table 1.

ANOVA[b]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	0.001	1	0.001	0.017	0.900[a]
	Residual	0.515	8	0.064		
	Total	0.516	9			
a. Predictors: (Constant), Year						
b. Dependent Variable: Mean minimum monthly temperature						

Table 1: Analysis of Variance

Although the results show increase to have not been significant (p>0.05), the point to note is that there was a variability attributable to the small increase. These result compared well with various studies which established that temperature were increasing in the unfolding climate variability and change scenarios (Maddison, 2009; Kabubo*et al,* 2007). IPCC (2007) compliments these findings. The annual mean maximum mean temperatures from 2001 to 2013 were computed and findings plotted in Figure 8.

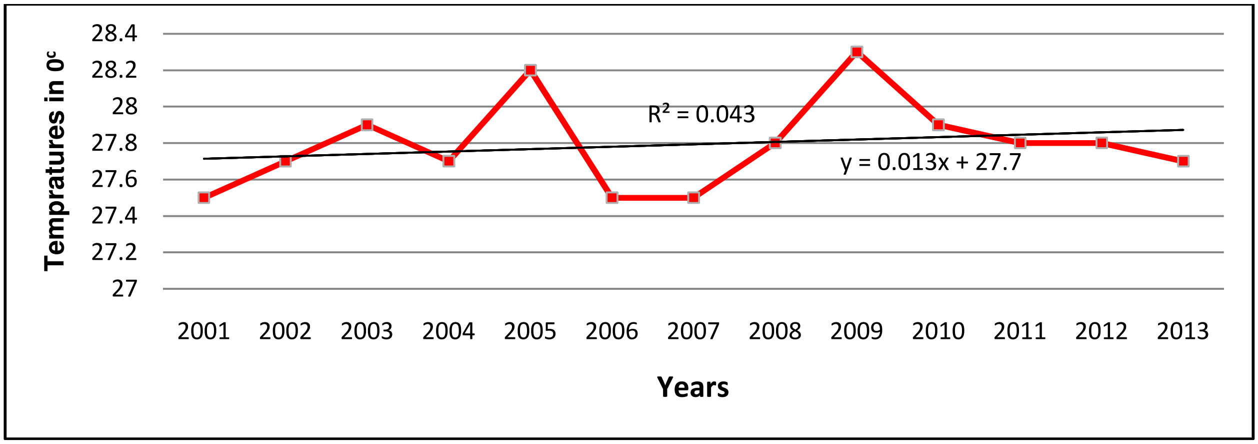

Figure 8: Anomaly in Inter Annual Mean Maximum Temperatures from 2001 to 2013
Source: KMS Records

The coefficient of y is positive (y=0.0132x+27.7) indicating that there was an increase the temperatures over the years as indicated in Figure 8. ANOVA was done to determine the significance in the annual mean maximum temperature and results summarized in Table 2.

ANOVA						
1	Regression	0.140	1		1.709	0.227[a]
	Residual	0.656	8			
	Total	0.796	9			
a. Predictors (constant) years						
b. Dependent Variable: Mean Maximum Monthly Temperature						

Table 2: Analysis of Variance

The results showed the variation to be insignificant (with index p>0.05) between 2001 and 2013. This could be explained by the fact that the timeframe under the study was relatively short to realize a significant increase. Nonetheless, there was evidence of variability in this climatic parameter.

From the foregoing, there are indications that there has been a variation in the temperatures over the period of study. Such anomalies affect the physiological functions of both plants and animals. For instance, high temperatures result in an increase in evapo-transpiration which deprives plants of their water requirements. Similarly, low temperatures cause frost like was experienced in then Rift valley and Central Provinces in 2012 resulting in loss of tea crop and pasture grass. Oteng'i (2009) acknowledges that temperatures in excess of 40^0C by day and 26^0C by night have adverse effects on crops. The frequency and severity of these incidences is important in agricultural production and hence the need to enhance farmer awareness.

3.1.3. Annual mean temperatures

From the annual minimum mean and annual maximum mean temperatures, the annual mean temperatures were derived and plotted in Figure 9.

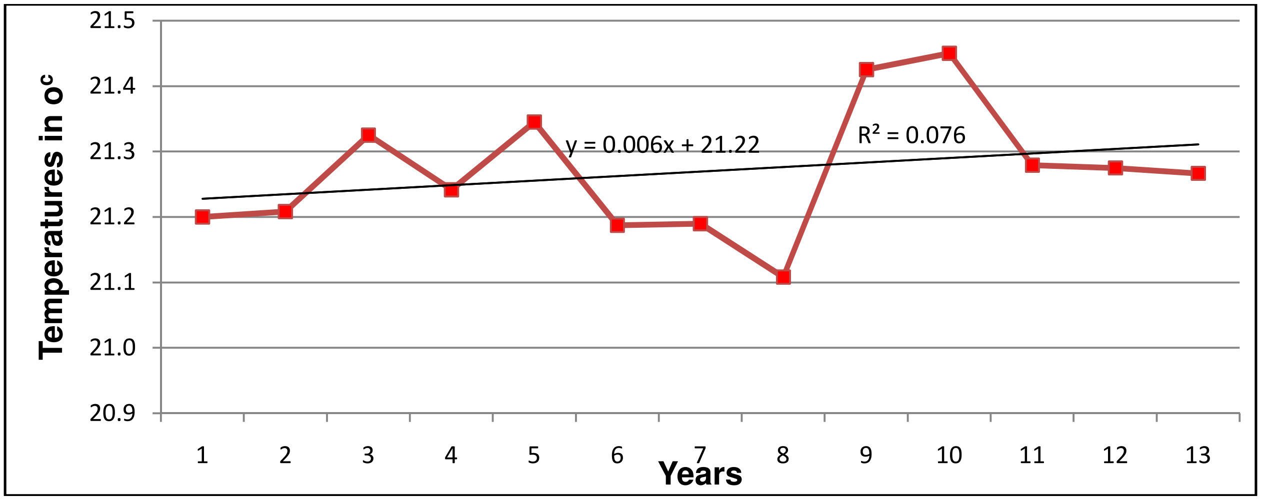

Figure 9: Anomaly in Annual Mean Temperatures from 2001 to 2013
Source: KMS Records

Regression was also used to establish the trend in the mean annual temperature between 2001 and 2013. The coefficient of y is positive (y=0.0069x+21.221) indicating that there was an increase in temperatures over the years. ANOVA technique was used to establish the significance of the variability and results indicated in Table.3.

ANOVA[b]						
Model		Sum of Squares	df	Mean Square	F	Sig.
	Residual	0.379	8	0.047		
	Total	0.425	9			
a. Predictors: (Constant), Year						
b. Dependent Variable: Mean annual temperature						

Table 3: Analysis of Variance

The results showed the increase was not insignificant (p>0.05) in the Annual mean temperatures between 2001 and 2013. This was attributable to the short time line of the study. However, since climate fluctuates naturally on all time scales diurnally seasonally, the anomaly was evident.

3.1.4. Trends in the Amount of Rainfall

The variability in the monthly mean in rainfall is as indicated in Figure 10

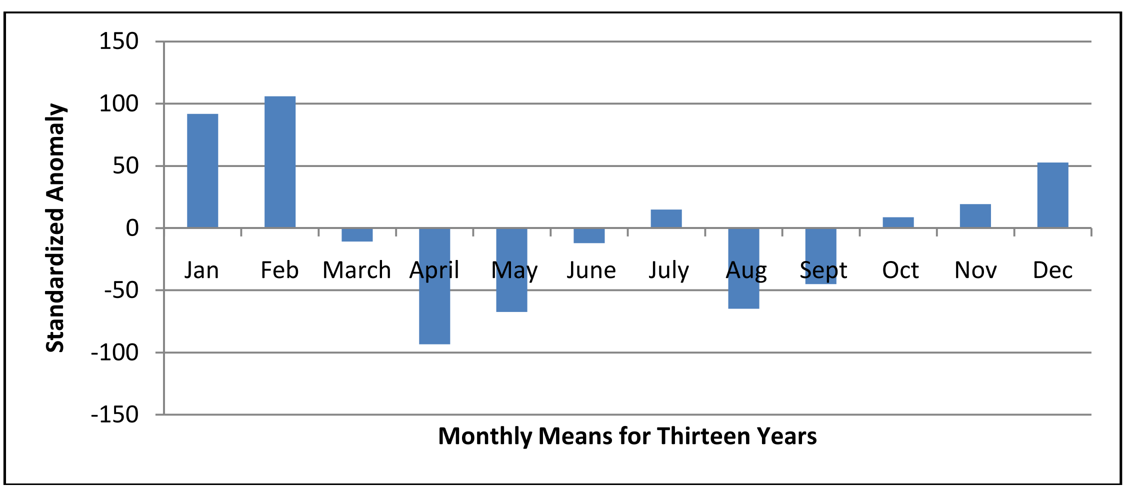

Figure 10: Anomaly in Monthly Mean Rainfall from 2001 to 2013.
Source: KMS Records

From the results, highest anomalies were experienced in January, February, April, May, August and December. Normally, there are two cropping seasons in most parts of Kakamega county that coincide with the long and short rains. Consequently, such seasonal anomalies presented challenges to agriculture, major one being insufficient or excess rainfall. This is because agricultural activities are

dependent on rain. This corroborates observation by the Kenya's national climate response strategy that there is a general shift in seasons in the country (GoK, 2009).
The variability in the annual mean rainfall was also plotted and findings summarized in Figure 11.

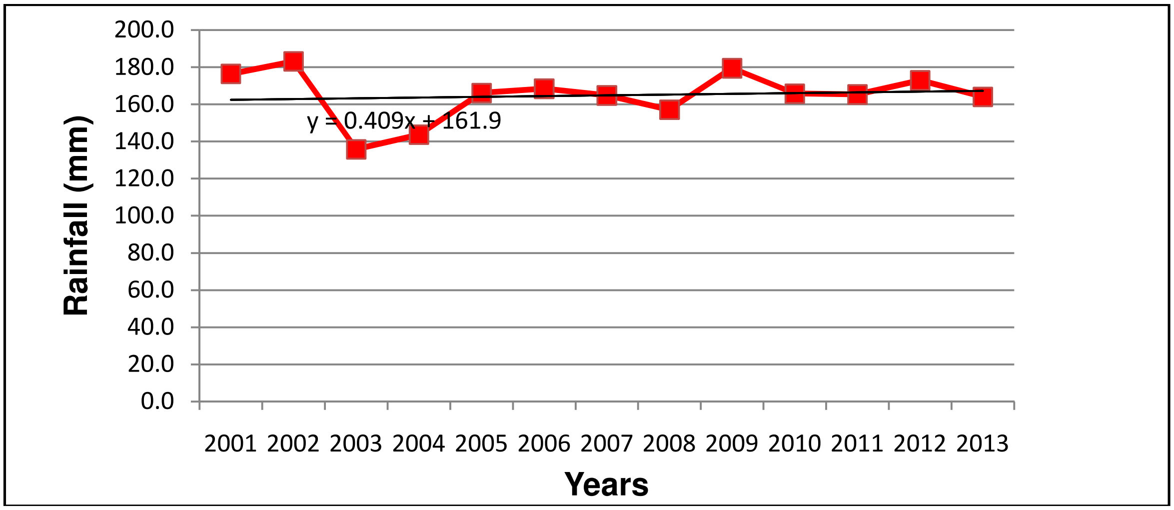

Figure 11: Anomalies Showing Inter-Annual Variability
Source: KMS Records

The coefficient (y = o.4092x +161.98) is positive indicating there was an increase in the annual mean rainfall. ANOVA technique established the increase was insignificant as indicated in Table.4.

ANOVA[b]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	15.709	1	15.709	0.034	0.859[a]
	Residual	3720.355	8	465.044		
	Total	3736.064	9			
a. Predictors: (Constant), Year						
b. Dependent Variable: Average rainfall amount						

Table 4: Analysis of Variance

Considering the timeline, results show there was a small increase (p>0.05). This supports the IPCC (2014) that observes that there is an increase in average annual rainfall in East and Central Africa.
The data was standardized and plotted to show the anomalies in variability in the annual means of rainfall. The results are indicated in Figure 12.

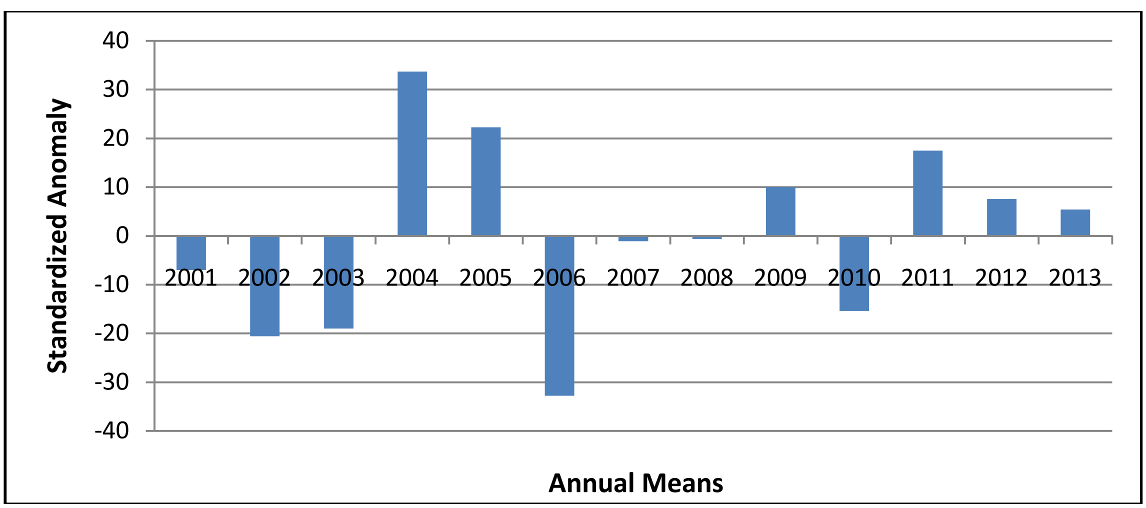

Figure 12: Anomalies in the Annual Means.
Source: KMS Records

Figure 12 shows the highest deviations in rainfall occurred in 2004, 2005 and 2006. The least deviations from the mean were experienced in 2007 and 2008. This shows inter-annual anomalies. These inter annual anomalies present challenges such as; (i) poor crop performance; deteriorating foliage and pasture for livestock; and (iii) reduced food security in most parts of the county.

3.1.5. Summary of the Findings on Analyzed Recorded Data

The regression analysis of the rainfall and temperature records revealed that there had been variability in these two variables over the period 2001 to 2013. The ANOVA test results showed that the increase in the amount was not significant in both, which can be explained by the short time line considered in the study. The variability or anomalies in rainfall and temperature had derivative impacts considered as indicators of climate variability.

Farmer awareness of the climate variability was assessed to establish if they corresponded with findings from analysed data. The findings are considered hereunder;

3.1.6. What the Respondents' Perceived as Indicators of Climate Variability

In this section, indicators of climate variability as perceived by the respondents were considered. These are considered crucial as they influence the adaptation process (Maddison, 2007).

3.1.7. Variability in Rainfall

Figure 13 shows how the respondents perceived the variation in rainfall.

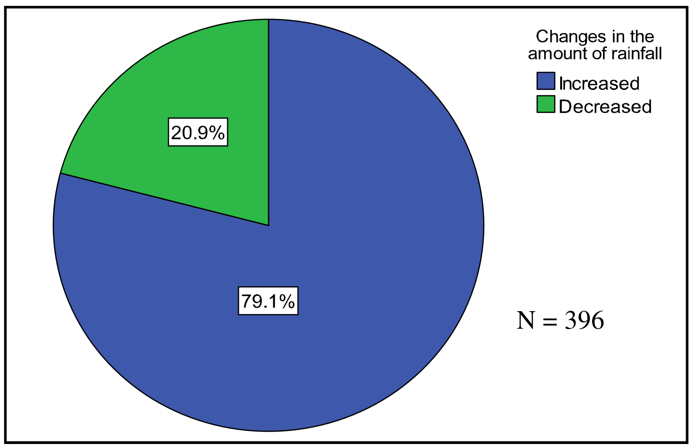

Figure 13: Farmers Perceptions on Variability in Rainfall in Kakamega County, Kenya

Seventy point one (70.1%) percent indicated that rainfall had increased and 20.9% observed that it had decreased. A Chi Square test conducted on the data showed that there was a highly significant (P<0.01) variation in the distribution responses on changes in the variability of rainfall($\chi^2_{1,0.01} = 134.41$). Thus a majority of farmers have perceived the variability in rainfall. This was corroborated by the KIIs. A participant at the FGD session in Lugari sub-county observed that there was heavy mist, fog and rainfall and weather was more predictable in 1994, when he settled in the county as opposed to when the study was carried out. The same respondent indicated that rainfall had become unreliable, appeared out of season and occasionally excessive downpours. Findings to establish if the responses varied per sub-counties were summarized in Figure 14.

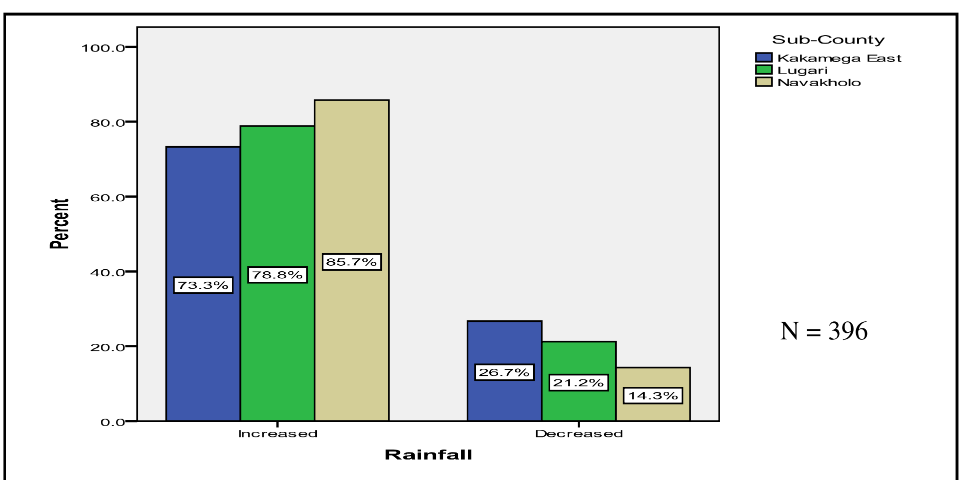

Figure 14: Variation in Rainfall per Sub-county in Kakamega County, Kenya

A Chi Square test of independence conducted on the data showed that there was a significant (P<0.05) association between responses and sub-county$(\chi^2_{2,0.05} = 6.51)$. This indicated similarities in farmer perception on how rainfall had varied in the sub-counties.
Otolo *et al* (2013) indicate that there is a high spatial and temporal variability in rainfall in Kenya. According to the respondents, this was manifested by delays on onset and early cessation, extended periods of dry spells, short but intense wet spells and stormy destructive weather episodes. A participant at the KII observed that many years ago, there was always heavy mist and rain was predictable and rain rarely occurred out of season. This is in conformity with the observations by Oteng'i (2009), that rainfall in Kenya is often skewed and at times, a larger portion of it falls early or even before the crop is planted.

3.1.8. Variability in Temperature
Farmers' perceptions on how temperature had varied over the period were indicated in Figure15.

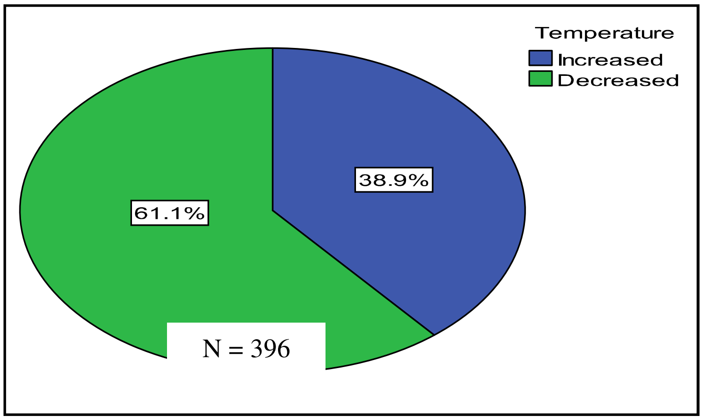

Figure 15: Famers Perceptions on Changes in Temperature in Kakamega County, Kenya

Sixty one point one percent (61.1%) of the farmers indicated that temperatures had increased over the period of study. The same was expressed at the FGD and KIIs as noted from a statement by a respondent; 'that some years back there was near zero visibility in the mornings due to mist as temperatures were low, twenty years on, one can afford to walk around in just a shirt without the warm clothing.' 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 changes in temperature$(\chi^2_{1,0.01} = 19.46)$.Thus a majority of farmers have perceived the variability in temperatures. Findings of per sub-county are presented in Figure 16 hereunder.

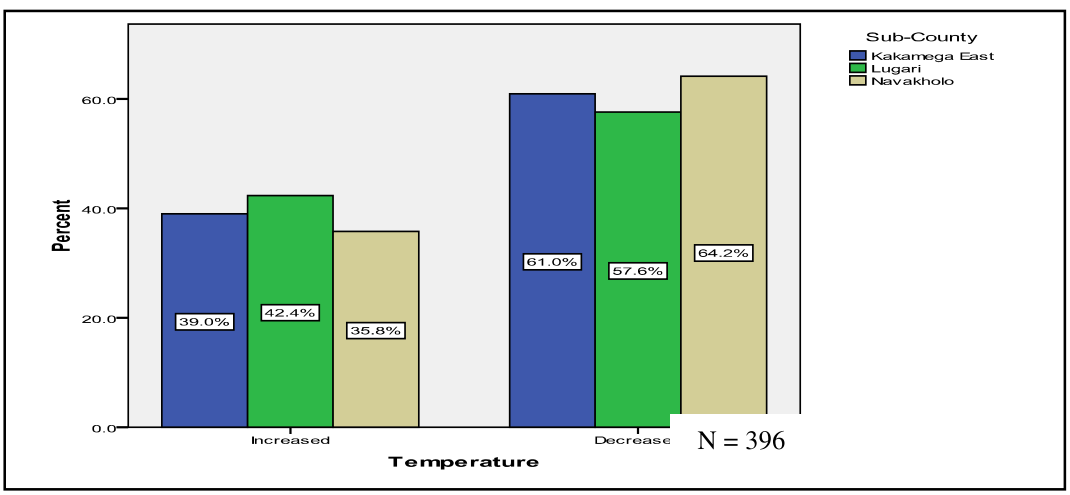

Figure 16: Variation in Temperature per Sub-county in Kakamega County, Kenya

Generally, temperature has less spatial-temporal variability compared to rainfall, but has significant consequences (GoK, 2013d; Oteng'i, 2009). In spite of the foregoing, local conditions can influence perception of climate variability by farmers (Okonya*et al.,* 2013; Yaro, 2013). Inspite of the foregoing, a Chi Square test of independence conducted on the data showed that there was no significant (P>0.05) association between farmer perceptions of how temperature had varied per sub-county$(\chi^2_{2,0.05} = 1.13)$.
Literature indicate that geographical zone that receive less precipitation are likely to experience the impacts of variability in rainfall than those that receive (Jaetzold*et al,* 2011: GoK, 2010; Kabubo*et al.,*(2007). This is because the latter accommodate wider fluctuations in rainfall hence can sustain a range of crops. Overall, the responses pointed to a high level of awareness by farmers of the increasing tendency in temperature. This is acknowledged by existing literature (GoK, 2010; IPCC, 2007; UNFCCC, 1998).

Further, these findings compare well with the demographic survey results that established that farmers in Kenya were aware of short-term climate variability as most of them had noticed an increase in temperatures (Kabubo*et al.,* 2007). Although temperature is not a major limiting factor in agriculture in the tropics it is important to observe that the climate change and variability could reverse this (Maddison, 2007).

3.1.9. Frequency and Intensity of Dry Spells in Kakamega Sub-county

Findings on frequency and intensity of dry spells are summarized in Figure 17.

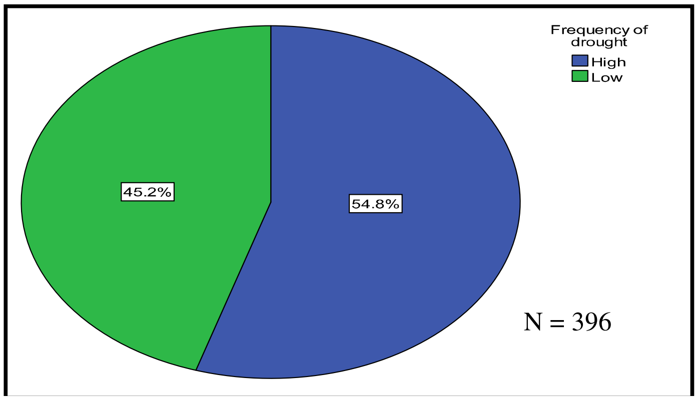

Figure 17: Frequency and Intensity of Dry spells in Kakamega County, Kenya

Most households perceive that the frequency of dry spells has increased with the rating of 54.8% increased and 45.2% low. A Chi Square test conducted on the data showed that there was no significant (P>0.05) variation in the distribution responses on the frequency of dry spells($\chi^2_{1,0.05} = 3.61$). One farmer quoted in verbatim observed that 'we now get frequent dry seasons than was in the past'. Dry spells are the result of climate variability that manifested by a late onset of the rainy season, irregular spatial distribution of rains, and an early end to the rainy season. Droughts occasioned a significant drop in crop yield. The perceptions of the respondents per sub-county are presented in Figure 18

Figure 18 shows further analysis of frequency and intensity of dry spells per Sub-county.

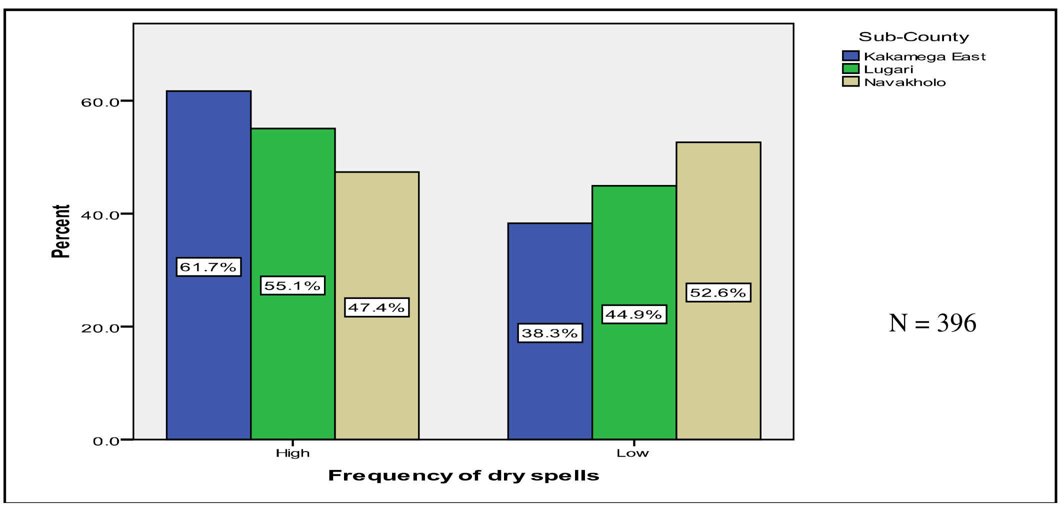

Figure 18: Farmers Perceptions on Intensity and Frequency of Dry spells per Sub–county

The perception of increased frequency of dry spells was higher in Kakamega (61.7%), followed by Lugari (55.1%) and finally Navakholo (47.4%). Some respondents expressed that they had experienced a drop in the frequency and intensity of dry spells. These were; Navakholo (52.6%), followed by Lugari (44.9%) and finally Kakamega East (38.3%).In both contexts, it is evident that anomalies had been experienced. A Chi Square test of independence conducted on the data showed that there was a significant (P>0.05) association between frequency of dry spells and sub-county of study($\chi^2_{2,0.05} = 5.68$).

These responses could significantly portray the existing differences in the AEZ. For instance where as the respondents in Navakholo and Kakamega East perceived them as short dry spells, those in Lugari observed them as longer spells and hence the differences. Dry spells which typically occurred in this county have adversarial impacts on both livestock and crop production. They were as a result of below normal rainfall over an extended period of time which resulted in water scarcity.

3.1.10. Frequency and Intensity of Floods in the Sub-county

Farmer perceptions on the frequency and intensity of floods are summarized in Figure19.

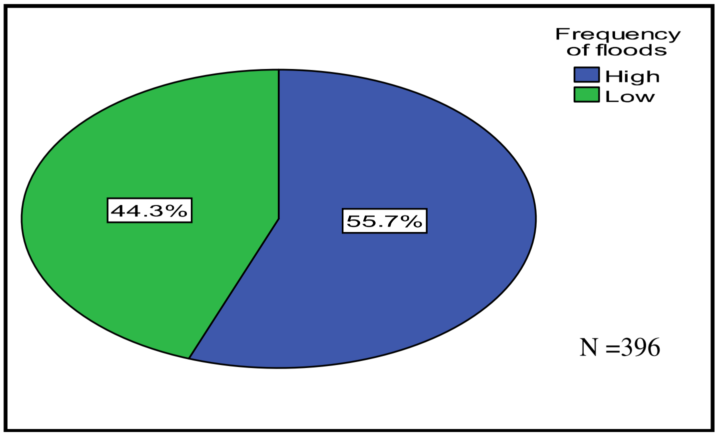

Figure 19: Frequency and Intensity of Floods in Kakamega County, Kenya

The responses were 55.7% said the frequency of floods was low and 44.3% indicated they were high. This almost equal proportion may also have been influenced by the existing local conditions and the most recent climatical events. Findings of farmer perceptions of the anomaly per sub-county are summarized in Figure 19.A Chi Square test conducted on the data showed that there was a significant (P<0.05) variation in the distribution responses on frequency of floods($\chi^2_{1,0.05} = 5.13$).

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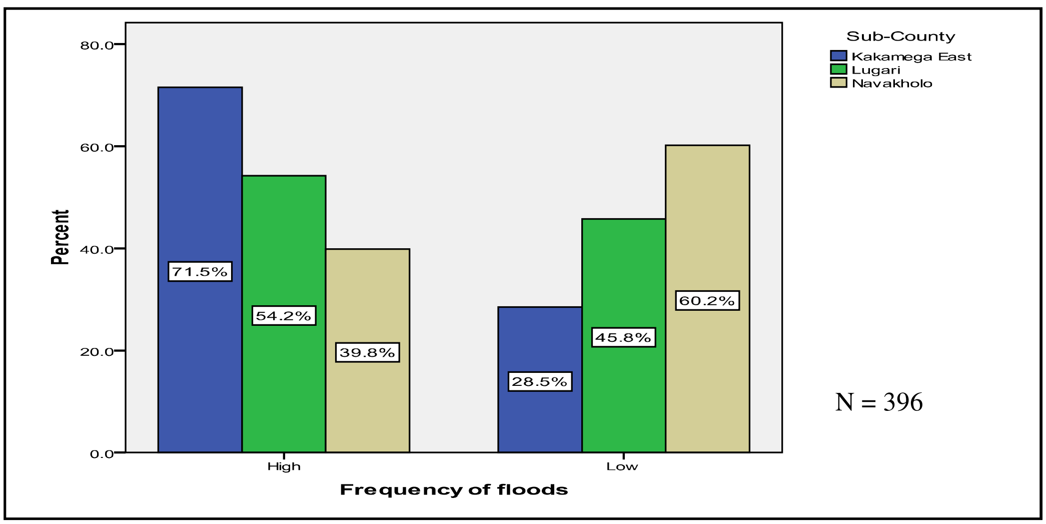

Figure 20: Frequency of Floods per Sub-county in Kakamega County

A Chi Square test of independence conducted on the data showed that there was a significant (P<0.05) association between responses on frequency and intensity of floods and sub-county of study($\chi^2_{2,0.05} = 8.49$).The findings indicate that the floods were experienced differently in each of the three sub-counties as the respondents perceived them differently across the sub counties. This was due to different climatical conditions that presented in the respective AEZ.

3.1.11. Frequency and Severity of Storms in Kakamega County

The results are summarised in Figure 21.

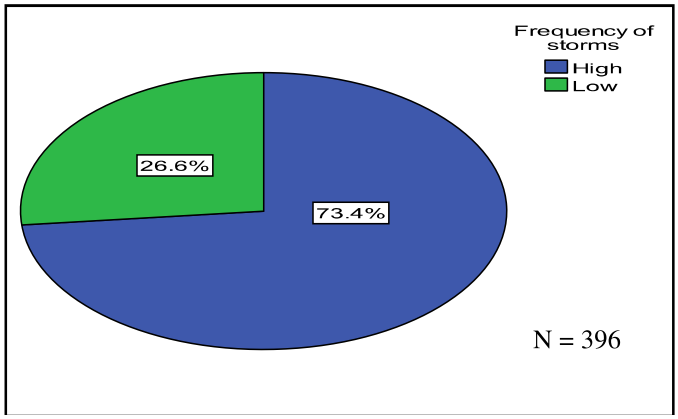

Figure 21: Frequency and Intensity of Storms in Kakamega County, Kenya

There was a large difference between the respondents who perceived frequency of storms having been high and those who perceived that it was low. More famers (73.4%) perceive that frequency of violent storms has increased in the sub-county. However, the percentage of those who perceive a decrease in frequency of violent storms is 26.6%. A Chi Square test conducted on the data showed that there was a highly significant (P<0.01) variation in the distribution responses on frequency of storms in the three sub-counties of study($\chi^2_{1,0.01} = 86.65$).
Findings per sub-county are indicated in Figure 22.

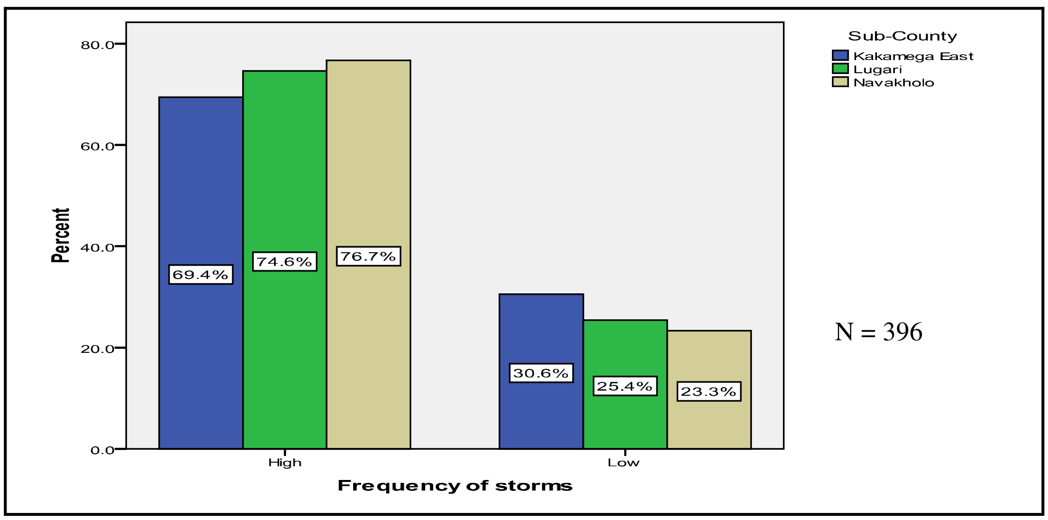

Figure 22: Frequency of Storms per Sub-county in Kakamega County, Kenya

Farmers perceived these changes in the occurrence of storms in a similar manner in the three sub-counties. This proves that most respondents have had similar experiences regarding this indicator of climate variability. This was similarly observed from the observation checklists and expressed by the KIIs. Respondents observed that the number of storms has increased over time, which resulted in flash floods that washed away their crops. A Chi Square test of independence conducted on the data showed that there was no significant (P>0.05) association between responses on perceptions on frequency of storms and sub-county ($\chi^2_{2,0.05} = 1.97$).This implied that the responses were not unique to any geographical zone. According to literature, Kakamega county is prone to thunder and hailstorms (GoK, 2008c; GoK, 2009). These are normally accompanied by heavy rainfall and strong winds which damage crops. The foregoing findings are consistent with observations made by Oteng'i (2009) that most precipitation in the tropics comes in short, intensive and highly variable downpours.

4. Conclusions and Recommendations

The analysis of the rainfall and temperature recorded data revealed that there had been variability in these two variables over the period 2001 to 2013. The variability in the rainfall and temperature had derivative effects such as flooding, droughts amongst others. These were considered as indicators of climate variability. The farmers' perceptions of the indicators of climate variability corroborated the findings of the analysis of recorded data. Amongst the indicators of climate variability cited comprised: (i) prolonged dry spells and droughts; (ii) frequent and intense episodes of wet spells; (iii) increased frequency of storms and floods (iv) delayed or seasonal rainfall uncertainties (v) earlier onsets or cessation of seasonal rains and; (v) shifts in seasonal patterns especially in short rains 'spilling' into the ordinarily dry January and February. Most of the farmer respondents indicated that their awareness of climate variability is rooted in their observation of its impacts in their agricultural practice.

The study observed that whereas a majority of the farmers had perceived climate variability, a minority had not. This perception of climate variability appears to hinge on factors well beyond the scope of this study. This study recommended further studies to determine these factors. It also recommended the putting in place of policies that promote increased awareness through information dissemination as this would inform adaptation strategies. It was envisaged that an informed farmer would make informed adaptation decisions.

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