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The Perception of Farmers on Climate Change and Variability Patterns in the Nzoia River Basin, Kenya

*Catherine N. Mbaisi[1] Emmanuel C. Kipkorir[2] Paul Omondi[3]
1.University of Eldoret, School of Environmental Studies,
Department of Environmental Planning, Monitoring and Management, P.O. Box 1125 - 30100, Eldoret, Kenya
2.University of Eldoret, Kenya
3.Moi University, Eldoret, Kenya

Abstract
Global research experts have indicated that there is a growing trend in climate change and variability. Climate change has been altering the exposure of countries to weather related hazards, often exacerbating already existing vulnerabilities over the recent decades. Increasingly, the weather experienced then in terms of amounts of rainfall and temperature is no longer the same as it has always been over centuries based on previous records and scientific findings. This paper sought to establish the perception of farmers on climate variability and patterns in the Nzoia River Basin, Kenya. The study adopted descriptive, and correlative research design. Data was collected using questionnaires, interview schedules and documented resource materials. The collected data was analyzed using Statistical Package for Social Scientists (SPSS) whereas climatic data of rainfall and temperature from Kenya Meteorological Service (KMS) and hectarage, and yield from the Ministry of Agriculture was analyzed using Microsoft excel. Results were presented in form of tables, charts and graphs. The study indicated that farmers had perceived an increase in temperature a decrease in rainfall, delay in onset of the rains, erratic and poor distribution of rainfall over the study period. The farmer's perceptions on climate risk as a result of climate change and variability taking place in the basin has greatly influenced the cropping calendar, on-farm investments and decision-making in agricultural management and production negatively affecting yield of maize in the region. The study recommends that the Government could help to counteract the impact of climate change on agriculture by investing in research, soil conservation measures, technology, irrigation and water harvesting development, establishing local meteorology stations that will give farmers relevant meteorological advice that will help them make informed farming options in each farming season.
Keywords: Climate change, Climate variability, Perception, Weather.

1. Introduction

Climate change refers to the permanent shifts in the traditional space-time patterns of climate for example, a change from one climate mode to another, which is outside the normal range of natural climate variability regardless of the causes. Climate variability is variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes among others) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may result from natural internal processes within the climate system (internal variability) or from variations in natural or anthropogenic external forcing (external variability) (IPCC, 2001a; RoK, 2010a).

Climate change results from the increased emissions and subsequent concentration of gases referred to as greenhouse gases in the atmosphere due to human activities. Increased concentration of these gases causes global warming accompanied by a shift in rainfall patterns. Land, presently not available for agriculture, could with increased temperature and rainfall support crops. In other regions, drought may become more frequent. Other possible effects include: increase in diseases and pests due to higher temperatures; variations in rainfall which could greatly affect surface and ground water resources (IPCC, 2007**).**

Anthropogenic factors are thought to be the main drivers of global warming. Human activities have led to changes in the chemical composition of the atmosphere by adding more greenhouse gases (GHG) to it. Between 1970 and 2004, global GHG emissions increased by seventy percent (70 %) (IPCC, 2007). Some of these effects are not entirely due to climate changes but a result of multiple factors such as late delivery of subsidized inputs and poor markets for farmers' produce (Nyanga *et al.,* 2011**).**

Climatic variations in Kenya have been associated with the global climate systems such as the EL-Niño Southern Oscillation (ENSO) phenomenon and Quasi-Biennial Oscillation (QBO) (Ogallo, 1992). The affected climatic parameters include rainfall, temperature stream flow, lake levels, mountain glaciers and palaeclimatological records. Rainfall shows, strong seasonality with bimodal distribution patterns (March – May and October – November), confirming to the seasonal latitudinal migration of the inter-tropical convergence zone (ITCZ) (Ogallo, 1992). This causes Kenya to experience two distinct wet periods, the short rains in October to December and the Long rains in March to May. The third rainfall peak (July – August) which is experienced in the Western highlands is due to the incursions of moist air masses from the Atlantic ocean and the forested basin of the Democratic Republic of Congo during the Northern hemisphere summer season (Ogallo, 1997).

Average annual rainfall ranges between 250mm to 2500mm and average potential evaporation ranges from less than 1200 mm to 2500mm (World Bank, 2007).

The hottest months in Kenya (January – March) are attributed to low cloud cover. Mean temperatures in Kenya follows a strong bi-modal seasonal pattern. Statistical analysis of climatological records is carried out as one of the approaches for climate change detection. Records of temperatures and rainfall are commonly used in climate change studies. Analysis of temperature records have given clear signals of climate change with the trend being of temperature rise over land at night in the Northern hemisphere. Rainfall records however, have not yielded any clear indication of climate change even though there appears to be a downward trend in the mean annual rainfall in some places (Ogallo & Ambenje, 1996; Andressen *et al*., 2008)

Studies show that farmers perceive climate change differently. Their different way of perceiving climate change influences their decision making process on appropriate adaptation measures (Mamba *et al*, 2015).Adaptation to climate change requires that farmers first notice that the climate has changed, and then identify useful adaptations and implement them (Maddison, 2006).The extend of farmers awareness and perception of climate variability and change and the type of adjustments they have to make in their farming practices influences their responses to these changes (Gbetibouo, 2009)

The studies have shown a high correspondence of resource users' perception of climate change and the meteorological data (Deressa *et al*., 2008). Rainfall variability, which is one of the critical aspects of climate change, has a significant impact on crop yield in rain fed agriculture. It influences rainfall intensity, duration, onset and ceasation which affect the farming calendar of the farmers.

Climate change affects crop yield either positively or negatively. However, there are also other agricultural inputs that determine the productivity of the agricultural sector, thus a shortfall in such inputs will result in low productivity. Nyanga *et al.* (2011) argued that some of the negative effects are not entirely due to climate changes but a result of multiple factors such as late delivery of subsidized inputs and poor markets for farmers' produce.

Mamba *et al.* (2015) indicated that farmer's perception of climate change and weather variability in particular rainfall, influences investment decisions and the resulting crop yield and food security. It is therefore essential that farmers perceive rainfall correctly, especially the onset of the rains so that they can invest adequately and appropriately.

Smithers and Smit (2009) contend that environmental perceptions are among key elements influencing adoption of adaptation strategies. Actions that follow perceptions of climate change are informed by different processes such as perception of risk associated with climate change, resource endowments, and cultural values, institutional and political environment and there is no guarantee that having perceptions that climate change has or is occurring would prompt effective adaptation responses (Weber, 2010).

The adopter perceptions paradigm posits that the adoption process starts with the adopters' perception of the problem and technology proposed (Adesina & Zinnah, 1993a). This paradigm argues that perceptions of adopters are important in influencing adoption decisions (Prager & Posthumus, 2010). Perceptions are context and location specific due to heterogeneity in factors that influence them such as culture, education, gender, age, resource endowments and institutional factors (Ervin & Ervin, 1982; Posthumus *et al*., 2010).

Some of the common negative effects were perceived to be poor crop production (due to flooding, prolonged dry spells and droughts), poor livestock production (due to increased diseases) and increased food insecurity. Other negative effects included increased pests and diseases, destruction of physical infrastructure, difficulty in planning because of increased variability of the weather and reduced access to inputs due to low income from poor crop production (Nyanga *et al*., 2011).

Smallholder farmers are aware of climate change through their experiences. This is a common finding from other studies on perceptions of resource users of climate change (Mertz et al., 2009; Deressa *et al.,* 2008; Slegers, 2008 and Marin, 2010). The smallholder farmers perceived shifts in the timing of seasons increase in temperature, droughts and floods. They perceived climate change to be caused by supernatural forces. Majority of farmers expressed shortening of the rainy season and increased variability in intensity and distribution.

2.0 Materials and Methods

2.1 Study Area

The study was conducted in Nzoia River Basin which lies between latitudes 1^0 30'N and 0^0 05' S and longitudes 34^0 and 35^0 45'E. The Nzoia River originates from Cherengani hills at a mean elevation of 2300m above sea level (asl) and drains into Lake Victoria at an altitude of 1000 m above sea level. It runs approximately South-West and measures about 334 km with a catchment area of about 12,900 Km^2, with a mean annual discharge of 1777 $x10^6m^3$/year. The Basin traverses Elgeiyo-Marakwet, West Pokot, Trans Nzioa and Uasin Gishu Counties in the North Rift Valley; Bungoma, Kakamega, Butere-Mumias and Busia counties in the Western part of Kenya and Siaya County in the formerly Nyanza Province. This is as depicted in figure 1.

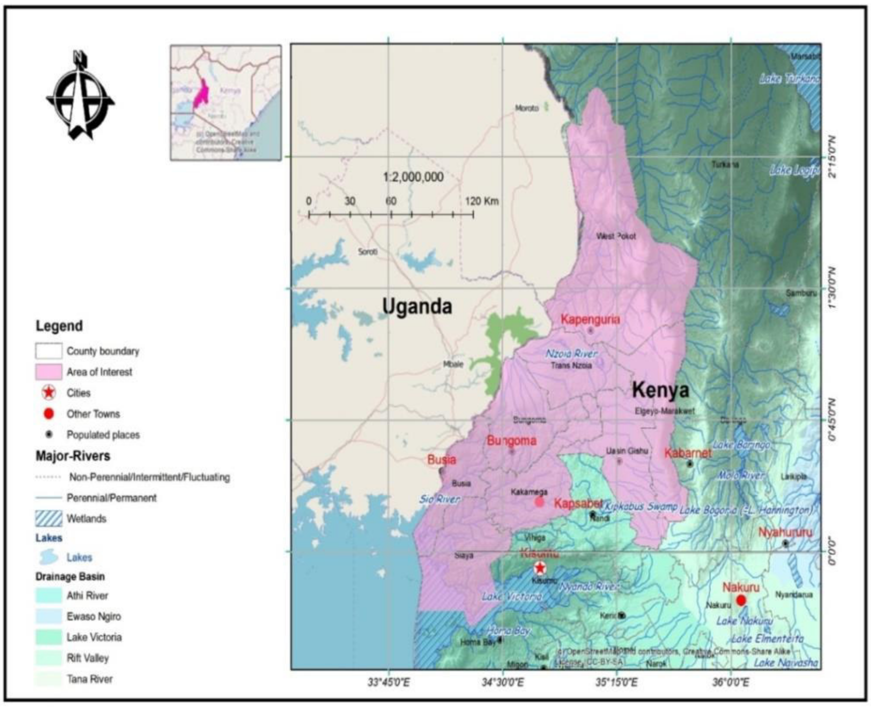

Figure 1. Location of the study area
Source: Author, Shuttle Radar Topography Mission (SRTM), 2011

The climate of the basin is mainly tropical humid characterized by day temperature varying between 16^0C in the highlands of Cherenganyi and Mount Elgon to 28 ^{0}C in the lower and semi-arid areas. The mean annual rainfall varies from a minimum of 1100 mm to a maximum of 2700 mm. The climate of the upper part represented by Trans Nzoia County is mainly highland equatorial. The rainfall is well distributed through the year. It has a bimodal rainfall pattern with long rains occurring in April to June while short rains occur in July to October. The mean temperatures is 18^0C but vary between 10^0C to 30 ^{0}C. The average daily relative humidity is 65% and the wind speed is 2 knots (RoK, 2013a).The middle basin experiences high rainfall ranging from 1000 mm 2400mm per annum. The County has high temperature ranging from a minimum of 11^0C to a maximum of 32^0C. The lower basin has a mean annual rainfall ranging from 1270mm to 1790 mm. The driest part in the lower basin receives between 760 mm to 1015 mm annually.

The agro ecological factors determine the suitability of an area for a particular land use. The performance of rain fed agriculture varies spatially due to the diverse agro-climatic zones. In the humid high altitude areas, agricultural productivity is high. In the medium altitude and moderate rainfall areas, arable rain fed farming is moderately suitable. However, there is a relatively high risk of crop failure due to the increased frequency of dry spells and uneven distribution of rainfall. The Nzoia River Basin is an important economic region both at the local and national level especially in the agriculture, tourism and fishing sectors. The economy of this region is largely rural and more than ninety percent (90%) of the population earns its living from agriculture and livestock. Most farms are privately owned with an average size of 1-3 ha with maize as their main food and subsistence crop.

2.2 Methodology

The study adopted the descriptive and evaluative research design. Stratified proportionate sampling was used to obtain the sample sizes. The Basin was stratified into three regions based on the agro-ecological zones thus; the upper zone, the middle zone and the lower zone. Trans NzoiaWest County was purposively sampled to represent the upper part of the basin because of the widespread maize growing by farmers. It is also considered to be one of the bread basket counties of the country in terms of maize production. Kakamega and Busia Counties were purposively sampled to represent the middle and lower zones respectively. Krejcie and Morgan (1970) model was used to obtain sample size for the study. Accoding to the model, as the population increases, the sample size increases at a diminishing rate and remains constant at slightly more than 380 cases. The formula

$$S= X^2 NP (1-p)/d^2 (N-1) +X^2P (1-p)$$

Where

S= required sample size

X^2= The table value of chi square for 1 degree of freedom at the desired confidence level

N= Population size
P= the population proportion (assumed to be 0.5 since this would provide the maximum sample size)
D= the degree of accuracy expressed as proportions (0.5)
Using this formula a total of 276 households, 22 government representatives and two civil society organizations were sampled. Questionnaires and interview schedules were administered to the heads of households. Key informants and policy makers. The data obtained from the interviews was then analyzed using Statistical Package for Social Scientists (SPSS) whereas rainfall and temperature data from Kenya Meteorological Service (KMS) and yield in bags per hectare data from the Ministry of Agriculture was analysed using Microsoft excel. Results are presented in form of tables.

3.0. Results and Discussion

3.1 Perception of farmers on the changes in rainfall

Annual rainfall in Kenya follows a strong bi-modal seasonal pattern (RoK, 2012). Generally, the long rains occur in the month of March to May, while the short rains occur between October and December with variations. A representation of 73 % of the household heads interviewed in the Basin indicated that they had observed a decrease in the rainfall trend as shown in Table 1.

Table 1. Perception of farmers on the rainfall trends

	Trans Nzoia West		**Kakamega**		**Busia**	
	Frequency	%	Frequency	%	Frequency	%
Increase in temperature	31	62	17	46	13	57
Decrease in temperature	7	14	12	32	8	35
Normal temperature	10	20	7	19	2	9
Unpredictable	2	4	1	3	0	0
Total	**50**	**100**	**37**	**100**	**23**	**100**

Source: Author, 2011

3.1.1. Decrease in the precipitation

When the farmers in different parts of the basin were interviewed 36% of them from the Trans Nzoia West and 24% from the Kakamega indicated that they had noticed a decrease in precipitation over the period. However, Only 13 % of the farmers in Busia County indicated that they had noticed a decrease in the rainfall pattern. Discussions with the County Directors of Agriculture in the basin indicated that they had observed a reduction in the amount of rainfall received over the years. The county Director of agriculture in Trans Nzoia West indicated that though there was a reduction in the amount of rainfall received, the effect on maize production depended on the stage of maize development at which the rainfall reduces.

Analysis of rainfall data from the Kenya Meteorological Service showed that the Basin has a Bimodal rainfall pattern where the Long rains occur in the month of March to May and the short rains occur in October to December. There is also a third peak from July to September. The analysis of the rainfall pattern in the different parts of the Basin showed a significant difference where the Long rains occurred in April to June in the Trans Nzoia West, and the short rains occurred in July to October. For Kakamega, the Long rains occurred in March to June but the peak was in May. The Short rains in Kakamega occurred in July to September but had their peak in August. For Busia County, The long rains occurred in March to May whereas the short rains occurred in August to October. Figure 2 below shows the annual rainfall trend in the upper basin.

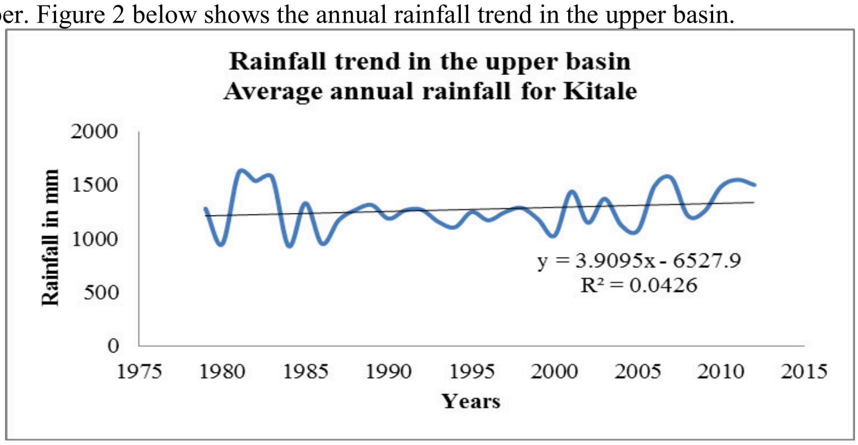

Fig 2. The Annual rainfall trend Ki tale

Although the annual rainfall pattern did not reveal a significant variability, analysis of the seasonal rainfall revealed significant variability. The results indicated that, for the Trans Nzoia West County, the MAM rainfall trends were decreasing, whereas the June, July rainfall patterns were increasing as shown in the fig 3 below.

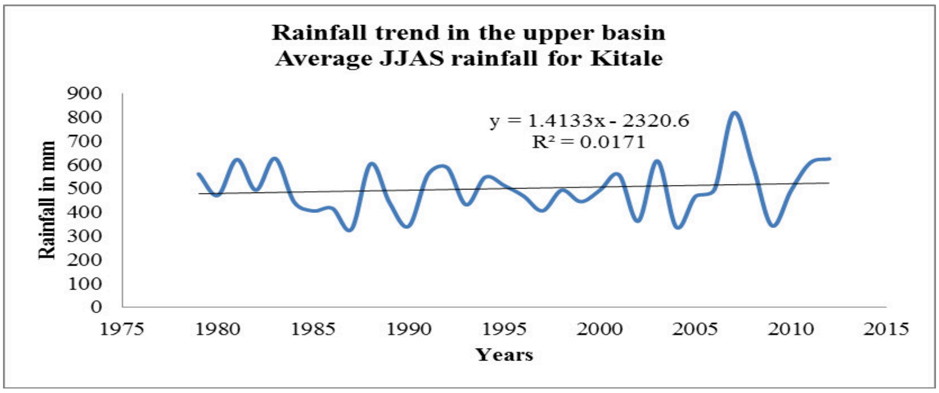

Fig. 3: Rainfall pattern of JJAS rainfall pattern for Kitale *Source: (KMS, 2011)*

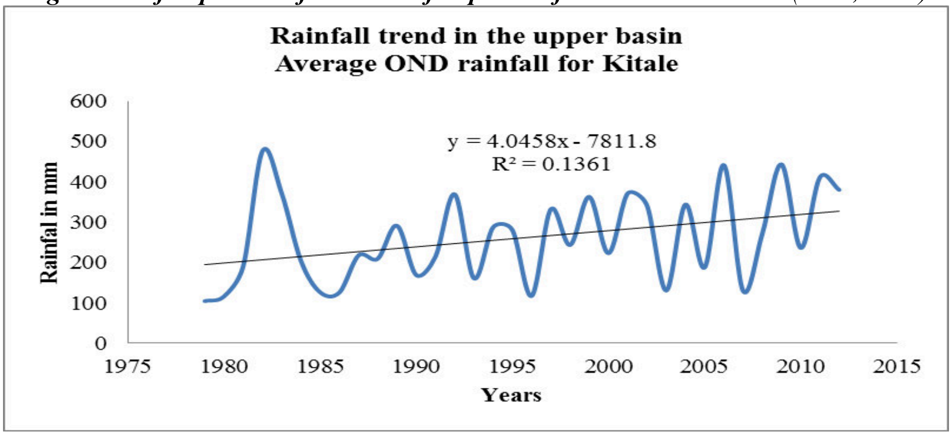

Fig.4: Rainfall trend for OND for Kitale ***Source: (KMS, 2011)***

Figure 4 shows the OND rainfall amount in the upper part of the basin has significantly increased over the years. This corroborates the findings of the farmers and influences their perception of reducing rainfall amounts because this season is the season for planting their maize crop and they are likely to notice any changes in the rainfall pattern which may affect their planting operations.

3.1.2 Lighter Density of the rainfall

Regarding the density of the rainfall, 35%, 28% and 11% of the farmers in Trans Nzoia West, Kakamega and in Busia respectively indicated that they had noticed a lighter density in the amount of rainfall over the study period. This corroborates the findings of the instrumental data obtained from the Kenya Meteorological Department (KMD) and analysis in Table 2 which indicated that the rainfall in the upper basin especially in Kitale had decreased.

3.1.3 Delay on the onset of the rainfall

At least 16% of the respondents in Trans Nzoia West, 33% in Kakamega and 57 % in Busia indicated they had observed a delay in the onset of the rains over the study period as indicated in Table 2. The delay on the onset of the rainfall interferes with the planting calendar of the farmers. Some farmers plant early others wait for the rains to start before they plant depending on the individual farmers judgment of the rainfall season. In this way, farmers lose out on the optimum yield when they do not make the right judgment and plant their crop either too early or too late into the rainfall season. Table 2 shows the planting dates of maize in the Basin.

Table 2: Planting dates for maize in various counties

	Trans Nzoia West		Kakamega		Busia	
	Frequency	**%**	**Frequency**	**%**	**Frequency**	**%**
Late February	9	7	0	0	7	14
Early March	18	15	12	13	23	45
Mid-March	42	34	44	49	16	31
Late March	25	20	11	12	4	8
Early April	19	15	17	19	0	0
Mid April	10	8	5	6	1	2
Late April	1	1	1	1	0	0
Total	**124**	**100**	**90**	**100**	**51**	**100**

Source: Author, 2011

Analysis of the instrumental data on rainfall revealed that there has been a delay in the onset of the rains especially the March, April May (MAM) rainfall which starts in around March in the whole of the Basin. This delay on the onset of the rainfall pushes the peak to occur in the JJAS season thus reducing the amount of rainfall received in the MAM season but increases the amount received in the June, July, August and September (JJAS) rainfall season. It also prolongs the planting season for the farmers in Trans Nzoia West and Kakamega. Most farmers normally plant on the onset of the rains. Farmers in Trans Nzoia start their planting in early March but their peak planting is in Mid-March when most farmers plant their crop and that is also when they receive peak rainfall. However, quite a number of farmers plant their crop up until early April. This is because; the rainfall pattern in Trans Nzoia West seemed to be continuous over a longer period of time. In Busia County, the farmers have a very short planting season mostly between early March and Mid- March. They have a span of two weeks only compared to the Trans Nzoia West farmers who have a span of Early March to Mid- April (RoK, 2011a).Therefore continuous rainfall gives the farmers a longer span of planting the maize crop. The challenge is presented when the planted crop does not get the right amount of rainfall during the critical development stages such as the reproductive stage leading to poor yields. The effect of rainfall on maize production depends on the onset of the rains and the general distribution of the rains throughout the growing period (Mugalavai *et al*., 2013).

For the farmers, every time there is rainfall, presents an opportunity to plant maize. The farmers plant from March to Mid-April. The challenge is whether the lately planted crop can get enough rainfall throughout the growing season to obtain optimal yield. The farmers' perception on the rainfall patterns prompts their appropriate responses. If they perceive reduced rainfall they respond by planting drought tolerant crops to adapt to the reduced amount of rainfall.

3.2 Perception of farmers on temperature trends in the Nzoia River basin

An interview with the farmers in the basin on their perception of the trend of the temperatures in the basin indicated that 80.4 % had noticed long term shifts in temperature whereas only 19.6 % indicated that they had not noticed any changes. Another 85.1 % of the farmers indicated that they had noticed a general increase in the temperatures in the basin as indicated in table 3. About 62 % of the farmers in Trans Nzoia West County, 46% in Kakamega County and 57% of the farmers in Busia County indicated that they had noticed an increase in the MAM season temperatures.

Table 3: Perception of the farmers on MAM temperatures

	Trans Nzoia West		Kakamega		Busia	
	Frequency	%	Frequency	%	Frequency	%
Increase in temperature	31	62	17	46	13	57
Decrease in temperature	7	14	12	32	8	35
Normal temperature	10	20	7	19	2	9
Unpredictable	2	4	1	3	0	0
Total	**50**	**100**	**37**	**100**	**23**	**100**

Source: KMS, 2011

Analysis of the seasonal temperatures revealed an increase in temperature trend. The MAM season is the season for sowing the maize crop in the whole Basin. Increased temperatures influence the growth and development of plants but up to a certain threshhold.

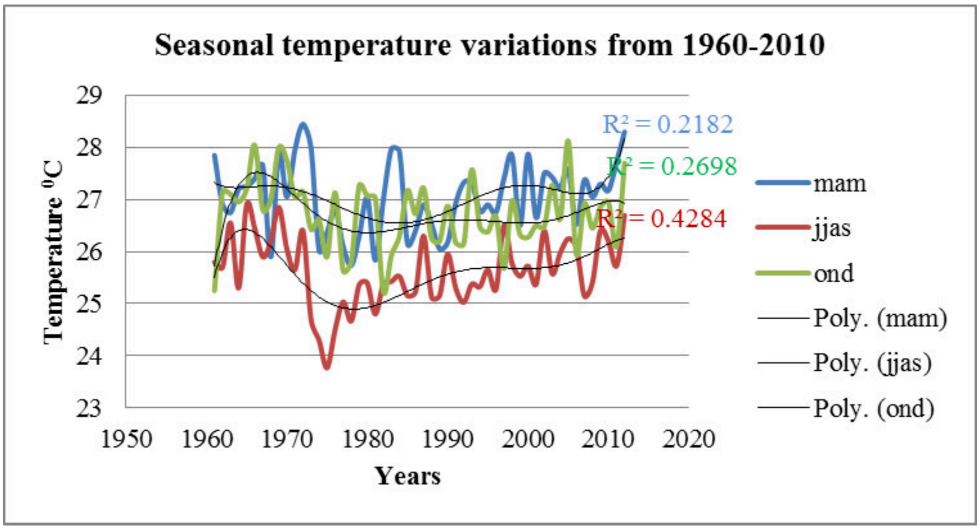

Fig.4.26 Seasonal temperature variations from 1960-2010 Source: (KMS, 2011)

A warming of the MAM season coupled with a delay in the onset of the rainfall discussed in section 3.1.3 will cause the sowing date to advance into the future. Pheonologically, early sowing helps to prolong the maturing period of the early maize cultivars and hence increase the maize yield. A shortening of the growing period by planting late will necesitate the growing of short season varieties which are not as high yielding as the late maturing varieties. The JJAS season is mainly the vegetative and reproductive stage of maize development depending on the time the maize was sown and the variety of the maize sown.

A total of 66% of the farmers in Trans Nzoia West, 69% in the Kakamega indicated that the JJAs temperatures had decreased, but 77% of the farmers in Busia County indicated the temperatures had increased. However analysis of the instrumental data over the study period revealed that both the annual and seasonal temperatures had increased. JJAS season is normally the coldest of all the seasons and the farmers may have found it colder compared to the MAM and OND seasons. The results also showed the JJAs season to have least warmed up compared to the other season of MAM and October November December (OND).

The mean temperature in Kenya follows a strong bimodal seasonal pattern. The temperature trends have given a clear signal of climate change with the trend being a rise in temperature over land (Ogallo & Ambenje, 1996; Andressen *et al.,* 2008)

This is corroborated by the findings of the (RoK, 2012) which indicated that the mean annual temperatures have increased by one degree in Kenya. Since 1960, an average rate of 0.21 ^{0}C per decade has been observed. This increase in temperature has been most rapid in MAM where the rate has been 0.29 ^{0} C per decade, and slowest in JJAS 0.19^0 C per decade. Recent reports from the IPCC confirm that there is a general warming across Africa in the range of 0.2 ^{0}C -0.5 ^{0}C per decade (Hulme, 2001, IPCC, 2001). This is also corroborated by the General circulation models which indicated that there would be an increase in the mean annual temperature of 2.5-5^{0}C. (McSweeney *et al.,* 2007) also showed that the increase in temperature would be most rapid in MAM season at a rate of 0.29 ^{0} C per decade.

High temperatures also cause increased mineralization of organic matter content in the soils thus reducing the organic matter content of the soils.These leads to reduced soil fertility and poor soil structure for optimum maize production. High temperatures coupled with high atmospheric humidity favours development of crop pests and diseases. This will accentuate these problems which are already contributing to a large extend to agricultural losses in Africa in pre and post harvest losses. In addition, higher temperature, incresed rainfall and higher carbon dioxide concentartion may agravate the problem of weeds in cultivated areas and the resultant competition may reduce maize/crop yield (Nyabundi & Njoka,1991).

3.3 Perception farmers on the effect of temperature changes

The MAM, JJAS and OND seasons are characterized by different agronomic activities. For example the maize is largely sown in the Month of March as shown in Table 2. Therefore late onset of rainfall and increase in temperatures of MAM will have an effect on the yield of maize. At least 29% of the farmers in Trans Nzoia West, 21% in Kakamega and 11% in Busia County indicated that high temperatures in MAM cause poor germination of the crop. In addition, it was highlighted by 21% of the farmers in Trans Nzoia West, 32% in Kakamega and 33 % in Busia that the increase in temperature causes wilting of the maize crop. The high temperatures cause wilting of the germinated young maize due to the intermittent dry periods occasioned by erratic rainfall and high temperatures which affect the performance of the crop.

Increasing temperatures at the reproductive stage of maize development affects the yield greatly. A representation of 33% of the farmers in Trans Nzoia West and 42 % in Kakamega indicated that they had noticed poor flowering and tasseling. On the other hand, 11% in Trans Nzoia West and 33 % in Kakamega indicated that they had observed stunted growth.

The rising temperatures in the OND are good for maize harvesting. Majority (80%) of the Farmers in Trans Nzoia West indicated that the increasing temperatures are good for drying maize, However, 25 % of the farmers in Busia indicated that the high temperatures cause wilting of the maize crop planted in the JJAS rainfall resulting to further yield loss.

4.0. Conclusion

The farmers in Nzoia river basin demonstrated that they are aware of climate change in terms of rainfall and temperature changes. A change in the rainfall patterns was noticeable over the years in which this study was carried out. They confirmed to having observed a decrease in the amount of rainfall received over the period. They also indicated that they had observed a delay in the onset of the rains and cessation of rainfall. As a result, they had made some adjustments in sowing dates such that they plant their crop on the onset of the rains to make use of the available rainfall in the season.

The observations made by the farmers is corroborated by the analysis of the instrumental data obtained from the Kenya meteorological service which also indicated that there is a reduction in the amount of rainfall received over the study period. The results also showed that there is a delay in the onset of the rains in the Basin.

The farmers also indicated that they had noticed a long term shift in temperatures. They indicated that they had noticed an increase in temperature over the years. There was a probable delay in the onset of MAM rainfall and an increase in the temperatures in MAM season prompting late crop planting by farmers since they have to wait for the onset of the rains before they start planting.

The farmers indicated that the JJAS temperatures were decreasing. However, analysis of the instrumental data from KMS indicated that the JJAS temperatures were increasing. In addition, analysis of the data shows that the JJAS season is the one that had least warmed up compared to the MAM and OND seasons. Given that the JJAS season is normally the coldest of the three seasons, it may have been difficult for the farmers to notice the slight increase in temperature and perceive the slight increase correctly without the aid of any instrument data.

5. Recommendation

The study concludes that the farmers perceive climate change in terms of rainfall and temperature correctly in most cases. However, there are cases where they do not make the right judgments and in such incidences they may not make appropriate management decisions and this will affect their maize production.

There is need to provide the farmers with accurate and timely weather information to help farmer's preparedness and decision making in terms of when to sow their maize crop and the right variety of maize to be sown according to the expected climate information.

References

Adesina, A.A. & Zinnah, M.M., (1993). Technology characteristics, farmer perceptions and adoption decisions: a tobit model application in Sierra Leone. *Agric. Econ., 9*, 297-311.

African Technology Policy Studies Network, ATPS 2013: Farmers' Perception and Adaptive Capacity to Climate Change and Variability in the Upper Catchment of Blue Nile, Ethiopia [Bewket Amdu, Azemeraw Ayehu, Andent Deressa], ATPS WORKING PAPER No. 77.

Andressen, J., Olson, M. & Maitima, (2008). *The effects of climate change and land use changes on climate and agricultural systems in Kenya.* Nairobi: Clip Policy Workshop.

Deressa, T., Hassan, R.M., Alemu, T., Yesuf, M. & Ringler, C. (2008). Analyzing the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile Basin of Ethiopia. *International Food Policy Research Institute* (*IFPRI) Discussion Paper No. 00798*. Environment and Production Technology Division, IFPRI, Washington D.C.

Ervin, C.A., & Ervin, D.E. (1982). Factors affecting the use of soil conservation practices: hypothesis, evidence and policy implications. *Land Economics, 58,* 277-292.

Gbetibouo,G.A.,(2009) Understanding Farmers' Perceptions and Adaptations to Climate Change and Variability
The Case of the Limpopo Basin, South Africa: *Centre for Environmental Economics and Policy in Africa* Department of Agricultural Economics, University of Pretoria.

Hulme, M. (2001). The years of drought: the Sahel 1973 –1998. *Global Environ Change, 11*(1), 19 –29/.

IPCC (Intergovernmental Panel on Climate Change). (2001 a). Climate change: The scientific basis. http://www.ipcc.ch/

IPCC (Intergovernmental panel on climate change). (2001). Climate change 2001: Impacts, adaptation, and vulnerability. Cambridge, UK: Cambridge University Press.

IPCC, (2007a) *Climate Change 2007: Impacts, Adaptations and Vulnerability*. Cambridge: Cambridge University Press.

IPCC. (2007b). *Climate Change: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth*

Krejicie, R. & Morgan, D.W. (1970). *Determining sample size for research activities.* Educational and Psychological Measurement, 30, 607-610.

Mamba, *et al.,* 2015. Perception of climate change a case study in Swaziland, Journal of food .//security. Vol. 3, No. 2, 2015, PP 47-61, 203-223): Nova science publishers.

Maddison, D. 2006. The perception of and adaptation to climate change in Africa. CEEPA Discussion Paper No. 10. Centre for Environmental Economics and Policy in Africa, University of Pretoria, South Africa.

Marin, A. (2010). Riders under storms: Contributions of nomadic herders' observations to analysing climate change in Mongolia, *Global Environmental Change, 20*, 162-176.

McSweeney, C., New, M., & Lizcano, G. (2007). *UNDP Climate Change Country Profiles-Kenya.* Oxford: University of Oxford. http://country profile.geog.ox.ac.uk

Mertz, O., Mbow, C., Reenberg, A., & Diouf, A. (2009). Farmers' Perception of Climate Change and agricultural adaptation strategies in rural Sahel. *Environmental Management, 43*(5), 804-816. doi: 10.1007/s00267-008-9197-0.

Mugalavai, E.M., (2013). Seasonal and spatial assessment of Agro-climatic parameters for Maize crop farming. Case of Lake Victoria Basin, Kenya. Unpublished Thesis. University of Eldoret.

Nyabundi, J.O. & Njoka, T.J. (1991). Impact of climate change on agriculture and forests in Africa, pp. 79-85 in: Ominde, S.H. & Juma, C. (eds). *A Change in the Weather. African Perspectives on Climate Change.* Nairobi: ACTS Press.

Nyanga, P., Johnsen, F., Aune, J., & Kahinda, T. (2011). Smallholder Farmers' Perceptions of Climate Change and Conservation Agriculture: Evidence from Zambia. *Journal of Sustainable Development, 4* (4), 73-85. http://dx.doi.org/10.5539/jsd.v4n4p73.

Ogallo, L.A. (1992). Dynamics of the East African climate. *Proc. Indian Acad. Sci. (Earth Planet Science)* 102: 203. doi:10.1007/BF02839191

Ogallo, L.J., & Ambenje, P.G. (1996). Monitoring drought in eastern Africa. WMO/TD No. 753, World Meteorological Organisation, Geneva.

Posthumus, H., Gardebroek, C., Ruben, R. (2010). From Participation to Adoption: Comparing the Effectiveness of Soil Conservation Programs in the Peruvian Andes. Land Economics, *86 (*4*),* 645–67.

Prager, K, & Posthumus, H. (2010). Socio-economic factors influencing farmers' adoption of soil conservation practices in Europe. In: Napier TL. *Human dimensions of Soil and Water Conservation.* Nova Science Publishers.

Republic of Kenya (2010). *National Climate Change Response Strategy*. Nairobi, Kenya: Government Printers.

Republic of Kenya (2010a). *State of Environment of Kenya: Effects of Climate Change and Coping mechanisms in Kenya*. Nairobi, Kenya: Government Printers.

Republic of Kenya (2012). *National Accelerated Agricultural Inputs Access programme: Implementation guidelines, work plans and Budgets.* Nairobi, Kenya: Government Printers.

Republic of Kenya (2013a). *Trans Nzoia County Development Profile: Ministry of Devolution and Planning.* Nairobi, Kenya: Government Printers.

Slegers, M. F. W. (2008). If only it could rain": Farmers' perceptions of rainfall and drought in semi-arid central Tanzania. J*ournal of Arid Environments*, 72, 2106-2123.

Smithers, J., &Smit, B. (2009).Human Adaptation to Climatic Variability and Change.In L. E. Schipper & I. Burton (Eds.), *Adaptation to Climate Change* (pp. 15-33). London: Earthscan.

Weber, E. U. (2010). What shapes perceptions of climate change? *Wiley Interdisciplinary Reviews: Climate Change*, *1*(3), 332–342. http://doi.org/10.1002/wcc.41

World Bank, (2007). *World Development Report* -2007. Nairobi: World Bank

Ajibade LT, Shokemi OO (2003) Indigenous approach to weather forecasting in ASA L.G.A., Kwara State, Nigeria. *Indilinga-African Journal of Indigenous Knowledge Systems* 2:37–44.

Bharwani S, Bithell M, Downing TE, New M, Washington R, Ziervogel G (2005) Multi-agent modelling of climate outlooks and food security on a community garden scheme in Limpopo, South Africa. *Philosophical Transactions of the Royal Society of London Series B-Biological Sciences* 360:2183–2194.