Effects of Rainfall Variability on Maize Production Among the Small-Scale Farmers in Endebess Sub County Between 2008-2018

MAIYO JONAH KIPRONO[1], DANIEL NYANTIKA[2], GEORGE TOM EKISA[3]
[1, 2, 3] *Department of Geography in the School of Arts and Social Sciences, Kisii University, Kenya*

Abstract- ***The effects of rainfall variability on maize production among small-scale farmers in Endebess Sub County between 2008-2018 are likely to be multifaceted and can have significant implications for agricultural productivity. Here are some potential effects. Insufficient or irregular rainfall can lead to fluctuations in crop yields. Maize, being a rain-fed crop, is highly dependent on adequate and well-distributed rainfall throughout the growing season. In years of below-average rainfall, there may be reduced soil moisture, affecting germination, plant growth, and ultimately leading to lower maize yields. In periods of low rainfall, water stress and drought conditions may prevail. This can hinder the normal physiological processes of maize plants, affecting photosynthesis, nutrient uptake, and overall crop development. Crop failure may lead to increased vulnerability among small-scale farmers, who often rely on their maize harvest for both sustenance and income. it is therefore imperative to understand effects of rainfall variability on maize production among the small-scale farmers in Endebess Sub County between 2008-2018. The study was based on 330 maize farmers in wards namely; Chepchoina, Matumbei and Endebess. Primary data was obtained from randomly selected farmers through questionnaires, while secondary data on rainfalls and maize production yields was collected from Kitale Meteorological Departments and Endebess Sub-County Ministry of Agriculture offices respectively between 2008-2018. The data collected was analyzed using Statistical Package for Social Sciences version 22 and Precipitations Concentration Index (PCI) values. The finding found that there was a positive relationship between rainfall variability and maize yields. The County government should put measures and policies that are aimed at protecting the forest cover. Forests help reduce the amount of carbon gas in the atmosphere, which is the main cause of climate change that normally led to rainfall variability effects. The related problems of rainfall anomalies are food insecurity, reduction of yield and increase of pest and diseases.***

Indexed Terms- ***Rainfall Variability, Maize Production***

I. INTRODUCTION

Climate fluctuation has significantly impacted food production plus extreme event. The yearly variation in climate has presented the most significant risk to food security globally. The climate variability refers to the long-term effect which lasts for periods of months (Waliser et.al., 2012). Crop production failure has been attributed to high precipitation events; floods and dry spell (Kumar et.al., 2006). This effect of weather has implication to food security. The affected region in the global world include; Europe, Australia and Brazil in Latin America. Brazil in Latin America is found in semi desert region which experience drought effects that was once an agro-ecological zone of crop production that receive bimodal rainfall pattern in October and January. The changes of climatic condition have led to acute variability effect to the region (Jose, 2007).

In Latin America, Mexico is considered to be the leading producer of maize corn at the average of 27.6 million metric tons, SIAP 2018. The entire population of the country consume the maize at the rate of 14.9 million metric tons per year. According to Abate (2015) studied the consequences of rainfall variations on agriculture. Outcome of the report show that weather variation is caused by global warming effect which is attributed by anthropogenic activities. The regional data survey of the national ENHRUM of the

household in the country show 22% of the household suffered rainfall effect, 67%, drought and 37% the flood effects. Rainfall variability was a devastating effect on the area which agriculture is predominantly rain fed and weather condition has affected their livelihood (Birhanu & Zeller, 2009).

Agricultural production is highly susceptible to variations in weather conditions and severe weather occurrences, including severe storms, flood as well as droughts (IFPRI, 2009). Climate change exerts a detrimental influence on agricultural production, particularly impacting maize farmers depending heavily on rain-dependent farming. Small-scale farmers have a critical role in guaranteeing domestic nutritional security in the country, and their dependence on rain-dependent farming as a strategy for dealing with unfavorable weather fluctuations has become increasingly limited due to the obstacles presented by climate variation (Nganga, 2006). The primary climate factors influencing crop growth include the strength and duration of precipitation, the correlation amongst yearly precipitation plus potential evapotranspiration, and the annual fluctuations in rainfall patterns (Karanja, 2007).

As per Ayoade et al. (2004), water is of utmost importance in plant productions growth. It serves as the channel by which nutrients and food are transported within the plant. Additionally, as reported by Ezedimma et al. (2007), water precipitation constitutes a significant portion of physiological plant tissues and acts as a reactant in photosynthesis. Water is essential for all metabolic processes within the plant. The agricultural industry heavily depends on predictable patterns of rainfall and temperature. Crop yields are notably affected by fluctuations in climatic conditions, which, in turn, have a profound effect on smallholder farmers livelihoods who primarily rely on rain reliant farming plus environmental resources for their sustenance (IPCC, 2012).

Sarker et al. (2012) and Kabubo and Mariara (2007) have noted that Kenyan climatical variation has led to inconsistencies in rain levels plus increased severe rain occurrences, as well as a higher frequency of erratic, dry spells, and severe events like floods, droughts, plus heatwaves. Raza et al. (2019) further emphasizes that the heightened these climatic occurrences frequency is expected to impact plant production yields in the area as outlined by the Intergovernmental Panel on Climate Change (IPCC) in 2008. Agriculture in the area is unusually prone to the complexities of severe weather conditions, not solely because it depend on rain practices but also because farming activities are predominantly oriented toward subsistence-based food production. In Endebess Sub County, maize production is primarily carried out on a small-holder basis, plus alternative other crops planted include wheat, sugarcane, beans, sunflowers, and commercial agriculture using a systematic approach. (Trans-Nzoia Strategic Plan, 2020/2021).

These small-scale maize farmers in Endebess Sub County encounter several challenges, including adverse weather conditions, rising poverty levels, and a scarcity of available water, as highlighted by the World Bank in 2009. The region boasts significant agricultural potential due to its rich alluvial soil plus there are 164 individuals living in every square kilometer, as reported by the Government of Kenya in 2019. However, this has led to heightened land fragmentation plus a decrease in corn production yields per hectare. The predominant production of corn in the area is carried out by small-holder farmers, who have pre-existing susceptibility to the effects of rain variation, as indicated by Ongoma et al. (2015). These farmers tend to cultivate the identical crop system on smaller plots of land year after year, leading to diminished soil fertility plus erosion.

Kisii county Agro-ecological zone is regarded as one of the Kenya predominant maize food store. The county involves the practice of mixed farming system where a number of cash crops are grown; maize, beans, tea and bananas. The region is considered as the hub of agricultural activities that promote millennium development goals number one and two in alleviating poverty and hunger (UN, 2012).

Ombuki (2018), studied the elements that impact the production of maize in Kisii County. Cross-sectional survey design was utilized and sampling of 10 wards. The outcomes uncovered that farmers' age, experience level and the farm inputs are numbers of attributes that affect maize production. Rain variation affects not just. maize production (Zea mays) but additionally affects alternative commercial plants cultivated in the

area, including sugarcane, wheat, and sunflower, as noted by Haerero et al. (2010). Consequently, the growing fluctuation in Endebess Sub County poses a risk to plant growth and the resulting outputs, which rely on the amount, intensity, and distribution of rainfall during the growing seasons. These fluctuations in precipitation have consequences for the quantity and quality of agricultural produce.

As per Kabubo-Mariara et al. (2007), a study was done to assess the effects of climate variation on crop agriculture. The exploration aimed to analyze impacts through crop modeling simulations, examining the biophysical adaptations to temperature stress plus water. The research assumed that farmers might not be adequately informed about available adaptation strategies. In response, this exploration sought to bridge the knowledge gap by offering actions taken to mitigate problems associated with the unpredictable nature of rain affecting small-scale farmers might encounter. (Tshuma & Mathuthu, 2014).

As per Moyo et al. (2012), both rain plus temperature exert significant Consequences for crop cultivation. Nevertheless, it's primarily rain that assumes a pivotal function in determining the distribution of plant yields. As noted by Makenzi et al. (2013), agricultural activities in tropical regions are often scheduled around rainfall amounts. Huho et al. (2012) emphasize that Sub-Saharan Africa heavily relies on rain reliant farming, that not only guarantees population's food providence but also serves as economics' growth key driver, closely following rain trends (as indicated by UNEP in 2008). Consequently, the scarcity of water plus the occurrence of severe weather events significantly impacts crop production (as highlighted by IPCC in 2007). Seasonal rain trends have delayed onsets of the long rain period, A decrease in the quantity of days with precipitation plus increased rainfall intensities, leading to disruptions in the agricultural schedule and adverse impacts on the maize production.

The impact of climate variability on small-scale agriculture has sparked discussions and deliberations among county policymakers and agricultural authorities, as noted by Harris et al. (2012Despite the predominantly adverse effects of unpredictable rainfall patterns on both human activities and natural environment (as highlighted by Mugalavai et al., 2008, and Philipe, 1998), there remains limited knowledge about The difficulties encountered by small-scale agricultural producers in their practices. Consequently, there has been insufficient attention given to the particular plant plus the climatical variability effects, particularly with regard to production of maize. This investigation aims to investigate the impacts of rain variability on maize production in Endebess Sub County.

The study carried out in west Africa by Gribbin (1975), showed that drought persisted within the Sub-Saharan Region of Africa in the early 1990s. It was responsible to the decline of crop harvest. This effect is associated with the south word shift in the climatic zone. Additionally, the northern Nigeria maize yield harvest fell from 7.65 tons in 1968 and 4 tons in 1971. The differences of maize tons were attributed by drought effects which led to reduced size of lake Chad water masses from 22000 kilometers to 6000 kilometers between the period of 1962 and 1973.

In Ethiopia, the human settlement has led to environmental degradation caused by deforestation pollution which has effect on the climate (KNAP, 1994). Climate variability in the Agro-ecological region, semi-arid region becomes increasingly erratic with shifts in frequency over a period of time and hence rainfall and temperature rises gradually. In East Africa, rainfall variability has influenced the maize production where livelihood is dependent on the rainfall. The failures of the season rainfall during the planting season is due to weather extremes (Omoyo, 2015).

Understanding the observed consequences of fluctuations in rainfall on maize by small-holder farmers has the potential to inform planning strategies to mitigate and adapt to different sectors of society that may be vulnerable to shifting climate patterns, as pointed out by Preston et al. (2013). This knowledge can help address the current and future agricultural requirements in specific agro-ecological zones in Kenya, where livelihoods are closely tied to the performance of rainfall.

II. MATERIALS AND METHODS

The study adopted descriptive and correlative research design using both qualitative and quantitative approaches. The target population was Endebess Sub-County had 2000 farmers registered in the Sub-County (Sub County Agriculture office by 2018). Small scale maize farmers were preferred more so because they major in the maize crop production. A sample of 330 was selected from the study population for data collection purposes. The study administered questionnaires to collect information from maize farmers in the ground field. The study obtained secondary data on maize yields, rainfall amounts from the Ministry of Agriculture office at Endebess Sub-County, Kitale Meteorological Departments in respective offices between 2008 and 2018. Other data included the shape of study, site extracted from the County Map of Trans Nzoia were used. Validity of instrument was determined by circulating the research tool to the supervisor and other experts in the field of research to evaluate the item objectivity of the questionnaires that were used inthe study. The study used test-retest method to determine reliability of the instrument. The analysis of data utilized both descriptive and inferential statistics and results presented in the form of a table percentages, charts and graphs.

III. FINDINGS OF THE STUDY

The second objective of this study was to examine effect of rainfall variability on maize production in Endebess Sub County and determine the extent, magnitude effects and occurrences. To achieve the objectives, the researcher interviewed the respondents by asking questions whether they had perceived the changes in rainfall patterns in the last decade as from 2008 – 2018 in the region. The respondents' views were as follows: -

Table 4.15: Respondents' perceptions on Changes in Rainfall Patterns

Responses	Frequency	Percentage
Yes	292	88.4
No Change	29	8.8
Don't know	9	2.8
Total	330	100

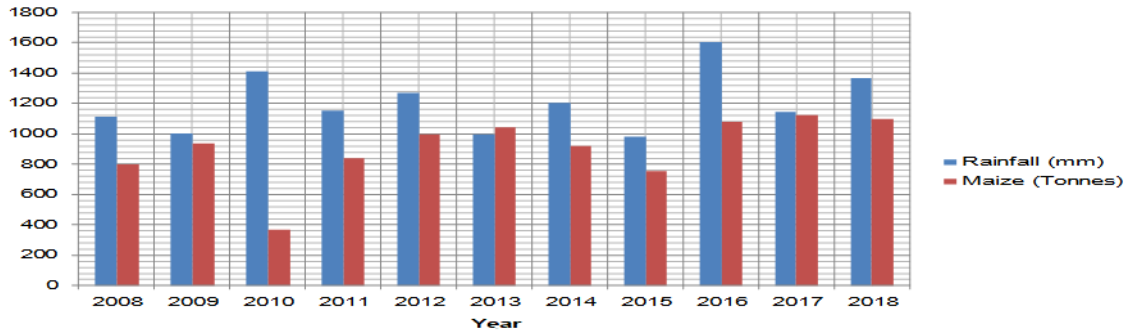
Source: Field data 2022

The results exhibited that most respondents, 292 (88.4%) agreed that changes in rainfall patterns have been noticed in the last ten years in the study area, as compared to minority of respondents of 29 (8.8%) and 9 (2.8%) who disagreed to the view that rainfall changes patterns had been observed. The study assessed farmers' perceptions on the effects of rainfall variability on food production on rain fed agriculture in Kenya. Reporting similar findings, (Mugalavai et al., 2011 & Adamgbe et al., 2013).

The respondents' perceptions indicated that rainfall variability was the likely indicator in the decline of water levels in rivers due to high temperatures and increases of population density that put pressure on the land use in the study area. The key informants' results indicated that climate changes have contributed to changes to rainfall patterns and amounts. The respondents perceive changes in precipitations as associated to changing the environment that is linked to reduction of forest cover, river water volumes capacity, delay of rainfalls and frequency of dry spells. The majority of interviewed key informants, linked the changes in precipitating patterns to climate change that is attributed by many factors like, Meso scale factors, changes of ITCZ winds, while the older farmers above 60 years, felt that changes in weather variations could be the results of disregard of early warming weather indicators.

- Effects of Rainfall Variability on Maize Production

The annual rain (mm) changeability plus maize yields (tones) in Endebess Sub County between 2008–2018 were computed using the bar graph as shown.



Source: Kitale meteorological/ Endebess Sub-County Agriculture office 2022

Figure: Effects of rainfall variability on maize production

Figure 4.11 shows that correlation of total annual rainfalls amount (mm) versus maize yields (tonnes) from 2008 – 2018 the findings appear that there is constant increase in rainfall compared to maize yields (tonnes). The total rainfalls recorded was13246.8mm and 9962 tonnes of maize yields recorded. The trends of two variables shows the increasing and decreasing slope. The highest rainfalls amount was 2016 (1607mm) and lowest was 2015 (980mm) while the maize yields (tonnes) 2010 (369 tonnes) and 2015 (756tonnes) respectively.

This finding shows that rainfalls continue increases and the additional again in the maize yields begin to diminish level. This situation happens due that rainfall amount is above the optimal and might result to water logging and affected maize productions as ascertained in 2010 (1411.7mm) and maize yield was 369 tonnes. These findings show that rainfalls continue increasing and maize yields is decreasing slope. This situation happens due that rainfall amount is above the optimal level. According to Adamgbe et al. (2013) findings shows that high rain variations has effects on maize yield changeability in Benue State of Nigeria. However, other factors like the changes in seasonal precipitation patterns may results to low yields of maize despite the factor that rainfall amounts are high. Apart from rainfall variability there are other variables that influences maize production, temperature and soil type. The growing temperature led to evapotranspiration rate rise hence making the maize crop to be unable to reach its maturity due to insufficient moisture in the soil level and hence resulted to losses of yields.

Table 4: Farmers Opinion in on effects of rainfall variability on maize productions

	Yes		No.	
Variables	No. of Respondents	%	No. of Respondents	%
Increased of crop pest and diseases	263	79.6 %	67	20.4 %
Reduced of crop yields	188	57%	142	43%
Delays of planting and harvesting	307	93%	23	7%
Reduced of water availability in soil	178	54%	152	46%
Increased of crop failures	264	80%	66	20%
Increased of crop yield	10	3%	320	97%
Increased of weed	17	5%	313	95%

Source: Field data 2022

The outcomes presented in Table 4.14 provide a summary of the responses from the interviewed respondents in the region. The vast majority of farmers, constituting 93%, expressed concerns about delayed planting and harvesting, while 57% of them identified reduced crop yield as a significant and challenging issue. The delay in planting and reduce of crop yield is correlated to one another.

The study's discoveries align with research done by Moyo et al. (2012) in Zimbabwe, where they observed the climatical alteration impacts on agricultural production. They uncovered that climate changes led to alterations in agricultural production, including a decline in crop yields due to delayed rainfall onset. Farmers were forced to plant their crops in subsequent seasons, which resulted in reduced crop production. These outcomes are in line with the findings of Jokastah et al. (2013), who studied smallholder farmers in East African semi-arid regions. Their research revealed that variations in rainfall, including dry spells, coupled with other factors like floods and drought, led to a decrease in crop yield. Furthermore, the outcomes of the study coincide with the research by Huho et al. (2012), which investigated varying rain trends and the impact on subsistence farming in Laikipia East Sub County over a 15-year period. Their findings indicated that shifts in rainfall patterns disrupted farming activities, resulting in crop failure due to severe weather settings like drought. This, in turn, led to reduced water availability in the root zone, which is reflected in your study's results (54% and 80%, respectively).

The respondents were asked to rate the magnitude of rain changeability in the region as witnessed in the last ten years. They indicated the results as follows; 76.9%, 57% and 54% of the respondents showed as follows; increase of plant pests plus diseases, diminished crop harvests..., and reduced water availability. However, some effects were perceived to be less magnitude in the study area. These include, increased yields and increased weeds.

The key informants interviewed also supported the above findings. They include, increased crop pest and diseases, increased weeds and reduction of yields. This is contributed by the changes in climatic conditions which leads to changes in rainfall patterns and hence bring effects. While the IPCC 2007, supported the findings that climate variability induced the favorable conditions for pest and diseases to multiply in numbers due to the rise in temperatures.

This is preferable by certain insects and pests which grow and multiply, for instance the stalk borer insect survive in high temperature condition. The decline in maize production may be due to delayed rains plus the dry spells occurrence. Dry spells lead to water stress in maize plants, and water availability is a critical factor for maize yield productivity. It is essential for maize development that there is an adequate supply of moisture in the root zone. The lack of sufficient water during critical growth stages can significantly impact maize crops and result in reduced yields. Water crisis during grain filling stage cause reduction of yields, concurs with (Basir et al., 2018).

This study finding coincides with Rao Moyo and Mudzonga (2012) who performed the study in Zimbabwe and found out that majority of farmers perceived the long-term rainfall changes was linked to climate changes, which resulted to changes in rainfall patterns and temperatures. This result was also in line with Bweket (2009) who assessed the impacts of rainfall variability and crop productions and observed that the changes in crop yield was attributed to natural and human factors.

CONCLUSION

The study established that there was seasonal rainfall variability within the period of study (2008 - 2018) hence, concludes that, there is a significant positive effect between rainfall variability and maize production in Endebess Sub County Kenya.

RECOMMENDATION

The County government should put measures and policies that are aimed at protecting the forest cover. Forests help reduce the amount of carbon gas in the atmosphere, which is the main cause of climate change that normally led to rainfall variability effects. The related problems of rainfall anomalies are food insecurity, reduction of yield and increase of pest and diseases.

REFERENCES

[1] Adamgbe, Emmanuel & Ujoh, Fanan. (2013). Effect of Variability in Rainfall Characteristics on Maize Yield in Gboko, Nigeria. *Journal of Environmental Protection*. 4. 881-887. 10.4236/jep.2013.49103.

[2] Raza, A., Razzaq, A., Mehmood, S. S., Zou, X., Zhang, X., Lv, Y., Xu, J. (2019). Impact of climate change on crops adaptation and strategies to tackle its outcome: A review. plants (Basel). 30;8(2):34. doi: 10.3390/plants8020034. PMID: 30704089; PMCID: PMC6409995.

[3] Ayoade, J. O. (2004). *Introductions to climatology for the topic 2nd Editions.* Spectrum Books Limited, Ibadan.

[4] Abate, T, Shiferau , B., Menkir, A., Wegary, D., Kebede, Y., Tesfaye, K., Kessie, M., Bogale, C., Tadesse, T, (2015). Factro Transformer maize production in Ethiopia Fund Security T, 965-981

[5] Basir, A., Aziz, A., Akhan, M. A., Khan, L. (2018). *Phenology and growth traits responses of maize Zea mays L) genotypes*.

[6] Birhanu, A., Zeller, M, (2009). *Estimate of rainfall shock on smallholder foods and security and vulnerability in rural Ethiopia.* Economic and police discussion paper No.2

[7] Ezedinma, C. I., Kormawa, P. M., Manyong, V. M., Dixon, A. G. O. (2007). Challenges, opportunities and strategy for cassava sub sector development in Nigeria. Proceeding of the 13 th ISTRC Symposium. p. 627-640.

[8] Gribbin, B. (1975). *Agriculture in the school*. London. Emerald Publisher Ltd.

[9] Herero, M. C., Ringler, C., Vande Steag, J., Thorton, P., Zhu, T., Bryan, E., Omolo, A., Koo, J. & Baert, A. (2010). *Climate variations and climate change and the impacts on the Agricultural Sector ILRI reports to the World Bank for the Project Adaptations to climate change of smallholder agriculture in Kenya*. Government Printer.

[10] Huho, J. M., Ngaira, J. K. Ogindo, H. O., & Masayi. W. (2012). The changing rainfall patterns and associated impacts on Subsistence Agriculture in Laikipia East District Kenya.*Journal of Geography and Regional Planning*, 5 (7), 198 – 206.

[11] IFPRI, (2009). *Climate change impacts on Agriculture and Coast Adaptations*. Washington DC 2006, 1002 USA.

[12] IPCC (2012). *Managing the risks of extreme events and disasters to advance climate change Adaptations.* A special report of working groups I and II of the intergovernmental panel on climate change, Cambridge University Press.

[13] Jokastah W. W. Leah Fillow & Haris D. (2013). Smallholder farmers' perceptions of the impacts of climate change and variability on Rain fed Agriculture practices in semi-arid and sub-humid regions of Kenya. *Journal of Environmental and Earth Sciences,* Vol. 3 No. 7; 2013.

[14] Jose, N. (2009). *WWW.Teafund*, footsteps in agriculture and climate change, Vol 3 Pg. 21-45

[15] Kabubo, M. J., & Karanja, F. K. (2007). The economic Impacts of climate change in Kenya and Agriculture Aricardian Approach. *Global and Planetary Change*, 57, 319–330.

[16] Karanja, M, (2006). The economic impact of climate change on Kenya Crop Agriculture policy research working paper. Pg 4334

[17] KNAP, (1994). Agriculture research. vol 2(6) pp173-182.

[18] Kumar Deepak & Kalita, P, (2017) reducing post-harvest loses during storage of grains crops to strengthen food security in developing countries foods.

[19] Makenze, P. Omondi, P, Maranga, E, & Wekesa C, (2013). Trend Analysis of climate change and its impacts on crop productivity in the lower Tana River Basin Kenya, Journal of environmental Research, Vol 1 (4) pp 237-248.

[20] Mugalavai, E. M., & Kipkorir, E. C. (2013). Assessing the potential of maize growing seasons for Western Kenya using Agro-climatic indices. *International journal for Disaster Managements and Risk Reductions*, 5 (1) 53 – 73.

[21] Nganga J. K. (2006). climate change impacts vulnerable and adaptations assessments in East Africa. Proceedings of the United Nations framework conventions on climate Change

Africa Regional workshop on adaptations Accra, Ghana 21-23 September 2006.

[22] Ombuki, C. (2018). Factors influencing maize production in Rural Kenya "case of Kisii county" *International journal of commerce and art*, 7(6), 1-15.

[23] Ongoma, V. Chen, H., & Omony, G. W. (2016). Variability of extreme weather events over the equatorial East Africa. Case Study of rainfall in Kenya and Uganda. *Journal of Theoretical and Applied Climatology.* Dol. 10.1007 100704 – 016 – 1973 – 9.

[24] Omoyo, M. (2015). Effects of climate variability on maize yield in the Arid and semi-Arid lands of lower Eastern countries of Kenya. *Agriculture and Food Security Journal*, Vol 4 pg 14-15.

[25] Moyo, M., Mvumi, B. M., Kunzekreguta, M., Mazimari, K., Crauford, P., & DOrward, P. (2012). Farmers perceptions on Climate change and variability in Semi-Arid Zimbabwe in relation to climatology Evidence Africa. *Crop Sciences Journal*, 20(2) 317 – 335.

[26] Philips, J., Makudze, E., Ungamai, L., Makardho, & Cake, M. (1999). *Current and potential use of climate forecasts for farm managements in Zimbabwe.* Paper presented at the Society for Applied Anthropology Meeting Tuscon AZ.

[27] Preston, B, L., Yuen, E. J., & Westaway, R. M. (2013). Putting vulnerability to climate change on the map a review of approach benefits and risks. *Sustainability Science,* 6(2),177-202.

[28] Rao, K. P. C. Ndegwa, W. G., Kizito, K. & Oyoo, A. (2011). Climate variables and change. Farmer perception and understanding of intra seasonal variability in rainfall and associated risk is semi-Arid Kenya. *Experimental Agriculture*, 47, 267-291.

[29] Saker. A. G. (2012). Effect of climate change in food losses threat to food security in Turkey *Agricultural system*, Vol. 112, p 11-16.

[30] Tshuma, N., & Mathuthu, T. (2014). Climate change in Zimbabwe perceptions of smallholder farmers in Mangwe District. *International journal of Humanities and social studies*, 2 (5), 318-325.

[31] UN, 2012

[32] UNEP (2008). *Climate change Adaptations and Mitigation What Organization are during institutes for Law and environment Governance.* Nairobi, Kenya.

[33] Waliser, D. E., Moncrieff, M. W., Burridge, D., Fink, A. H., Gochis, D. S., Goswami, B. N. & Jakob, C. (2012). The year of tropical convection (May 2008 – April 2010) climate variability and weathers highlights. *Bulletin of the America metrological society*, 93(8), 1189-1218.