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Community Livelihoods and the Changing Weather Patterns: A Case for the Maize Crop Performance in the Lower AthiRiver Basin, Kenya

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Abstract

Background: This study was carried out in the lower AthiRiver Basin, in the coastal region of Kenya. Weather patterns in the study area have become very variable over the years. Specifically, rainfall has become quite erratic,spatially and in temporal terms. The temperatures have remained higher over the years hence affecting local community livelihoods. The aim of the study was to establish how the changing weather and climatic patterns have affected livelihoods and specifically crop farming with special reference to the maize crop yield. Maize is the staple food in the study area and low yields can immediately translate into poverty and food insecurity. The specific objectives include: i) to establish the trend of maize crop yield in lowerAthi River basin over a period of 37years; ii) to determine the effect of overall and effective rainfall on crop yield; iii) to determine the effect of temperature on crop yield; iv) to establish the combined effect of rainfall and temperature on maize crop.

Materials and Methods: Retrospective longitudinal research design was used to obtain historical data for analysis. Data was analyzed using descriptive and inferential statistics. Specifically, the study used measures of central tendency, measures of dispersionas well as correlation and regression.

Results: The results showed varying trends and correlation between climate, (rainfall and temperature) and crop yields. In the period 1975 to 2014, crop production in the lower Athi River Basin (with an exception of 1987 and 1998 where the crop yield was exceptionally low figures) recorded a higher crop yield (mean = 795.14, sd = 280.809). Correlations between crop yield and overall rainfall was not significant. However, correlation between effective rainfall and crop yield was significant where r=0.534495 and p value of 0.0005843, correlations were significant at the 0.05 level, (2-Tailed). There was a significant linear relationship between maize crop yield and temperature, Pearson Product Moment correlation was calculated which was statistically significant at 5% level of significant($R = -0.6295$, $t = -6.875$, $df = 72$, $p\,value = 0.000$). The 95% confidence interval of the correlation coefficient was (-0.7501, -0.4684). Hence, there was a negative strong linear relationship between temperature and crop yield. The results show that temperature affects crop yield in that at 5%, temperature is statistically significant predictor to crop yield, ($t = -6.875$, $pvalue = 0.000$). The negative relationship indicates that a unit increase in temperature reduces the crop yield by a margin. It shows that the higher the temperature the lower the crop yield, other factors being constant. The figures suggest a relationship among the study variables of temperature, rainfall and crop yield.

Conclusion: There seems to be a general consensus that weather variability and climate affect maize crop yield and in general community livelihoods. There is urgent need for stakeholder involvement in agriculture, awareness creationand the intensified adoption of climate smart or precision agriculture to reduce the impacts of weather variability and climate change on crop yields for sustainable livelihoods in the study area.

Key Words:Climate Change, Weather Variability, Correlation, Livelihoods, Climate Smart Agriculture, Precision Agriculture

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I. INTRODUCTION

This study examines the effect of weather variability and climate change on the yield of maize crop as a livelihood option for the local communities in the lower Athi River basin. It has generally been observed that the weather patterns globally and locally in the current study area are changing. However, the exact locations where the weather variability and climate change has occurred or intensified is not always obvious. Also where such changes might have occurred, the effect and impact of such changes vary spatially and in temporal terms. There is therefore need to carry out studies in different parts of the world, the current study being one of them in order to ascertain the local situations. An over view of climate change and livelihoods, including crop yields is given between the lines. Livelihoods encompass a variety of occupations and activities that are usually repeated for subsistence purposes. Climate change has had adverse effects on local livelihoods including crop yields and livestock farming thereby threatening the very socio-economic base that communities rely on (Schlenker& Lobell, 2010; Marco, 2009; 2010). Crop production has been adversely affected in that staple foods like maize no longer offers increased yield as it was in the past three to four decades (Schlenker& Lobell, 2010; Garutsa, et al, 2018). The Athi River basin suffers from erratic rains and high temperatures hence the concern on livelihoods in relation to crop yields. For sustainable livelihoods, there is need to establish the trend of rainfall and temperature for informed decisions and policies. Literature exists on the relationship between climate change and weather variability on livelihoods from different parts of the world. In China for example, a study carried out by Liu, et al, (2013) on maize production in north east China confirmed that climate change and weather variability affected maize crop yield and that the yield went down due to its susceptibility to climate variability (Liu, et al, (2013). The effects of climate change and climate variability have resulted in low yields of staple food such as rice and water scarcity (Ford, et al, 2012). In sub-Saharan Africa studies have confirmed variability in crop yields as changes in climate manifest themselves (Cooper, et al, 2008). Accelerated climate change has had an impact on the Yak herding livelihoods in the eastern Tibetan plateau. The region has experienced increasing temperatures and erratic rainfall patterns that have adversely affected the community's herding practices resulting in food insecurity in the region, (Haynes, et al 2014). The Athi River Basin has undergone similar experiences hence the need for further research to establish the rainfall and temperature patterns in relation to the community livelihoods. The changes in climatic conditions have also affected soil fertility prompting relocation, (Reilly et al, 2003).In the Sub-Saharan Africa including Kenya, climate change has negatively affected livelihoods (Liette& Barry, 2015). Food security has not been attained by many African countries that have also experienced water shortages, (Connolly-Boutin, & Smit ,2016). This has resulted in poor crop yields, (Laux, et al, 2010). Climate change has also resulted in food insecurity manifested in the form of malnutrition, famine, migration and inter-ethnic tensions, (Kotir 2011). Climate change therefore makes the realization of Millennium Development Goals, (MDGs) and/or Sustainable Development Goals, (SDGs) a challenge, (Le Blanc, 2015). Kenya's 2010 constitution and the Vision 2030 Agenda all advocate for sustainable livelihoods. This can only be achieved through policies and institutional frameworks informed by research.

II. MATERIALS AND METHODS

Study Design: Retrospective longitudinal research designwas used to establish the trend and variations in crop yield in the study area over the years. This design allows the investigator to formulate ideas about possible associations and investigate potential relationships without necessarily confirming casual factors.

Study Location: The study was carried out in the lower Athi River basin in in the coastal region of Kenya. The longitudinal and latitudinal extent of study area is 3°37′49″S - 2′3° S and 39°50′59″E. The choice of the study area was influenced by the magnitude of the impacts associated with climate change and weather variability. The effects of climate change and weather variability affects livelihoods, hence the need for research and recommendation on strategies to address the impacts.

Study Duration: January 2014 to March 2015

Research Variables: The dependent research variable was maize crop yield, while independent variables were weather elements of temperature and rainfall as observed over a longer period of time.

Sampling Methods: The study used non-probabilistic sampling method, that is purposive sampling technique was used to identify the study area andkey informants. This sampling techniques was used because it allows researchers to get information that are relevant to the study and hence, makes it possible to handpick for qualities in line with study objectives (Creswell, 2003). A sample of 25 key informants from line ministries were enlisted for the study to generate data on policy and institutional frameworks.

Procedure Methodology

Data was obtained from both secondary and primary sources. Primary data was obtained through key informant interviews.Secondary data included crop yield and weather and climatic elements of temperature and rainfall. Crop data was obtained from county and sub-county agricultural offices and agricultural research centers. Meteorological data (rainfall and temperature) was obtained from field stations in the study area and from relevant online data centers. The main meteorological stations included Msabaha and Mtwapa all located in the coastal region of Kenya and within the vicinity of the study area. Additional secondary data was also obtained from relevant government and local offices through document search (records), content analysis and desktop reviews.

Statistical Analysis: Data analysis was done using both quantitative and qualitative statistics. Qualitative data was organized into themes and presented accordingly. For quantitative data, descriptive statistics were used to calculate average values and to establish trends in rainfall, temperature and crop yields. It also involved the use of correlation and regression to give summary statistics for the variables considered in the study. The main statistical and data analysis tool or software used was Microsoft Excel. The results were presented in thematic and graphical forms.

III. RESULT

Maize crop performance

Maizecrop yield (performance) in the study area in the period between 1975 to 2014 shows that crop production in the lower Athi River basin (with an exception of 1987 and 1998 where the crop yield was exceptionally low figures) recorded a moderate crop yield *(mean = 795.14, sd = 280.809)*. The mean values however conceal great fluctuations in crop yield based on climate and weather patterns. The crop yields are low compared to expected yields in the study area which is about 1.4 to 1.8 Tonnes per acre. The varieties of maize crop suitable for the study area are PH1 and PH4. These varieties grow in lowland agro-ecozones. PH1 is expected to yield 20 x 90kg bags per acre, or 1.8 Tonnes per acre on average, while PH4 is expected to yield 15 x 90kg per acre or 1.4 Tonnes per acre on average. These maize varieties are referred to as Pwani Hybrids. The results from this study are therefore far much below the expectations. The communities in the study area depend on maize as a staple food hence the low yields translate to insecurity in terms of food available.

Relationship between temperature and maize crop yield

The objective for this section was to determine the relationship between temperature variations and maize crop yield. To check whether there was a significant linear relationship between maize crop yield and temperature, Pearson Product Moment correlation was calculated which was statistically significant at 5% level of significant($R = -0.6295, t = -6.875, df = 72, p\,value = 0.000$). The statistics indicate that there is a relationship between temperature and crop yield. The 95% confidence interval of the correlation coefficient was (-0.7501, -0.4684). Hence, there was a negative strong linear relationship between temperature and crop yield. The results show that temperature affects crop yield in that at 5%, temperature is statistically significant predictor to crop yield, ($t = -6.875, pvalue = 0.000$). The negative relationship indicates that a unit increase in temperature reduces the crop yield by 68.013. It shows that the higher the temperature the lower the crop yield, other factors being constant.

The summary statistics is given below:

Pearson's product-moment correlation data:
Yield and Temperature
t = -6.875, df = 72, p-value = 1.877e-09
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
-0.7501260 -0.4684114
sample estimates: cor -0.6295306

Simple linear regression model was used to determine whether temperature was significantly contributing to the yield. The analysis checked and confirmed that there were no major influential points. Normality Assumption was assessed using QQ plot, Figure 1. Assessment of the normality assumption of data using QQ plot shows that the data was approximately normal. In terms of the distribution of residuals using Residuals Fitted Plot, the residuals plot shows that the residuals are centered around zero and do not seem to violate the homoscedasticity assumption. The summaries are given below:

The Linear Model: $Yield = 2824.872 - 68.013\ Temperature$
Model is significant (F =47.27 , p-value = 0.000)
Variation accounted for by temperature is 38.8%
Residuals:
Min 1Q Median 3Q Max
-774.48 -112.42 56.58 125.57 465.52
Coefficients:
Estimate Std. Error t value Pr(>|t|)
(Intercept) 2824.872 320.873 8.804 4.85e-13 ***
Temperature -68.013 9.893 -6.875 1.88e-09 ***
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 213.7 on 72 degrees of freedom
Multiple R-squared: 0.3963, Adjusted R-squared: 0.3879
F-statistic: 47.27 on 1 and 72 DF, p-value: 1.877e-09

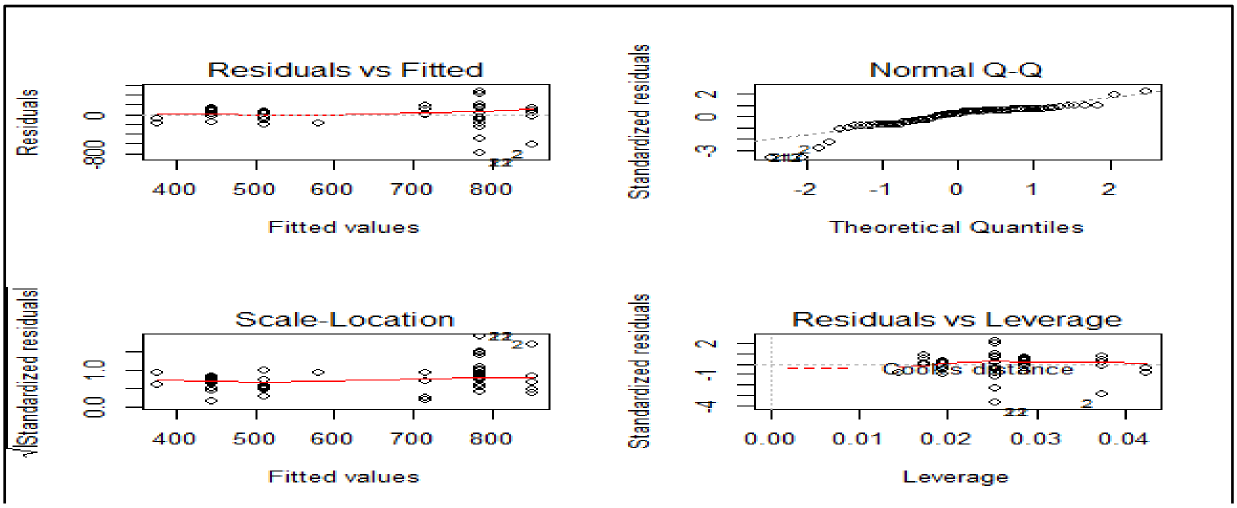

Figure 1: QQ Plot for Normality Assumption Assessment

Relationship Between Overall Rainfall and Crop Yield

The objective of this section was to determine the relationship between overall rainfall variations within selected time-frame towards crop yields as a means of livelihood in the lower Athi River basins along the Kenyan coast.To check whether there was correlation between rainfall and crop yield, Pearson's Product-Moment correlation was used to establish the relationship between rainfall and crop yield. The results indicate that at 95 percent confidence interval, the relationship is negative. There is a weak negative relationship between rainfall and crop yield (-0.05944245). The relationship is not significant hence overall rainfall is not a good predictor of crop yield. The statistics are given below:

Correlation Between Overall Rainfall and Crop Yield
Pearson's product-moment correlation
data: Yield and Rain
t = 1.4761, df = 72, p-value = 0.1443
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
-0.05944245 0.38481317
sample estimates: cor 0.1713841
Linear Model Between Rainfall and Crop Yield
Residuals:
Min 1Q Median 3Q Max
-618.08 -170.55 -46.97 227.19 581.35
Coefficients:
Estimate Std. Error t value Pr(>|t|)
(Intercept) 506.87192 86.30156 5.873 1.22e-07 ***
Rain 0.12522 0.08483 1.476 0.144

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
Residual standard error: 270.9 on 72 degrees of freedom
Multiple R-squared: 0.02937, Adjusted R-squared: 0.01589
F-statistic: 2.179 on 1 and 72 DF, p-value: 0.1443

The Relationship Between Effective Rainfall, Seasonal Rainfall and Crop Yield

Effective rainfall or precipitation is that amount that is actually added to the soil during rainfall episodes. It is the difference between total or overall rainfall and actual evapotranspiration and runoff or overland flow. It is the rainfall that eventually become available to crops for growth. Seasonal rainfall is part of the overall rainfall that falls in a given season, for example, during the short or long rainy periods and whose totals give overall annual rainfall for a particular place. In order to confirm the relationship between rainfall and crop yield, further analysis was done using seasonal rainfall, effective rainfall and crop yield to establish whether there are differences with the results from overall rainfall. This move was occasioned by the fact that studies have confirmed positive relationships between effective rainfall and crop yields, (Shahzada&Azmat, 2014).

Regression Curve Estimation, (Crop Yield, Effective and Seasonal Rainfall)

When effective rainfall was regressed for rainfall and crop yield, positive trends were observed. Regression curve estimation of crop yield and rainfall is also positive for both seasonal and effective rainfall. When effective and seasonal rainfall were correlated with crop yield, the results show that correlation is significant at 0.05 levels, (2-Tailed). The 2-tailed test is useful when the direction of the relationship of variables cannot be determined in advance especially in exploratory data analysis as in the current study, Figures 2 and 3.

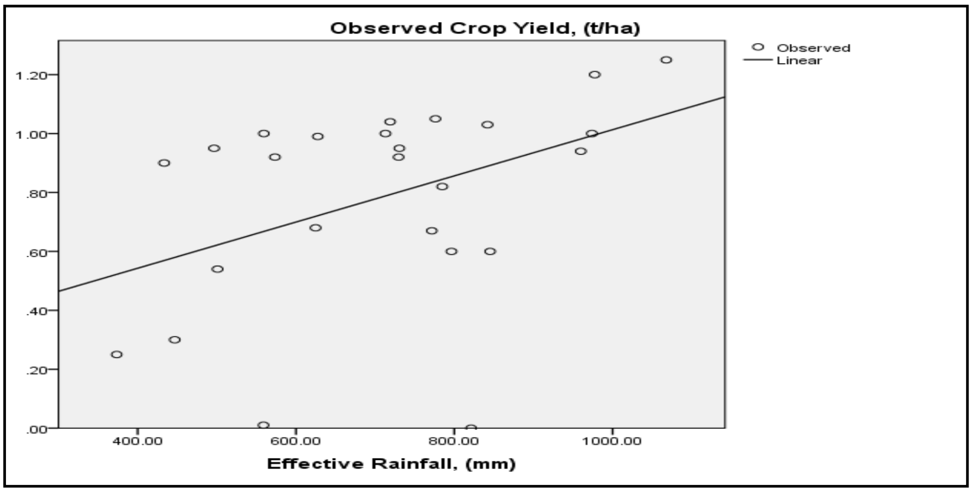

Figure 2.: Regression Curve Estimation for Crop Yield and Effective Rainfall

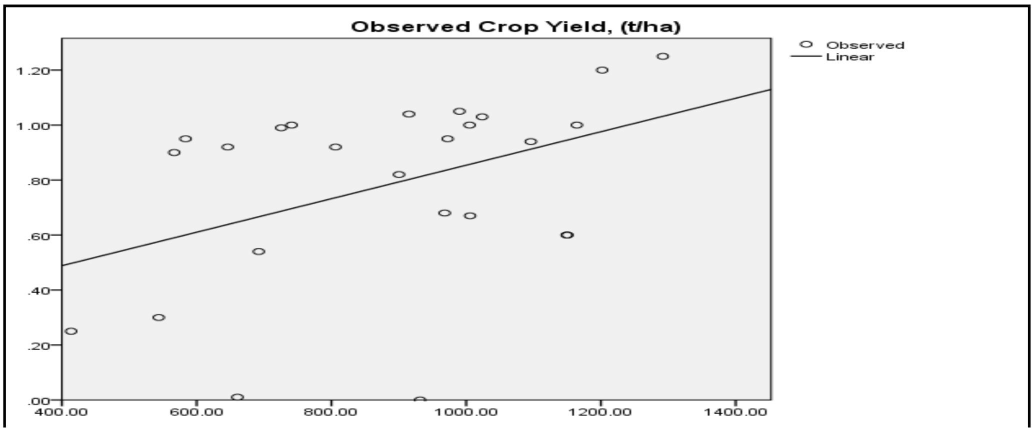

Figure 3: Regression Curve Estimation for Crop Yield and Seasonal Rainfall

The results show that there is a positive relationship between effective and seasonal rainfall with crop yield. Crop yield and seasonal and effective rainfall had the following results: r= 0.433805 and 0.534495 respectively. This confirms that indeed, effective rainfall has a stronger positive correlation with crop yield.

Regression results for seasonal rainfall and crop yield were significant having given a p-value of 0.040941. On the other hand, regression results for effective rainfall and crop yield was more significant with a p-value of 0.0005843. The summary results are given below:

Regression Statistics for the Relationship between Seasonal Rainfall and Crop Yield

Multiple R	0.411574868
R Square	0.169393872
Adjusted R Square	0.133280562
Standard Error	315.9994005
Observations	25

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	468384.9	468384.9	4.690622	0.040941
Residual	23	2296679	99855.62		
Total	24	2765064			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	282.2189818	242.1236	1.165599	0.255723	-218.652	783.0897	-218.652	783.0897
900.3	0.578687695	0.267195	2.165784	0.040941	0.025952	1.131424	0.025952	1.131424

Regression Statistics for Relationship Between Effective Rainfall and Crop Yield

Multiple R	0.535138036
R Square	0.286372718
Adjusted R Square	0.255345445
Standard Error	292.9034018
Observations	25

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	791839	791839	9.22971	0.005843
Residual	23	1973225	85792.4		
Total	24	2765064			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	114.5810377	229.4082	0.499464	0.622197	-359.986	589.148	-359.986	589.148
784.8	0.965202055	0.317705	3.038044	0.005843	0.307979	1.622425	0.307979	1.622425

Combined Effects of Rainfall and Temperature on Crop Yield

The results from analysis of combined effects of rainfall, temperature and crop yield show that both rainfall and rainfall contribute in influencing crop yield. There is however marginal effect of temperature adjusting for rainfall. The statistics are given below:

Linear model: Effect of Rain Adjusting for Temperature

Residuals:

Min	1Q	Median	3Q	Max
-774.45	-114.82	51.19	136.97	433.99

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	2704.07820	328.85776	8.223	6.46e-12	***
Rain	0.09741	0.06650	1.465	0.147	
Temperature	-67.13090	9.83344	-6.827	2.44e-09	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 212 on 71 degrees of freedom

Multiple R-squared: 0.414, Adjusted R-squared: 0.3975

F-statistic: 25.08 on 2 and 71 DF, p-value: 5.753e-09

Key Informant Observations

Key informant interviews revealed that the line ministries have put in place mechanisms to monitor climate change and weather variability. Crop productions falls under the Ministry of Agriculture which has equally put in place policies and mechanisms to address challenges in crop production. Other key organizations include National Drought Management Authority and Kenya Meteorological Department, among others. The Kenya government has also put in place climate change policies and institutions to address climate change, weather variability and associate disasters.

IV. DISCUSSION

Maize is the staple food for a large percentage of the indigenous coastal communities in the study area. Different varieties of maize are recommended for different livelihood zones. The yield per hectare for the different varieties has also been established. The varieties suitable for the study area are PH1 and PH4. These varieties grow in lowland agro-ecozones. PH1 is expected to yield 20 x 90kg bags per acre, or 1.8Tonnes per acre on average, while PH4 is expected to yield 15 x 90kg per acre or 1.4Tonnes per acre on average. The results on crop yield shows lower yields compared to what is expected. Hardly did the yields approach the expectations as majority were below 1000Toness per acre.

The study has confirmed that rainfall and temperature variability affects crop yield. Higher temperatures result in low yields. Any future increase in temperature in the study area will affect crop yields adversely, other factors remaining constant. The results show negative correlation between overall rainfall and crop yield. Agriculturalists consider that portion of total rainfall as effective when it directly satisfies crop water needs as well as surface runoff which can be used directly for crop production on their farms or by being pumped from water collection points such as water pans or dams. A percentage of water is lost when it rains through interception by leaves of plants, or that which is lost through evapotranspiration, or from evaporation from soil. Part of the water is lost through percolation, leaching and infiltration beyond the plant roots. In the field of agriculture therefore, soil types, cropping patterns, socio-economic and management factors all have direct impact on the extent of effective and ineffective rainfall. The agronomic practices including the quality of seeds, and technologies used are also factors to be considered. Policies should be directed towards adaptation and mitigation to climate change. Improved soil water management resulting in effective rainfall that enhances crop yield should be encouraged.

Even though rainfall is not showing a positive correlation with crop yield, the contribution of rainfall towards crop yield cannot be ignored totally. The correlation figures for overall rainfall and crop yield are low perhaps due to the great variability of rainfall in the study area and the use of overall rainfall figures not taking into consideration total losses due to deep percolation and stored rainfall. This is indicating that it is difficult to correlate erratic rainfall patterns with crop yield. When the rains are too much, floods occur and crop are washed away and hence destroyed. When there is scanty of rainfall, this again affects crop yield. The start of short and long rains, when the rains end (either abruptly or prolonged or in good time), how the rainfall was distributed during the entire growth period, from planting, germination, flowering to maturity, how adequate the rainfall was, land preparation and soil management procedures, whether the farmers adopted climate smart agriculture or not are among the issues that could make it difficult to achieve a positive correlation between rainfall and crop yield. The use of technology including farm machinery and geospatial tools such as GPS and Unmanned Aerial Vehicles could also influence crop productivity. Others include management of harvest to minimize waste and security of the crop towards harvesting period. However, whether the rains are too much or too little, the most important issue to consider is the effectiveness of that rain. How much is used by plants considering soil and water management practices. On the other hand, temperature variations require specific interventions I farm management to ensure adequate soil moisture for plat growth.

V. CONCLUSION

Maize is a staple crop among communities in the study area. When the crop performs poorly the local communities in the study area face shortage of food hence insecurity. The population in the study area have been marked for relief food quiet often due to poor performance of the staple crops. Challenges facing maize farming in the study area include climatic hazards and especially floods and drought which lead to destruction of the crop and eventual poor yields and hence reduced income to the farmer. The other problems include high cost of production (cost of farm machinery and fertilizers is high); pests and diseases as well as monoculture. Farmers in the study area also practice prolonged and repeated planting of maize leading to exhaustion of soil.

REFERENCE

[1]. Creswell, J.W., (2003): Qualitative, Quantitative and Mixed Methods Approaches. SAGE Publications, London

[2]. Connolly-Boutin, L., & Smit, B. (2016). Climate change, food security, and livelihoods in sub-Saharan Africa.

[3]. Regional Environmental Change, 16(2), 385-399.

[4]. Ford, J. D. Lea Berrang-Ford A., Bunce C. M., Maya I., Tristan P., (2012). The Status of Climate Change Adaptation in Africa and Asia; RegionalEnvironmental Change (2015). 15:801–814 DOI 10.1007/s10113-014-0648-2
[5]. Garutsa, T. C., Mubaya, C. P., & Zhou, L. (2018). Gendered differentials in climate change adaptation amongst the Shona ethnic group in Marondera Rural District, Zimbabwe: A social inclusions lens. AAS Open Research, 1(14), 14.
[6]. Kotir, J. H. (2011). Climate change and variability in Sub-Saharan Africa: a review of current and future trends and impacts on agriculture and food security. Environment, Development and Sustainability, 13(3), 587-605.
[7]. Laux, P., Jäckel, G., Tingem, R. M., &Kunstmann, H. (2010). Impact of climate change on agricultural productivity underrainfed conditions in Cameroon—A method to improve attainable crop yields by planting date adaptations. Agricultural and Forest Meteorology, 150(9), 1258-1271.
[8]. Liu, Z. Yang, X., Hubbard, K.G., & Lin, X. (2013). Maize Potential Yields and Yield Gaps in the Changing Climate of Northeast China. GlobalChange Biology, Volume 18, Issue 11, November 2012, Pages 3441-3454
[9]. Marco, G. (2009). Justice in Funding Adaptation under International Climate Change Regime. Springer Science and Business MediaMarco, G. (2010). An ethical approach to climate adaptation finance. *Global Environmental Change*, *20*(1), 74-81.
[10]. Reilly, J., Tubiello, F., McCarl, B. Abler, D., Darwin, R., Fuglie, K., Hollinger, S., Izaurralde, C., Jagtap, S., Jones, J., Mearns, L., Ojima, D., Paul, E., Paustian, K., Riha, S., Rosenberg, N., Rosenzweig, C., (2003). U.S. Agriculture and Climate Change: New Results. Climatic Change, March 2003, Volume 57, Issue 1-2, pp 43-67
[11]. Shahzada Adnan &Azmat Hayat Khan, (2014). Effective Rainfall for Irrigated Agriculture in the Plains of Pakistan. Pakistan Journal of Meteorology; Vol. 6. Issue, 11
[12]. Schlenker, W., & Lobell, D. B. (2010). Robust negative impacts of climate change on African agriculture. Environmental Research Letters, 5(1), 014010.

1Bertha Othoche. "Community Livelihoods and the Changing Weather Patterns: A Case for the Maize Crop Performance in the Lower AthiRiver Basin, Kenya."*IOSR Journal of Humanities and Social Science (IOSR-JHSS)*, 25(7), 2020, pp. 45-52.