CLIMATE VARIABILITY AND FOOD SECURITY IN KISII COUNTY; KENYA

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DECLARATION

This thesis is my original work and has not been submitted for the award of a degree in any University.

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DEDICATION

This Research thesis is dedicated to my family for allowing me to use family resources to achieve this level of education.

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ABSTRACT

Climate variability and change has been found to be one of the variables that affect economies of many countries leading to food scarcity in several parts of the world. Kenya is no exception. This research was conducted in Kisii County and it investigated how climate variability affects food insecurity. The objectives of this study were; first to examine the precipitation and temperature trends in Kisii County, secondly to establish the effect of climate variability on food production and lastly, to identify the coping strategies adopted at household level to mitigate the impact of food shortages. The research questions were; is there any significant trend and pattern of rainfall and temperature in Kisii County? is there any significant impact of climate variability on food production in Kisii County? and finally, which are the possible strategies adapted at household levels to cope with food insecurity in Kisii County?. The study population was composed of agricultural officers, Kenya Meteorological officers and farmers. Purposive sampling was applied in the selection of agricultural and meteorological officers whereas multistage sampling was used to select respondents at household level. Primary data was gathered by use of a pretested questionnaire. The questionnaire was first pre tested in neighbouring Homabay County whereby it was established to thirty respondents. Their responses were tabulated, computed and yielded a Cronbach coefficient alpha index of zero point nine two zero. Mann Kendall statistic test was applied to establish whether the trend of precipitation and temperature observed was significant, whereas chi square test was used to determine whether the coping strategies observed varied significantly at household level. The data used was mainly for rainfall and temperature from Karlo and coffee substation weather stations, while food crop production trends and the prices of maize and beans were obtained from agricultural offices at Marani and Bomachoge Chache sub counties. From the analysis, rainfall did not show any significant trend in Kisii County whilst temperature trend, revealed a significantly upward trend over the years, at ninety five confidence level. The analysis of major crop yields and their price trends indicated a decreasing trend of food production resulting into high prices over the years. This meant that farmers could not produce sufficient food to sustain themselves to the next harvesting season, hence forcing them to adopt different coping tactics at household level that varied significantly. The coping techniques preferred include, purchasing food from nearby markets for majority of farmers, whilst others got food aid from donors. Since most of the farmers were food insecure, the study recommended that, County government and National governments should bring climatic information to the farmers, establish alternative sources of water to cushion farmers during prolonged dry spells and lastly encourage farmers to embrace deep rooted crops such as bananas which can withstand dry conditions. Since the study only examined two climatic factors i.e rainfall and temperature, there was need to undertake research on other alternative crops that can withstand the prevailing climate and also evaluate the effect of land sub-division. This will additionally contribute to national efforts towards realization of Vision 2030.

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DEFINITION OF OPERATIONAL TERMS

Climate change- Climate change refers to global variation or change in regional average weather conditions mainly as from the last half of the 20th Century to date, due to accumulation of carbon dioxide emissions as result of using fossil fuels and loss of CO_2 absorbing vegetation.

Food Security- Food security is situation whereby all people at all time have access to not only enough and safe food, but also that which is economical, nutritious and capable of meeting the required dietary needs for life that is active and healthy.

ABBREVIATIONS AND ACROYNYMS

AEZM	Agro-Ecological Zone Model.
AFIDEP	African Institute for Development Policy.
APO	Asian Productivity Organization.
ASAL	Arid and Semi-Arid Land.
AWSC	African Women Studies Centre
BMI	Body Mass Index.
CDC	Centre for Disease Control.
C.F.S.	Committee of World Food Security.
DJF	December, January, February.
ENSO	El-Nino/Southern Oscillation
ET	Evapo-transpiration.
FAO	Food and Agricultural Organization.
GDP	Gross Domestic Production.
GOK	Government of Kenya
CMIP	Coupled Model Inter-comparison Project.
IFPRI	International Food Policy Research Institute.
IOD	Indian Ocean Dipole
IPCC	Intergovernmental Panel for Climate Change.

ITCZ	Inter Tropical Convergence Zone
JJA	June July and August.
KCG	Kisii County Government.
KNBS	Kenya National Bureau of Statistics.
LTM	Long Term Mean
MAM	March April May
MoA	Ministry of Agriculture.
NACOSTI	National Council of Science, Technology and Innovation.
NALEP	National Livestock Extension Program.
OND	October, November, December
SON	September, October and November
USAID	United States Agency For International Development
WHO	World Health Organization.

CHAPTER ONE

INTRODUCTION TO THE STUDY

1.1 Background Information of the study.

Climate change may be caused by natural processes or by other human influences. The natural processes include volcanoes, internal variability in climatic factors or sun's radiation. Human activities that influence climatic change alongside land use changes include, release of greenhouse gases and changing of concentration of suspended particulate matter in the atmosphere (Margaret 2018). Climate alteration affects directly food systems and food accessibility globally (Ray *et al.,* 2019). Food security is attained when all people have access to enough food that is safe and nutritious for their dietary needs and preferences (Global Strategic Framework 2012). Conversely in 2017, hunger and famine was widespread globally leading to severe malnutrition and poor health (Food Agricultural Organization *2017*). Malnutrition includes imbalance, excesses or deficiencies in a person's access to energy intake (FAO 2018). The modern complex global food systems that are struggling to satisfy the ever increasing need for food from the increasing world populace, are seriously under threat from the effect of climate change (Chase *et al.,* 2019, Stevanovic *et al.,* 2016) and the projection is that, if a solution is not in place in good time, then this threat is likely to affect the pillars of food security such as: its availability, accessibility, utilization and stability.

It is estimated that close to 2 billion people in the world are facing modest or severe food shortages (UNICEF 2019).In some areas of North America, southern and eastern states have shown consistent decline in food crop yield as result of climate alteration (Ray *et al.,* 2019). In Canada seven out of 22 neighborhoods of Toronto are not only

at a great risk of limited access to food after extreme weather events, but also have high instances of food insecurity (Kimberly *et al.,* 2018). In Vietnam, maize growing has been affected by climate change in some areas such as Muong Te district which is located to the north western part of Vietnam in Lai Chau province. In addition, other districts located in Mekong delta have experienced low food crop yields especially maize as result of adverse effects of floods and droughts. The middle zones of Vietnam have not been spared either, whereby maize yields have declined due to weather extremes such as tropical cyclones, flooding and droughts (Louis *et al.,* 2019).

In a study that was done in Pakistan by Saijad *et al* (2017) on the repercussion of climate transformation on food crops, it was revealed that, wheat is the leading stable food in Pakistan. The study continues to show that during its process of production, rainfall patterns and prolonged winter periods have damaged and lowered its yields leading to food insecurity. For instance, during 2013-2015, there was a reduction of 1.9% in the production of wheat from 25.979 million tons to 25.478 million tones.

In Senegal, Komlan *et al* (2017) reveals that food insecurity was more common in the central and southern parts of the country mostly in Kolda, Ziguinchor and Kedugu areas. In these regions, rain fed rice production varied between 1 to 2 tonnes/ha. Among the many reasons revealed by the study was a strong relationship between precipitation and cereal crop production mostly in Ziguinchor.

In Southern Africa Development Community (SADC) region, rainfall trend during 1960 to 1996 was analyzed by Sylvester *et al* (2018) who showed that precipitation

was extremely variable between 1960-1961 and 1988-1989. However, from 1989-1990 onward, the rainfall variability was dominated by a decline in rainfall amounts mainly in summer. This reduction in rainfall impacted negatively in food production hence exacerbating SADC vulnerability. The study further revealed that, during 2015/2016 El Niño Southern Oscillation (ENSO), the induced drought was estimated to have affected over 40 million people who became food insecure, by not only causing 643,000 livestock deaths but also caused a short fall of 5.1 million tons in maize production.

In East Africa, a study in Uganda was carried out amongst the Batwa in Kanungu District. It indicated that, food insecurity among the households was quite high in the dry season compared to wet seasons whereby during the dry season, food insecurity increased significantly by 4% (Kaitlin *et al.*, 2016). In Kenya unfavorable weather conditions in 2019 led to the reduction of cereal production, which in turn led to food shortages (FAO 2020a). As a result of the food shortages, maize prices rose up to a worsening scenario. For instance, close to 70% of ASAL counties in Kenya recorded higher maize prices in January 2020 compared to previous years 2016-2018 (National Drought Management Authority 2020).

1.2 Statement of the Problem.

Accessibility to food security is very critical to human survival (Manap and Ismail 2019). When a higher proportion of people in a region are able to access nutritious and sufficient food, instances of malnutrition and poor health are greatly reduced (FAO 2019). Contrary, Kenya is among the countries that have been listed as low-income food deficit countries globally (FAO 2020b), whereby close to 2.7 million people were estimated to be food insecure in 23 out of 47 counties in Kenya in

January 2017, (NDMA 2017) by March, their number had increased to 3 million people (Kenya Food Security Steering Group 2017). According to Kisii County development plan 2018-2022, the poverty levels in the county stood at 44.5% while the number of stunted children ranged between 36-46% (Kenya National Bureau of Statistics 2015). Approximately, 32% of the population in Kisii Central rely on food bought from the market (Gichere *et al.,* 2013) and this situation has worsened to the extent that, about 47 % of the residents in Kisii County by 2014 had no enough food in their households (African Women Studies Centre 2014).

This has attracted a number of food programs in Kisii County including *Njaa marufuku* which deals with value addition and Kenya Agricultural productivity and agribusiness project that deals with improvement of agricultural system through adoption of agricultural technology. In addition, a number of researchers such Ogechi and Waithaka 2014, Nyariki *et al* (2015) and Kumba *et al* (2015) have come up with solutions to food insecurity. Food shortages may lead to many challenges in the county whereby it may reduce labour production, cause hunger and eventually reduce life expectancy.

Despite the many studies and food security programmes active in Kisii County, there is still a high incidence of food scarcity. Among the investigated factors were; the effect of land fragmentation, use of agricultural land, and land use/cover changes on food security by Kumba *et al* (2015), the effect of land fragmentation on food security and implications of land use cover changes on food security by Nyariki *et al* (2014) and Ogechi and Waithaka (2014) respectively. While all these aspects contribute towards understanding the cause of food insecurity in the County, the study believes

that, the effects of climate variability and change has not been studied exhaustively, hence the purpose of this research.

1.3. Research Objectives

The main objective of this study was to examine the impact of climate variability on food security in Kisii County. The study was guided by the following specific objectives;

i). To analyze rainfall and temperature trends in Kisii County.

ii). To determine the effect of climate variability on food production in Kisii County.

iii). To identify the coping strategies at household level adapted to reduce the impact of food shortage.

1.4 Research Questions

The study was guided by the following specific questions:

i. Is there any significant trend and pattern of rainfall, and temperature in Kisii County?
ii. Is there any significant impact of climate variability on food production in Kisii County?
iii. Which are the possible strategies adapted at household levels to cope with food insecurity in Kisii County.?

1.5 Assumptions

The study worked on the following assumptions:

i. That household respondent will be available and they will give truthful information.
ii. That agricultural officers will co-operate and be willing to release the required data.

iii. That intervening variables not under study will not have significant effects on the findings.

1.6 Justification and significance of the study

There was no useful data on rainfall and temperature trends in Kisii County. Among the literature reviewed, no study had been done before on climate variability and how it affects food security in the county hence need for this study. It is with this optimism that the findings from this study would be used to project the future of food security with the changing climate. In addition, the study would also assist the Kisii County government planners and ward representatives in planning for their county and electoral wards respectively. When the findings of this study will be published, it will positively contribute to the body of knowledge done by other researchers. Lastly the knowledge gaps for further studies will be identified, and any effort to fill them will be a step forward to realizing food security for attainment of Vision 2030 and the Big 4 Agenda in Kisii County and other counties in Kenya through formulation of policies based on research findings.

1.7 Scope and limitation of the Study.

Kisii County is made up of 11 sub-counties, 33 Divisions, 103 locations and 237 sub-locations. The Sub-counties are Marani, Kisii South, Gucha South, Kenyenya, Bomachoge Chache, Nyamache, Kisii Central, Sameta, Etago and Masaba South. Due to its demographic and geo -physical homogeneity Marani and Bomachoge chache sub-counties were purposively sampled for this study because they had the highest number of food security programs in the county (KCG, 2013). This study considered climate variation for only 31 years which is above the minimum threshold of 30 years required observation for average weather conditions. The year 1983 was taken as the starting year because it conspicuously stand out as the year when droughts in Kenya

started worsening systematically compared to preceding years (Omoyo *et al*., 2015, Anya and Semazzi 2006). Production trends for Beans, maize, sweet potatoes and bananas were only available between 2009 -2015 in Marani while in Bomachoge Chache they were available between 2006 -2015. Market prices were only available for Maize and Beans in both sub counties. In addition, temperature readings were only available at Karlo weather station. Rainfall totals were available from two weather stations; Karlo and coffee substation and they only covered up to 2013. All other weather stations in Kisii County did not have sufficient data.

The following were the limitations experienced during the study;

i. Many weather stations in Kisii County that collect rainfall totals had been run down. The study only used data from the two stations Karlo and coffee substation that had rainfall totals covering 31 years.

ii. The study area had many roads in a bad state that could not allow the use a motor vehicle. The study used motor cycles in transportation of research tools and in some instances walking was preferred.

iii. Some respondents were nervous in revealing their state of food security. The researcher explained clearly the objective of the study and informed the respondent that the information gained would be under confidential cover and their name was optional.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews some of the existing scientific literature on the following factors; Forcing mechanisms on climate variability in Kisii County, climate change, effects of climate variability and change on food security, adaptation to climate change, food security and the conceptual frame work of the study.

2.2 Climate Changes

Since climate change happens slowly and gradually, it is hard to be perceived in the absence of scientific data. Scientists detect climate change by examining average trends of climatic elements occurring in a span of time. Changes happening in the earth‘s environment may originate from the revolution of the earth around the sun or they may be caused by human modification of the environment hence leading to climate change (Tranter,2017, Ebele and Emondi, 2016). The rate at which climate change is taking place in modern times is quite high, compared to what has been witnessed before the pre industrial period. Lately, temperatures are on upward trend globally especially in Bangladesh (Syed and Al Amin 2016) with strong evidence linking human related activities on the surface of the earth (Margaret, 2018).

In a research done by Tajeda *et al* (2016) in Equador, the climatic data for precipitation and temperature was collected and pre- processed at a research center for El Niño. Once the data was processed, then trends of precipitation and temperature was computed using Mann Kendell trend test. Results from various weather stations located along Andean mountain chains coded as PC1 indicated that, there was no trend in precipitation even though there were some spikes during wet and dry seasons. On temperature, the result showed a steep increase.

In the horn of Africa Ghebrezgabher *et al* (2016) investigated long term trends of climate change and droughts. The study collected information from 46 weather stations located within and outside the region. Their result showed that, rainfall and temperature oscillated up and down at a rate of -0.3913 and 0.0084 per year. The trend for rainfall was not significant at 95% confidence interval while the trend for temperature was significant at 99% confidence level. The peak amount of rainfall was captured in 1961, 1967 and 1997 while the lowest was recorded in 1943, 1984, and 2009.The warmest year was in 2009 by 1.004C°.

In another study mounted in South Africa by Wilgen *et al* (2016) investigating temperature and rainfall trends, data was computed for 80 years. The findings from the research indicated that, there was a vital yearly increase in one of the temperature variables in nine out of 13 weather stations. In some weather stations located to north western parks such as Kalahari, Gemshock, Richtersveld and Aurabiesfall, revealed greatest increase in temperature trend. In those other ones located in the parks and had data for 50 years, they showed that, maximum temperature had risen by 1.95°C since 1960. On precipitation patterns, the study indicated that no significant trend was detected across the study area.

Climate change in Uganda, is already taking its toll on the farmers' crop production. Across all agro ecological zones, drought had the highest impact of approximately of 37% of the household, compared to the effect of floods at 20% of the household (Okonya *et al.,* 2013). Most of the farmers in Uganda have been affected by the variation in rainfall both in amount and intensity. In addition to the variation in rainfall, temperatures have also been noted as having been on the increasing trend for the last 10 years (Nsubuga and Rantenbach 2018). High temperatures have impacted negatively on the yields of both cereals and coffee, leading to high prices (Mawenjje

2016). In addition, rainfall across Uganda has been unreliable and highly vary on its onset, cessation and even in its distribution, leading to low crop production or total failure.

Climate change is clearly manifesting itself and it is increasing at a frightening pace, inform of the rising temperature and rainfall unpredictability whereby, some parts of Kenya, Ethiopia and Tanzania experience rainfall that has no significant trend (Gebrechorkos *et al.*, 2019). This has made Kenya to be vulnerable to the impacts of climate change (Marigi 2017). In a research done by Marigi (2017) in the southern Kenya, data was collected from five weather stations namely; Makindu, Katumani, Mutomo, Kitui and Mwingi. Mann Kendall's Tau test was used to compute the trends. The findings were that, the trend for heavy rainfall days were decreasing while the frequency of the number of warm days had increased in the area. For instance at Katumani and Makindu weather stations, there was an increase in the number of warmer days that were over 25°C5% significance level. In addition, the frequency of cold nights was also on the increase. Minimum temperature of less than 10^{th} percentile was on upward trend in Katumani and Kitui stations at 5% significance level. On days with maximum temperature of less than 10^{th} percentile of maximum temperatures, cold day time was on a decreasing trend as the frequency of warmer nights increased.

The vulnerability to climate change across Kenya mainly depends on the region's exposure, sensitivity and its adaptation. For instance droughts and floods have accounted for the highest impacts that have caused colossal economic losses in terms of destroyed property and loss of livelihood such as staple crops like maize and tea (Ochieng 2016, Marigi *et al.*, 2016).

Temperature and precipitation changes are two climatic elements which are of great concern to agricultural activities in Kenya. For instance both minimum and maximum

temperatures on the normal average seasons of December to February, March to May and September to November exhibits a rise in temperature across the northern parts of Kenya while some parts have no well defined patterns of precipitation trend due to its high spatial variability (Indeje *et al.,* 2000). The climate change that is being felt in Kenya is happening at an alarming rate hence endangering natural resources such as flora and fauna.

There is an indication that ASAL is increasing and expanding towards the remaining rich flora and fauna areas in Kenya. In addition, the increasing trend in temperature and much longer periods of drought may not only lead to more frequent and intense forest fires but also may expand the ecosystem range of pests and other pathogens (Madegwa *et al* 2016). The frequency and intensity of climate change events, such as drought and floods have also taken toll of productive assets, personal property and even life in some parts of Kenya. Famine cycles have been worsening from 20 years in 1964-1984 to 12, and in 1984-96 to 2 years, 2004-2006 onwards to date, almost yearly (GOK, 2010). This has made the government of Kenya to spend huge sums of money estimated to be 20 billion between 2005 -2009 in providing various food stuffs to feed a population of about 3.5 -4.5 million people every year (GOK, 2010). Food shortages may continues in Kenya since large areas in Kenya had witnessed more than 100mm drop in rainfall during the long season by 2010 (FEWS 2010). This decline has made the acreage of the area under crop production to also decrease making the agricultural production in Kenya to be on a downward trend (Patel *et al.,* 2012; AFIDEP 2012).

Comparatively before 1970, agricultural production rate in Kenya was 4.8 % p.a. but between 1980 -1990 the production rate declined to 3.3 % and then worsened to 1.7 % between 1990 -2000 (Patel *et al.,* 2012). Such a decline further worsens the fact that

about 65% of the populace in Kenya depends on farming and natural forests for their survival. Worse still, the ongoing subdivision of the arable land per capita, is now less than 0.14 ha. Yields from s mall plots are exacerbated by frequent droughts and floods (Patel *et al.*, 2012) that lead to perpetual food insecurity that is experienced in the country, which may lead to malnutrition. In central Kenya, the biggest challenge facing farmers in market gardening is unpredictable rains and lack irrigation tools (Ndukhu *et al.*, 2016). Changes in climatic variables such as rainfall and temperature affect crop productivity in situations where rainfall delays in its commencement or is accompanied with occasional erratic floods that cause damage to crops.

The Kenyan government has responded positively to climate change and its effects by setting up an implementation plan in its long term development policy, the Vision 2030. This policy is aimed at changing Kenya into a middle level income country that provides high class life in a fresh and safe environment. Vision 2030 has three pillars namely; social, Economic and political pillar. Food security is entrenched in the economic pillar. In this pillar, agriculture has been emphasized. For instance, the government intends to increase income through agriculture, livestock and fisheries. This will be done through the processing and value addition to agricultural products before marketing and through innovations in modern agriculture. This will be achieved through better yields in key crops and utilization of currently uncultivated land. Other ways through which the government hopes to raise agricultural production, is to implement consolidated land legislation, fertilizer subsidy initiative and setting up of disease free zones for livestock in ASAL regions. To achieve this goal, climate change and population dynamics are key issues to be addressed. Vision 2030 may not be realized if challenges facing its implementation are not tackled in good time. For instance, the realization of the Vision 2030 in Laikipia County is being

challenged by ecological environment, brought about by climate change and variability (Kilonzi and Ndungu 2014).

In Trans Mara East Sub County, Narok County, Simotwo *et al* (2016) reveals that, out of the contacted farmers, 33% had 2.1 ha to 2.5 ha farms, whereby large portions of land were under the cultivation of maize and beans while smaller portions were left for cattle keeping. The cultivation of crops that can withstand droughts such as sorghum, finger millet, and sweet potatoes were given much smaller portions of land, an implication that the adaptive crops have not been given prominence in the changing climate. In terms of climatic factors, Trans Mara east sub-county has witnessed major shifts in mean annual amounts of rainfall. For instance, between 2000-2015 rainfall totals received in the area, did not only decline, but also the peaks of long and short rains became irregular from one year to another whereby, between 1980 -1999, this rainfall peaks had been missed in some instances. The authors have only examined the trends of rainfall in various weather stations and have not linked the trends to food security which is the main focus of this study.

2.3 Forcing Mechanisms on Climate Variability in Kisii.

2.3.1. Local Control Factors.

Lake Victoria influences rainfall in East Africa, whereby it has a strong influence of high rainfall peaks in the areas that lie to the north east and south west (Evans *et al*., 2020, Finney *et al.*, 2019). Other local factors include Kenya highlands, insolation, wind circulation patterns over Lake Victoria and their interaction with large scale mechanisms such as moist westerlies from Congo basin. Westerlies from Congo basin results into the experienced frequent thunderstorms and the enhanced rainfall activities in the afternoon over the western parts of Kenya (Nicholson 2016).

2.3.2. Large Scale Factors

2.3.2.1. Effect of ENSO on Rainfall Pattern in Kisii.

El Niño /Southern Oscillation (ENSO) is one of the largest global teleconnections across the world. It is a naturally occurring phenomenon that involves fluctuating ocean temperature in central and eastern equatorial pacific together with atmospheric changes. ENSO has greater control of climatic patterns in several regions of the world (Rembold *et al.,* 2015). With the present advancement in technology and research, its prediction and eventual occurrence can now be done accurately between ranges of one month to nine months in advance. This has helped many communities in the world to prepare for the hazards that are associated with it, such as heavy rainfall, floods and droughts. El Niño and La Niña are oceanic components, whereas the southern oscillation is simply an atmospheric counterpart. ENSO is comprised of three distinctive phases; El Niño, La Niña and neutral phase.

El Niño starts with wide spread warming of the surface water in middle and eastern parts of Equatorial Pacific Ocean and it usually begins in the middle of the year reaching its climax during November –January. After which it then decays over the first half of the following year. It can last for 18 months and it may re-occur every 2-7 years with varying intensity (Siderious *et al.,* 2018). On the other hand, La Niña occurs with the large scale cooling of the ocean temperature producing opposite atmospheric conditions of the El Niño episode (Fer *et al.,* 2017). Finally during ENSO neutral phase, the patterns observed in the atmosphere are controlled by other prevailing climatic factors. For instance, Temperature shifts during El Niño and La Niña usually come with much higher large scale variations in air pressure, a condition better known as Southern Oscillation. Southern oscillation is an east-west air flow that occurs in between the Indo Australian and Pacific regions. The southern oscillation

has two phases namely: the negative and positive. Negative phase which is associated with El Niño episode occurs when abnormally high air pressure is experienced over Indonesia and anomaly of low pressure covers central and /or eastern tropical pacific. The positive phase of the southern oscillation which is associated with La Niña episode, occurs when abnormally low air pressure covers Indonesia while an anomaly high pressure prevails over either middle or eastern regions of tropical pacific or both.

Through its recurring redistributions of heat and atmospheric momentum in the Pacific Ocean, the influence of ENSO is felt as far as East Africa, in terms of rainfall variability. For instance in 2011 and 2013, East African region experienced serious food crisis that led to famine conditions including the Greater horn of Africa (Bahaga *et al.,* 2019). Among the many factors that may have contributed to this kind of crisis, failed rains in both the boreal winter of 2010-2011 and boreal spring of 2011 played a significant role. Back to back failures of these rains were connected to the dominant La Niña conditions. In addition, regions of East Africa in recent times have witnessed a large boost in the number of below normal rainy days seasons, which may be linked to warm western pacific and Indian Ocean (Funk, 2013, Indeeje *et al* 2000).

In Kenya, the 2015 El Niño event was quite similar to 1997 in many ways even though it was superior. Most of the 2015 global models of El Niño indicated that, it reached its peak during the Northern Hemisphere winter season between November-February and persisted into spring season after which it transited to ENSO-neutral conditions by June 2016 (Opijah *et al.,* 2015). In June 2016 there was a strong La Nina event which was a negative phase of El Nino resulting into 2016-2017 droughts in the country (Uhe *et al.,* 2017).

Indian Ocean Dipole (IOD) is a large scale factor that is highly associated with rainfall variability in Eastern Africa. It is an ocean and atmosphere phenomenon in the

Equatorial Indian Ocean associated with mainly, the difference between sea surface temperature anomalies that arise in western Indian Ocean between 50º E- 70º E, 10º S-10º S and Tropical South Eastern Indian Ocean between 90º E- 110º E, 10º s-0º (Lu *et al.*, 2018). The IOD is characterized by both positive and negative phases. The IOD positive is registered when the eastern part of Indian Ocean is warmer than normal while the western part of the Ocean is cooler than normal. The positive IOD is associated with rainfall in E. Africa (Merchant *et al.,* 2006) while the negative phases are associated with droughts. Strong positive phases of IOD in East Africa were observed in 1961,1963, 1967, 1972, 1991, 1994 and 1997 while strong negative phases were witnessed in 1954,1956, 1960, 1971, 1974, 1992, and 1996 (Bahaga *et al.,* 2019, Owiti and Ogalo 2008).

2.3.2.2. Effects of Inter-Tropical Convergence Zone (I .T.C.Z.) on Rainfall pattern in Kisii.

The zonal arm of ITCZ crosses E. Africa twice a year. This results into warm moist air to be drawn into the low pressure zone as part of Hadley cell circulation. Hadley cell is a zonal mean meridional mass circulation in the atmosphere located between 30 S and 30 N (Schmidt *et al.,* 2017). It is usually characterized by equator ward mass transport by frequent trade wind flow in lower atmosphere, and pole ward mass transport in the upper atmosphere (Troposphere). The convergence of the northerly and south easterly trade winds from both the southern and northern hemisphere, form stagnant wind conditions better known as “doldrums” (Klocke *et al* 2017). ITCZ is the prime factor behind the bi-modal precipitation experienced in East African region, whereby long rains are experienced in the month of March till May, whereas short rains occur during the month of October cease in December (Ongoma *et al.,* 2015). The first passage of the apparent movement of the sun takes place during the month of

March and it becomes overhead along equator at noon on 21st while the second passage occurs in September when it is overhead at equator again on 23rd (Nabil *et al.,* 2018).The authors have clearly provided both the local and large scale factors responsible for rainfall distribution in the world. This understanding is critical in rainfall trends and its repercussion on food security, which is the focus of this research.

2.4 Climatic Factors Affecting Food Security.

2.4.1 Droughts

Droughts set in when a deficiency of precipitation occurs over a prolonged period of time leading to shortage of water in a locality (Wang *et al.,* 2016). Droughts occur in different parts of the world affecting people in a number of ways that include crop failures leading to famine. Famine may lead to malnutrition and other health related issues. The consequences of droughts have been experienced at a wider range of geographical scales in N. America. It is estimated that the world witnessed about 642 drought events from 1900 to 2013 (Masih *et al.,* 2014). Drought is a very complex phenomenon that greatly varies in terms of its intensity, onset, cessation, duration and the area covered. Mega droughts have been reported in America and China. Dry and arid regions that increased significantly during the 20th century are attributable to the drying since 1970s and the trends are expected to continue increasing in the 21st century (Masih *et al.,* 2014).

In Sri Lanka, prolonged droughts have seriously reduced the quantity of food, whereby all crops and vegetation have been destroyed (FAO 2017). As a result of such drought, animals such as goats, cows and buffalos have struggled to meet their daily consumption needs. In the face of hunger, people in Sri Lanka have tried to

respond to food shortages in many ways. For instance some people have reduced the quantity of food intake, by dropping a number of meals they take per day while some people have replaced their preferred foods and switched to others during droughts (diet diversification).

In Dikgale community located in Limpopo province of S Africa, Rankoana (2017) carried out research on the community's sustainable subsistence farming practices. The study used qualitative study design method. Data was collected from the community by direct interaction with farmers, and information was obtained from 250 participants comprising of 98 males and 152 females. The result was that, planting of seeds started when the first rain drops commenced whereby farmers could mix different seeds together and then sow them simultaneously. It was revealed that farmers used their native farming techniques such as sowing crops on different soil types, applied fertilizer, selected quality seeds and attended their crops in the field. On rainfall forecasting, farmers used their indigenous methods of weather forecasting as opposed to scientific weather forecasting. For instance they could study the behavior of some local tree species such as *Acacia senegali* and also observed celestial bodies to mark the start of a new season. However, if a bad season is predicted, then sowing of seeds was postponed until such time that rainfall shall have come in sufficient amounts before planting is commenced.

Ethiopia experienced one of the worst droughts in recent decades in 2015 (Hirvonen *et al*., 2018). It is the second most populous countries in Africa with approximately 94.3 million people and it has been cited as one of the food insecure countries (Mohammed 2017).The livelihood of the rural populace in Ethiopia depends on rain

fed agriculture (Lewis 2017) and therefore perennial food insecurity experienced in the country is strongly linked to severe recurrent droughts. For instance, the study that was done by Darkwa *et al* (2016) reveals a strong relationship between the production of beans and rainfall variability.

In Tanzania, a study was carried out in Moshi rural district along the slopes of Mount Kilimanjaro, to explore the perceptions and reliability of local residents on weather forecasting by Chengula and Nyambo (2016). When the data was collected and analyzed, it revealed that local people use their own traditional methods of weather forecasting as opposed to modern and scientific method, by applying the use of locally available indicators such as plant phonological changes, birds and animal behavior, insects behaviors, amount of clouds, astronomical changes, religious and traditional calendar and finally myths and rainmakers.

About 80 % of the entire territory in Kenya is arid and semi arid and the periodical droughts that are experienced in many countries of the greater horn of Africa have become part of the climate system in Kenya which has put farmers and pastoralist in danger. The food insecurity witnessed in Kenya especially in 2011 is largely attributed to rainfall failure in the two consecutive seasons namely 2010 short rains and 2011 long rains (Bahaga *et al.,* 2019, Winkler *et al* 2017, Cattani *et al* 2016). As from June 2016 onwards, there was a strong La Niña event evolving which led to 2016 -2017 drought in the country (Uhe *et al.,* 2017). Droughts in Kenya are caused by uneven temporal and spatial distribution of rainfall both within the year and between the years (Ayugi *et al* 2016).

Tropical rainfall systems are known to be quite unpredictable and highly erratic in amount and time. Droughts such as those that occurred in 1973, 1975, 1988, 1998, 2010, 2011 and 2017 in Kenya were associated with the cold phases of La Niña (Uhe *et al* 2017, Ghebrezgabher *et al* 2016, Cattani *et al* 2016). In addition, Okal et *al* (2019) carried a research in Tana River basin using normalized vegetation index. From the study, droughts were traced in the basin as early as 1983 and since then they have become more common in the recent years with a return period of 2 to 3 years. This situation is not better than other parts of the country. For instance, in west Pokot County, drought has not only reduced drastically maize yields but also plummeted yields in sorghum and green grams. For many years, West Pokot has had droughts that impact negatively on food security. The best example is in 2011 and 2014 when farm yields went down due to drought (Lolemtum *et al.,* 2017). In 2013, Kisii Central, one of the sub counties in Kisii, lost about, Ksh. 5,731 per household in terms of cattle, goats, pigs and poultry due to droughts and floods (Gichere *et al.,* 2013).

2.4.2 Floods

Floods are overflows of a mass of water that overwhelm the surface of the land (Week and Wizor, 2020) and it is a disaster that is common in many countries whose destructive aspect is quite enormous. In Thailand, floods occurred in 2011 and grossly affected farms, industries and impacted negatively on the economy. For instance floods were estimated to have destroyed about 17,578 square kilometers of farmland, displaced about 2.5 million people and caused an overall economic damage and losses amounting to USD 46.5 billion (Haraguchhi and Upmanu, 2015). In Sri Lanka, heavy rainfall that pounded the country in 2017 caused floods and landslides in the southern western parts leading to food insecurity to approximately 900,000 people (FAO ,2017).

In Bhadrachalam and Kukunoor Mandals in India, the consequences of the floods on agriculture were more felt in 2013 compared to other years. In this period heavy rains caused widespread damage and loss of homes including destruction field crops during July –August rains (Ramarkrishna, 2014). The second spell of heavy rainfall in August led to massive floods again that caused huge destruction in 30 villages and affected thousands of acres along the course of River Godavari. In this river, the volume of water rose rapidly from 43 ft on 8th August at 9.00 am to 60.5 ft by 8.00 pm in the evening. This made the river to overflow and it broke its banks, hence causing havoc to adjacent agricultural fields along its flood plain.

In a study that was done in Mile 12 in Lagos in 2010, floods had drowned animals and swept crops in many farmlands. According to Olajuyigbe (2012) floods affected the communities living along the White Volta basin in the Tolon area in Kumbugu District of northern Ghana. The effect and damage of floods in the region was quite high because it affected about 2000 households whereby crops and farmlands were destroyed.

In Kenya, the stream flow in River Yala causes serious flooding conditions in its watershed. In Kisii, crop and animal losses during floods are attributable indirectly to climate change especially through the associated diseases and directly to the physical impact of floods on crops and animals. For instance, crop failure in Kisii central was estimated to be three times less than the expected harvest per household in 2013 (Gichere *et al.*, 2013).

2.4.3 Postharvest Losses

The term post harvest losses refer to the losses that occur after harvest until the produce reaches the consumer (Magray *et al.,* 2017). The decrease of post harvest food losses is a very important component to ensure future global food security since more than one third of the food is wasted after harvesting (Kumar and Kalita *2017*). In the Asian Pacific regions, the spoilage of fresh farm produce is mainly accelerated by the nature of hot and humid climatic conditions of the regions. For instance post harvest losses account for between 10-20% losses in Bangladesh (Majumder *et al.,* 2016). In Pakistan, a study done in Peshawar valley indicates that an estimated 20% of the total tomato crop harvested is lost after harvesting (Mujib *et al.,* 2007).

In sub-Saharan Africa, postharvest losses reach 40 % of the total harvested cereals (Kumar and Kalita *2017*). After harvests from the farm, the unusual rains may moisten the farm produce leading to mould growth (Mendezo *et al.,* 2017). This is so because most of the developing countries depend on the weather for reducing moisture in the farm produce. If unfavorable weather condition blocks the reduction of moisture content in farm produce, then the postharvest losses increase. In addition, if a bad weather persists and the dampened grains are stored, then mycotoxin yielding moulds, like *Aspersillus flavus* may produce aflatoxin. Aflatoxin may cause health related problems in humans and animals (Chauhan 2017, Kumar and Kalita 2017). In Swaziland, about 16.6 % of the harvested maize was lost due to damp conditions (Rembold *et al., 2011).*

Post harvest losses have been reported in Dodoma and Manyara regions in Tanzania. In these regions, farmers incur losses during pre and post harvest handling operations. Such losses are caused by many factors that include wet conditions during and after

harvests (Abass *et al.,* 2013). Even though important variations do exist in the quantities of the food lost in the field and during storage, it is projected that farmers loose 25% to 40% of the food, before final marketing or consumption. In Kenya climate change and variability contributes greatly to post harvest related losses. It is estimated that during maize production, 12% to 20% is lost after harvesting has been done (Onyango and Kevin, 2017). To lower the huge amount of postharvest losses many in the rift valley region of Kenya apply the use chemical insecticides (Peter *et al* 2019). The writers have only looked at the frequency of droughts, floods, and the role of postharvest losses but have not focused on actual influence in food security over time. This is the main focus of this study.

2.5. Effects of Climate Change on Food security.

Climate change and variability cause a decline in crop production (Afful 2016) and both developed and developing countries are being hit at an alarming rate not only in terms of global food, but also in energy crisis. However, the greatest impact is being felt in poorer developing states, where it is estimated that a global warming upsurge of average temperature of 2.5° C may lead to a reduction of *per capita* income of 1.3%. (Richard 2018).

In central Asia, weather elements were analyzed for a period of 20 years in the provinces of Kaskhastan, Krygystan and Uzbekistan. It was found that an upward trend of precipitation from the normal mean values was positively related to higher yields throughout the year, except for spring when it was observed that excessive precipitation led to lower yields. The lower yield was brought when planting of crops and field operations were retarded while widespread flooding caused favorable conditions for the development of plant diseases like yellow rust (Mirzabaev, 2013).

In response to weather shocks, there have been institutional and technical shifts to increase adaptation capacities in the region. For instance agriculture has been privatized, price fluctuation of farm input and market prices have been stabilized apart from maintaining open cross border trade in agricultural commodities.

In Africa climate change and its manifestation is very rife in Northern parts of Ghana. In this area, communities that never experienced double tragedy in terms of droughts and floods between seasons are now witnessing the effects of climate variability. As result of this, most households who depend on agriculture for their livelihood have now become food insecure. Food security in Ghana is now much more difficult to achieve than any other time before, under climate change regimes as vulnerability to droughts and floods continue to increase (Marza *et al.,* 2015). Climate change is projected to have far reaching effect in Ghana for the next few decades (Dinko, 2017). Elsewhere the situation is not any better, since about two thirds of sub-Saharan Africa also depends entirely on agricultural activities, where women account for over 60% of the farm workforce (Lopez *et al.,* 2016). Climate change affects agriculture, leading to water shortage, increased livestock and human diseases. Climate change mainly affects different dimensions of food security like its availability, stability, accessibility and utilization (Patel *et al.,* 2012). If temperature increases by over 3°C, it will lead to reduced agricultural production and subsequently rise in food prices by approximately up to 40%. The distribution of marine fisheries is also influenced by temperature increase. It is estimated that by 2030 food production should increase by 50% to level up with the demands in urban population. This may not be achieved since climate change is projected to cause a decrease between 1-7 % by 2060. (Patel *et al.,* 2012).

In the Southern Tigray of Northern Ethiopia, rainfall and crop production was analyzed for a period of 13 years (2000-2012). In this study that was done by Abrha (2015), they found out that, there was a large annual and inter annual fluctuations in rainfall and crop production in Tigray region. For instance they found out that maize production was the most fluctuating crop in production followed by wheat and Barley. In precipitation, Belg rainfall starts about first week of April and lasts for a period of 27 days hence giving famers a very short growing season while Kremt rainfall has an onset of first June, lasts until first week September. Averagely in the two growing season, Kremt had a lower standard deviation of 10 days while Belg rainfall had a higher standard deviation 13 days. When Mann Kendall trend test was conducted on annual and Kremt rainfall, it was found out that, there was a decrease of averagely 2 days in every year in the last two decades. Episodes of drought's different degrees of severity and duration have been noted in the semi arid region of Northern Ethiopia (Yimer, 2015). Generally in some parts of Ethiopia such as the northern parts, face food insecurity in a ratio of 1-4 people due to reduction in precipitation and a rise in temperature (Sisha, 2020).

Indirectly climate change creates a very serious threat to human health through heat related deaths and the changing patterns of infectious diseases which may end up causing mortality and morbidity hence affect labour. Even though climate alteration does not generate novel health problems, it may exacerbate health issues in Kenya and in many other countries. The economic costs of malnutrition are not only quite high but also substantial, they can cost about 10 % of an individual life time earnings and may lead to GDP decline between 2-3 % on average (Ecker, 2012).

A direct consequence of climate is felt in terms of increased frequency of harshness of excessive events mainly floods and droughts that lead to crop failure (Nelson 2009; Patel *et al.,* 2012). Reduced crop yields, degradation or desertification, disruption of food supply chains and finally increased costs of distributing food leads to food insecurity (Agwu *et al.,* 2011; Nelson 2009; Patel *et al.,* 2012). The rising temperature leads to increased evapo-transpiration which in turn reduces soil moisture. Less soil moisture in the soil adversely affects crops. Climate change also affects human health through heat stress. In places that are near the sea, sea level rises can threaten food systems. For instance, coastal floods occasioned by the rising of the sea level, cause loss of cultivable land due to inundation and salinization of soil and water resources.

Along the lower river Tana in Kenya year after year, rainfall variability is a significant impediment to the establishment and sustainability of rain fed agriculture. Whereas Tana River region produces huge quantities of cassava and Mangoes per unit area in normal weather situations (Makenzi *et al.,*2013), studies have indicated the presence of a significant connection amid crop yields and seasonal rainfall in other crops such as Maize, Green grams and rice whereby they perform poorly during dry seasons. The authors have only examined the effect of climate change over a time frame of less than 20 years while this study considers rainfall over 32 years.

2.6. Food Security

The key dimensions of food security include physical availability and accessibility, adequate utilization of the food by the human body, being nutritious and good dietary quality which is safe for human consumption. Food plays a critical role in the development of a human body; hence it is taken as a right even though billions of people in the world are facing food insecurity that may be including other aspects such under nutrition (Smith *et al.,* 2018, FAO, 2017). Food insecurity points to a

situation, where an economic and social condition at a household level is a limiting factor to accessing adequate food (Murthy, 2016). Food insecurity afflicts communities in many parts of the world and the rising food prices in the last few years are set to be more volatile. For instance, across 134 countries in the world, it is estimated that, about 10.8% of the population in high income countries were food insecure whereby 3.1% were under severe food insecurity while in low income countries the situation was worse whereby 56.5% were food insecure out of which 29.5% had severe food insecurity (Escumilla, 2017). World population is expected to increase and reach just about 9 billion mark by the year 2050 from the current 7 billion. In addition, it is also expectated that, by the year the year 2080, the farm production rates in less developed countries would decline by 20% as result of climate change. This is projected to happen even though by that time there will be a high demand for food (Beddington , 2010). Therefore this high demand will require a robust approach to food security that includes food engineering and emerging agricultural food crop technologies to contain the food demand in Africa.

A study done by Ahmadi *et al* (2017) in Canada, investigated the health eating, knowledge on best food eating habits, body mass index status, sex, education and household income among the Anglophone and Francophone residents. Data was obtained from the Canadian food guide, Canadian community health survey and Rapid Response group. When data was analyzed, it revealed that among the Anglophone, men were more obese at 23.9% while women were obese at 22.3%. In terms of weight, men were overweight at 40.2% while women were overweight at 27.8%. The study further shows that, women were more underweight at 3.6%

compared to men at 2.7%. Lastly on normal weight, men were normal at 33.2 while women were at 30.2%.

In Bangladesh, a study done by Leidman *et al* (2020) investigated dietetic status of children between the ages of 6-59 months. The aim of their research was to find out the dietary status of the children in informal settlement of Cox's Bazar District. The study used cross sectional cluster survey. It collected data by using anthropometric indices which were mainly height, weight and mid upper arm circumference. After the analysis of the result, the study revealed that majority of the children in the informal settlement was found to be safe and higher than WHO thresholds.

In Africa about 256 million people suffered from food insecurity in 2017-2018 as a result of collapse in crop yields, livestock deaths and absence of water as result of climatic changes. This was an increment of 44 million people compared to 2014 scenario (FAO 2020a). Food inaccessibility has been increasing in Africa and yet most of the African states are not on track to stamp out hunger by 2030. Most of the food insecure states are spread across Africa in 28 countries such as Ethiopia, Northern Nigeria, Somalia and Kenya among others (World Bank, 2017).

Food shortage can either be long term or temporary and it is usually associated with the poverty of the people affected. There is a strong relationship between hunger, poverty and diseases (Romo, 2016). Both are caused by lack of sustainable food availability. Hunger reduces the body's immunity to diseases while people living in poverty, are not able to produce or acquire enough food for their dietary needs, hence they become susceptible to diseases. Food shortages witnessed in Kenya in 2016-2017 are attributable to among other factors, drought conditions during the La Niña (Uhe *et al.,* 2017). In Makueni County, residents felt that they were food insecure at

50.3% while 21.8% felt that they were secure (Nyale *et al.,* 2019). Food insecurity in Makueni County has been attributed to poor rains and insect pests that attack the food crops. Food deficits in the county have been perennial phenomena for some time. For instance, Wambua (2013) revealed that the low enrollment in primary schools was as a result of food insecurity whereby, a big amount of family resources were being channeled to purchase food stuffs instead of being spent in education. In Bungoma county, residents who felt food insecure devised several methods of plummeting the impact of food deficit by lowering the number of food served per day, offering labor for cash or food, borrow money to purchase food, selling assets while others bought food on credit (Wabwoba,2016). The Authors have highlighted the projection of high demand for food in 2050 and 2080s whereby population will increase to approximately 9 billion people .This study focuses on how the increased population will access sufficient food in the changing climate.

2.7. Research Studies in Kisii County

There have been a few studies on food scarcity in Kisii County. For example, Kumba *et al* (2015) investigated the effect of agricultural land use on house hold food availability in Kisii central. Their research revealed that nippier grass and natural grass had a high impact on house hold food security compared to crops and fruits. However, their study only focused on the influence of agricultural land use and land cover while rainfall and temperature were not considered.

Masese *et al* (2016) investigated the weather shocks and how they affect farming practices in Kisii central. The study used descriptive survey together with qualitative research design. The sample size used was 118 households who were randomly sampled and a questionnaire was applied to gather information. When data was obtained and analyzed, the result showed that, 56.8% were males while 43.6% were

females. On education 63.6% had secondary education, 17.8% had college education, and 16.1% had primary level while 2.5% had no formal education. On climate change, the study examined rainfall from 1994 to 2010 while temperature was examined from 2007 to 2011. The study revealed that rainfall had varied in 1994 to 2011 but had no significant trend. On temperature, the study showed that, the mean temperature for January was 21.8ºC, December 21ºC and July 19.7 ºC for a period of 5years. Like the earlier researcher this research did not examine the effect of climate change on food security which is our main objective.

Ombuki (2018) mounted a study in the county on possible factors influencing the production of maize. Their study applied cross sectional research design and data was collected immediately after harvesting in March 2018. The aims of the research were to examine factors affecting the production of maize in Kisii County. Random sampling was used to identify 10 wards out the 45 wards. A questionnaire was used to collect data. After analyzing the obtained data, several factors were revealed as influencing the production of maize. They included age of the farmer, the experience of the farmer, visits from extension officers and adoption of high yielding maize varieties as well as the total acreage of land under maize farming. This study has not looked at climate variability therefore a gap which our study will endeavor to fill.

Gender dynamics in participatory fish farming towards a sustainable community Development was another study that was mounted by Ongaro (2018). The objectives of the study were; to evaluate gender dynamics in achieving food security, to find ways of capacity building in women in fish farming and lastly investigate ways to monitor, evaluate and respond to participatory fish farming. The research applied descriptive method involving qualitative and quantitative approach. It used a sample size of 160 participants. Purposive cluster sampling method was used to select

respondents. After the analysis of the result, the study revealed that, out of the 160 participants 72 were male while 88 were females. Finally the study concluded that, fish farming was an alternative source of protein during climate alteration. This study did not examine the effect of climate variability on food security hence a gap that our study will fill.

Lastly Wamalwa *et al* (2016) carried studies in Kisii County whereby they examined how perception of climate change affects farming activities and also how the same perception influences the adoption of climate smart agriculture among the small scale farmers in Kisii County. They found out that farmers were recognizing climate change problem that was characterized by rising temperature, changing rainfall patterns and the presence of new pests and diseases. Wamalwa *et al* (2016) did not consider the extent of the influence of rainfall variability on production of food in the county, therefore in conclusion, this study focuses on characterization of precipitation, temperature and further analysis of climate variability which is its principal objective, will give a vital stride in giving a good starting point for the understanding of the repercussions of climatic elements that exert greater influence on the availability food security in Kenya, more so in Kisii County.

2.8. Conceptual Framework

To have a clear view of the relationship between climate change and food security, this research relied on the conceptual framework presented in figure 2.1 below. A conceptual frame work simplifies the path taken by a research and places it within the theoretical constructs in a research field (Adom *et al.,* 2018). The conceptual framework below relies on Agro-Ecological Zone model (AEZM) as used in Edame *et al.,* (2011). AEZM is a model that refers to division of land into small units that have same characteristics in terms of suitability and potentiality. Similar

characteristics include; climate, landscape and soil. In figure2.1 below the dependent variables are quantity of harvested beans, maize, sweet potatoes and bananas while independent variables are commencement and cessation of rainfall, minimum and maximum temperature. Food security will be achieved if the following indicators are significantly reduced; large amounts of postharvest losses and high prices of beans and maize. The foregoing outcomes will be reduced, if the climatic factors that affect food security such as commencement and cessation of rainfall and temperature are carefully considered in farming activities. However the intervening variables such as cultural land tenure, fake seeds and fertilizer, declining land fertility and maize lethal necrosis were beyond the control of this study.

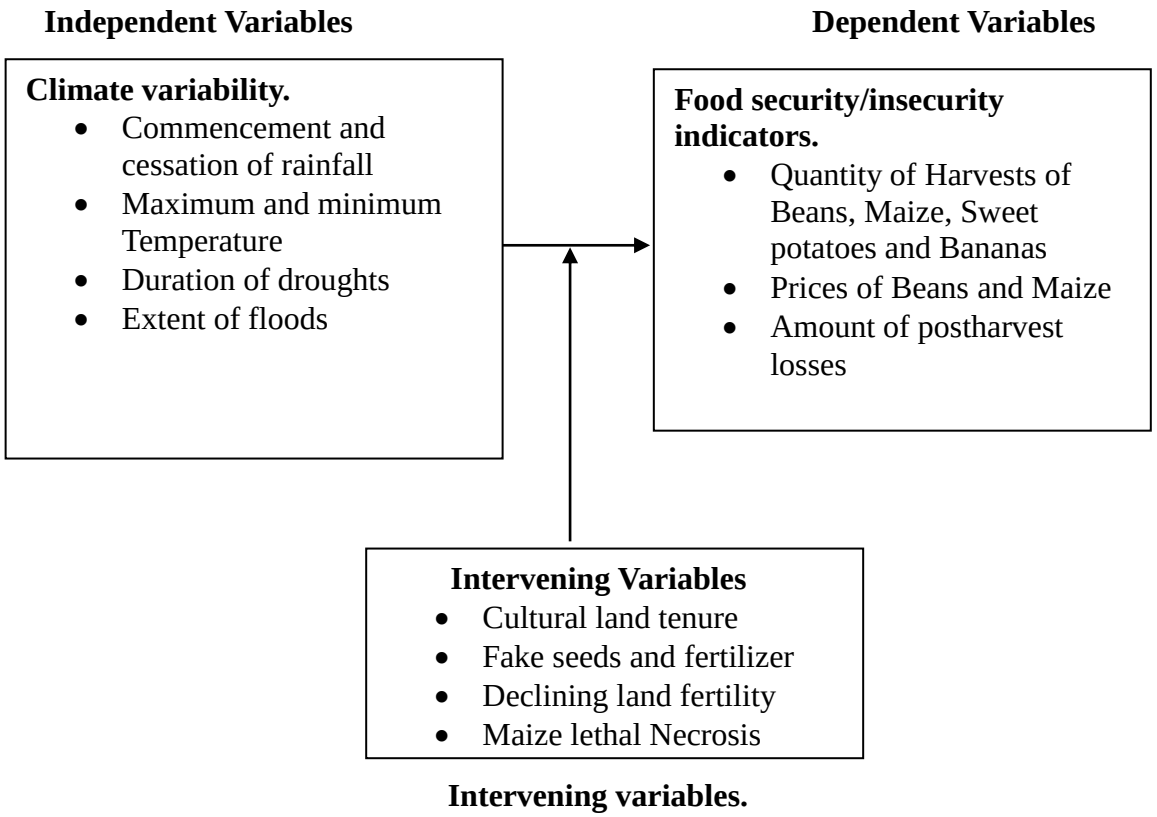


Figure 2. 1. Conceptual framework of climatic factors, dependent and

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter has the following sections; study site, study population, research design, sampling strategy, data collection, validity and reliability of data collection instruments, ethical considerations, assumptions, limitation, data presentation and analysis.

3.2 Study Site

Kisii county is comprised of Marani, Kisii South, Gucha South, Kenyenya, Bomachoge Cha chache, Nyamache, Kisii central, Sameta, and Masaba South,The study was carried out in Marani and Bomachoge Chache sub counties. Marani and Bomachoge chache were purposively targeted because they had the largest number of food security programs (KCG 2013). Kisii County borders Narok to the south, Nyamira County to the East, Homabay County to the North and Migori County to the West. The altitude of the County ranges between 1500m -1800 m above sea level. It experiences double maxima rainfall during MAM and OND. It has an average annual rainfall of about 1500mm per year. The County is located along latitude 0°41'S and Longitude 34°36'E.

Kisii County has a population of 1,266,860 and 304,054 households (KNBS 2019). The county population consists of 605,784 males, 661, 038 females and 38intersex. Kisii Couny has a total surface area of 2542 km^2 and the density its populace is 958 inhabitants per km^2 (KNBS 2019). It has a high agricultural potential area and its economic activities include subsistence farming, dairy farming, small scale tea and coffee farming. In 2012, the county received both long and short rains which were above LTM leading to flooding that destroyed the production of beans (MOA, 2013).

Kisii County has food poverty percentage of 60% and it is majorly affected by droughts and floods (KCG, 2013). Even though Kisii County has a high economic potential, about 44.5% of its population live below poverty line (KCG, 2018).

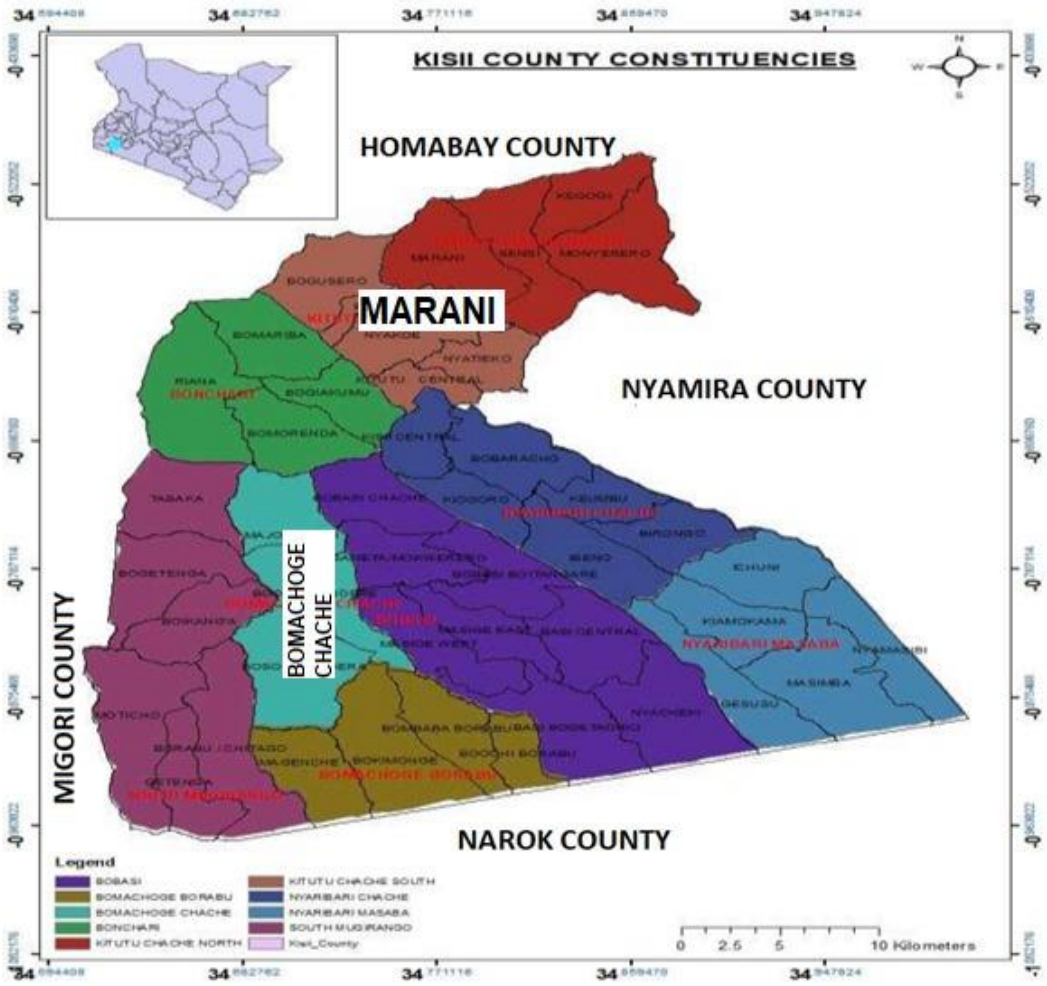


Figure 3.1. A map of Kisii County showing Constituencies

Source: IEBC, (2007)

3.3 Study Population

The study focused on trends in rainfall and temperature, production trends of food crops and farmer's coping strategies in Kisii County. The study population was composed of Kenya meteorological officers, agricultural officers designated in food crops sections and farmers at household level.

3.4 Research Design

The study adopted ex post facto research design as it is used in Eshetu and Tessema (2017), Vasanthi and Sudheendra (2018) and Chouhan *et al* (2018). Ex post facto research design was adopted because it allows the researcher to conduct an investigation after variations in the independent variable have occurred (Kpolovie 2016). In this research design, all independent variables remain as such.

3.5 Sampling Technique

Purposive sampling technique was applied to identify agricultural officers in the County office and at sub County level. This technique permits a researcher to make use of cases possessing the required information (Tongco , 2006; Mugenda, 2008). Multistage cluster sampling was applied household level to select farmers. This technique allows a researcher room to split the study area into various levels (Taherdoost, 2016a). The researcher divided into two locations Bomachoge Chache and Marani. The number of household respondents was determined by Godden's 2004 formula (Godden 2004)

$SS=z^2x\ (p)\ x\ (1-p)/c^2$

Where,

SS=Sample size

Z=Z value [A] (1.96 for 95 % confidence)

P=The proportion of farmers picking a choice estimated to be having a characteristic of 0.7 (assumed) of farmers.

C= Confidence interval expressed as a decimal (e.g 0.05=+/-5 percentage point).

Calculation; $SS=1.96^2x0.7x0.3/0.0025=323$. The study had 161 farmers from Marani and 162 from Bomachoge Chache.

3.6 Validity and Reliability of Instrument

According to Taherdoost (2016b) Validity is the level to which an instrument measures what is intended to measure. The research questionnaire was availed to the research supervisor to evaluate its accuracy and adequacy.

Reliability is the extent a tool yields the similar outcomes on several trials (Mugenda ,2008). For accuracy purposes, the research questionnaire was pretested in the neighboring Homabay County in terms of consistence, so as to produce accurate response as per objective three. The formula for testing instruments to prove their reliability was 1951 Cronbach's Coefficient Alpha. Cronbach's alpha is used to determine a test's internal consistency and it is usually expressed as a digit between 0 and 1, with values closer to 1 indicating very good consistency (Tavakol and Reg, 2011). In this research the cronbach's coefficient was computed using five items that had five choices and yielded a coefficient Alpha of 0.920. Since the research instrument yielded an alpha value of more than 0.70, then the instruments had met the recommended threshold.

3.7 Ethical Consideration

The data that was collected was very sensitive because it touched on people's livelihood; therefore the information gained was kept under confidential cover and used for the purposes of this research only. In addition, before respondents and informants divulged any information, their consent was sought first. Lastly before the commencement of the field work, the researcher had been granted an official permission from Masaai Mara University, NACOSTI (Appendix 6) and finally from Kisii County Education office (Appendix 5).

3.8. Data Analysis and Presentation

Data was analyzed as per the specific objectives of the study:

3.8.1 Study Objective One

The duration of 31 years was taken because it is above the minimum threshold that is required for the observation of average weather conditions of a place in order to determine its climate. Rainfall and temperature data (only available up to 2013) was analyzed from two weather stations in Kisii County. The measurable variables were, rainfall totals, minimum temperature and maximum temperatures. The annual average readings were computed and then subjected to Mann Kendall test analysis using the following formula:

$$\text{Sign } (T_j - T_i) \quad = 1 \text{ if } (T_j - T_i) > 0$$

$$= 0 \text{ if } T_j - T_i) = 0$$

$$= -1 \text{ if } T_j - T_i) < 0$$

Where T_j and T_i are derived annual temperature or rainfall values in years j and i given in a chronological order.

The above formula was used to calculate statistic value (S) and the probability value Z. A positive value S indicates an increasing trend, a negative S value shows a decreasing trend, while a zero value denotes no trend (Ahmadi *et al.,* 2015). Also the probability value associated with value S and the sample size value was computed in order to quantify the significance of the trend observed.

3.9.2 Study Objective Two

In this study objective two, the average mean of maize, beans, sweet potatoes and bananas was first computed to show variance in production and then a comparative line graph was generated to show production trends of each commodity. In addition, the mean of the prices of beans and maize was also computed to show variance in price and then a comparative line graph was also generated to show production trends of each commodity.

3.9.3 Study Objective Three

In this objective, Chi-square formula was applied to establish whether the observed variation in coping strategies was statistically significant at 95 % confidence level.

$$X^2 = (O-E)^2/E^2$$

Where,

X^2 = Value of chi-square.

O= Number of people buying food from nearby markets or number of people getting assistance from relatives and other donor agencies.

E= The average of the number of people buying food from nearby markets and those receiving assistance from relatives and other donor agencies subtracted from the observed value.

From the formula, the p value from the chi square score would be significant if it is less than the 0.05 whereas if it would be greater than 0.05 then the variance observed would not be significant.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction.

This chapter has the following sections; Gender distribution of respondents, Kisii county precipitation and temperature, production trends in beans, maize, sweet potatoes and bananas in Marani and Bomachoge chache Sub Counties, coping strategies, adaptation techniques and summary of the result.

4.2 Socio–Demographic Information of the Respondents.

Respondents were asked to state their gender and figure 4.1 below gives the gender summary of those interviewed. The figure shows a great number of respondents were female at 78.5% while men were at 21.5%. In traditional African society, men are often out of their homes working for the family or are in towns where they formally employed. This corroborates with (Lopez *et al.*, 2016, Rankoana *2017*) findings that in Africa and other areas, men dominate informal and formal employments that require higher skills compared to women who form a greater proportion of the agricultural production in farms and other labour intensive undertakings that are sometimes lowly remunerated. The computed X^2=117.22, df =1, p=0. 00001 implied a significant difference between the number of males and female respondents.

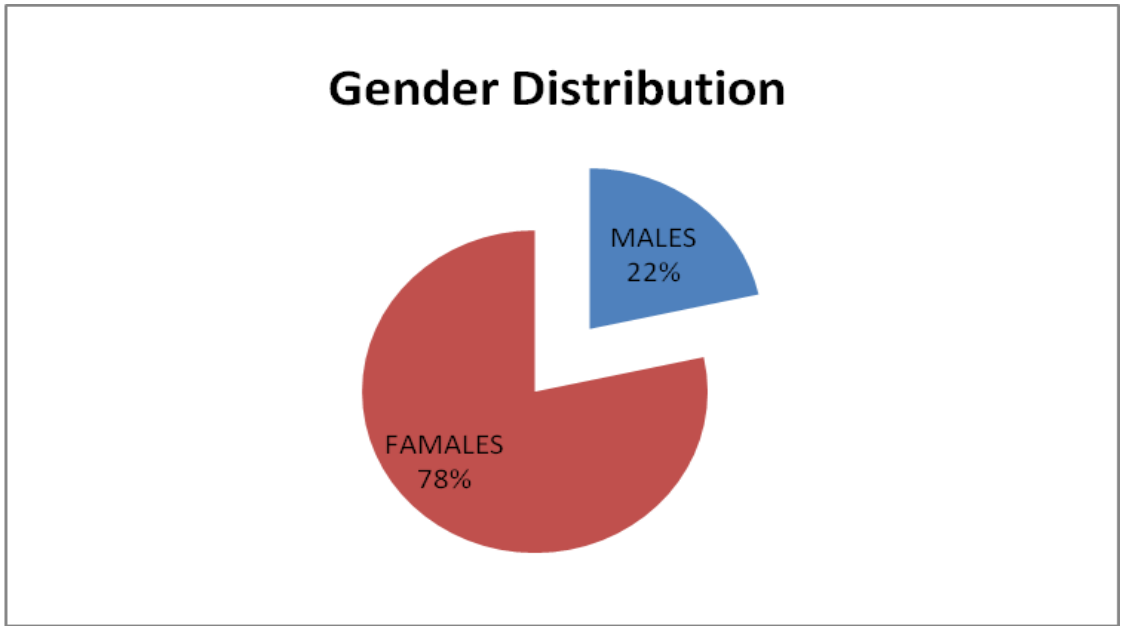


Figure 4.1Showing Gender Distribution of Respondents.

Source: Author

4.2.2 Age of the Respondents.

The respondents were further asked to indicate their age in years and figure 4.2 shows their age sets. From the figure, majority of the farmers were aged between 38-47 years. This may be attributed to the fact that at this age, most of them have the responsibility of fending for their families either through manual jobs, or through farm activities. This finding agree with Lopez *et al* (2016) that energetic members of the community who mainly supply labor to farms are those who are between the ages of 30 and 45 years, hence this group should be targeted for food security programmes. The computed X^2= 64.8 df =4, p=0.00001 was statistically significant.

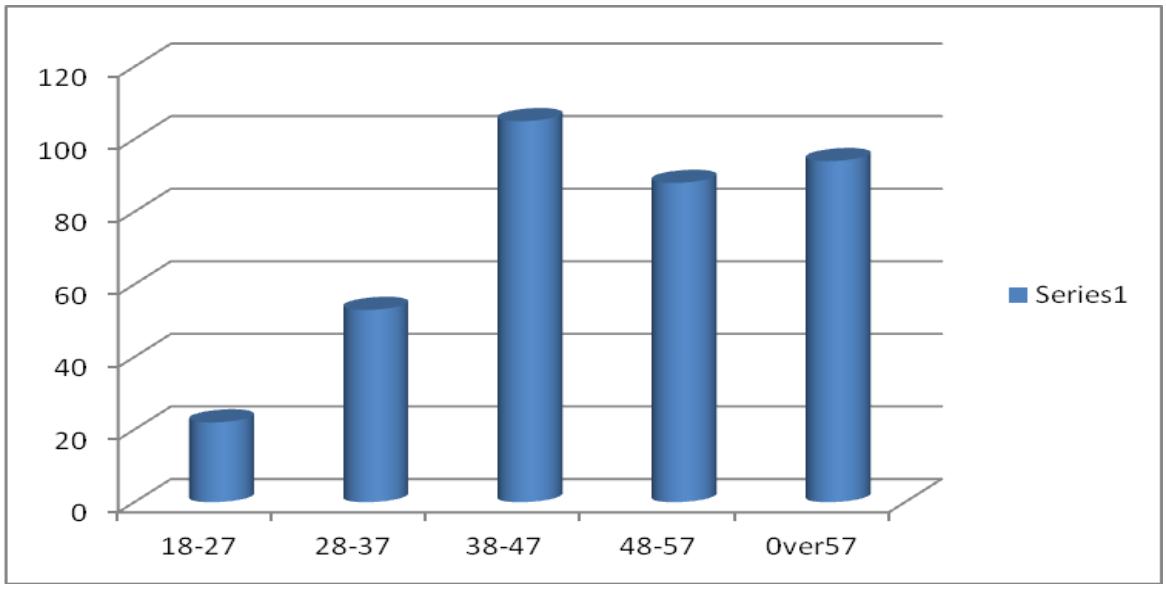


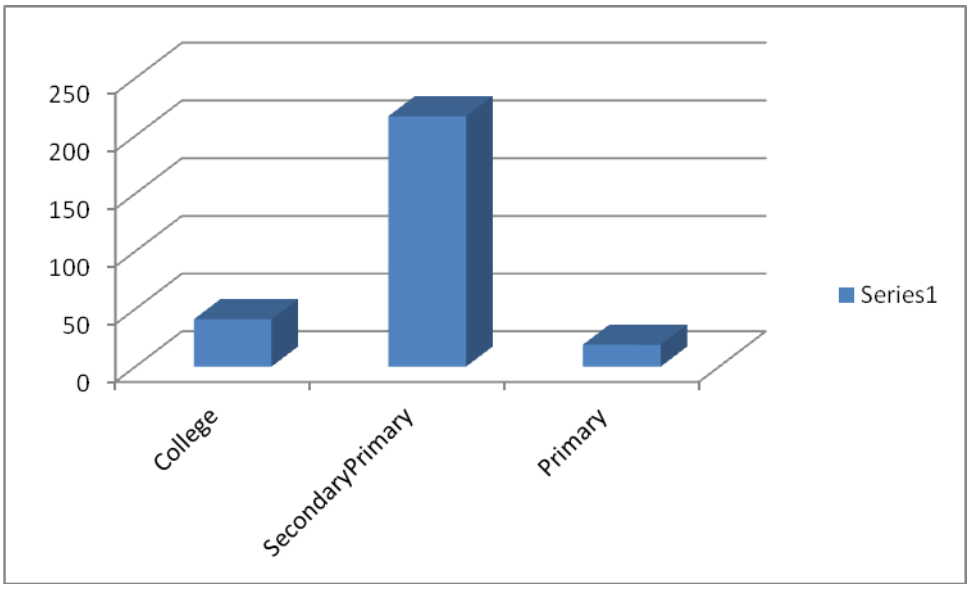
Figure 4.2 Showing age Distribution of Respondents.

Source: Author

4.2.3 Education Level of Respondents

Figure 4.3 below shows the educational level of respondents. From the figure, majority of the farmers at 67% had secondary education level; primary education level was at 22% while college level was at 11%. A good number of the farmers were those who had attained secondary education. Similar findings were also observed by Masese *et al* (2016) that most farmers had completed secondary level of education. The computed X^2= 250.2 df =1 p=0.00001 hence statistically significant.

Table 4.3. Education level of Respondents



Source: Author

Figure 4.3 Showing Educational Level of Respondents.

4.3. Changes in Precipitation in Kisii County.

Figure 4.4. Below, shows the average precipitation of Karlo weather station and Kisii coffee substation from 1983 to 2013. The p value computed using Mann Kendall test was 0.590 ($p>0.05$). There was a trend in average precipitation in the two weather stations but not statistically significant. This corroborate the findings of Gebrechorkos (2019) and Indeje *et al* (2000) that some regions in Kenya, Ethiopia and Tanzania do not have clear patterns of precipitation indices as result of rainfall variability largely brought about by local factors and not by large scale factors.

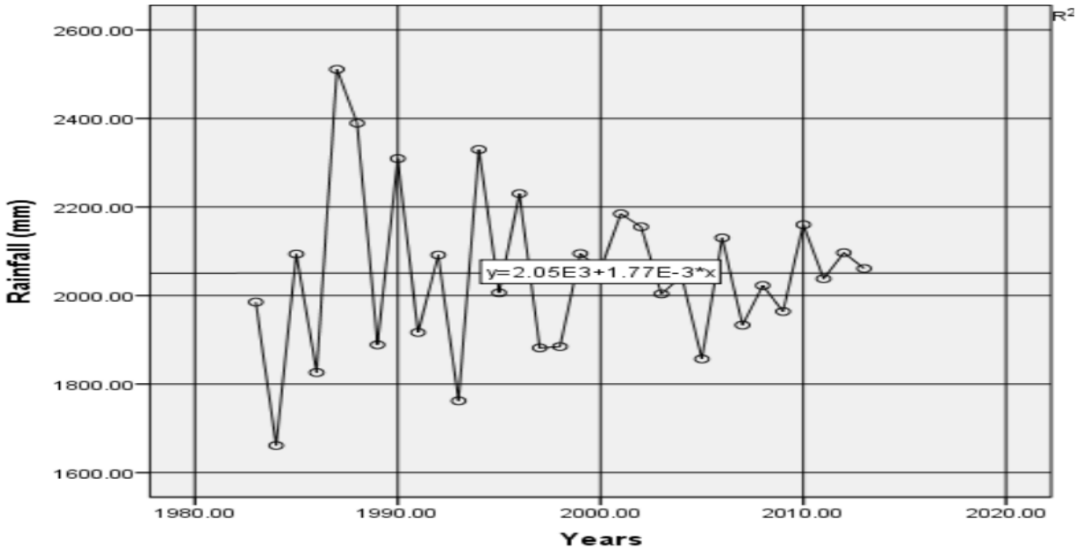


Figure 4.4 showing average precipitation of two weather stations.

Source: Author.

4.4 Kisii Average Minimum and Maximum Temperature Trend Time Series

Figure 4.5 below shows Kisii average minimum and maximum temperatures trend series. From the figure, the mean temperatures have been rising in Karlo weather station. The computed Mann Kendall p value of 0.001 ($p<0.05$) reveals that temperatures are rising over Kisii at a significant pace, since the p value is not greater than alpha level of 0.05. This finding can be associated with much more wider range of factors that are not limited to global warming (Funk *et al* 2008) and land use cover change (Otieno 2013). Elsewhere similar findings were found by Syed (2016) that temperature in Bangladesh showed an upward trend between 1978 -2007.

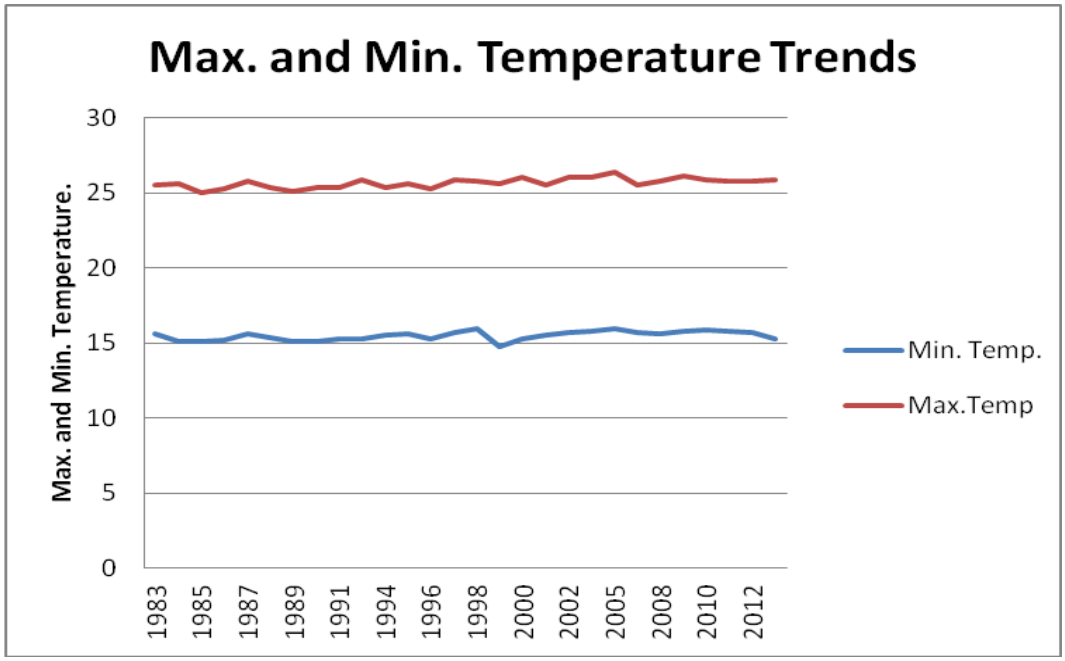


Figure 4.5 showing Kisii average Temperature Variation.

Source: Author.

4.5 Perception of Rainfall Reliability

Respondents were asked to show whether, the commencement of precipitation has been predictable in Kisii County within the last three years and table 4.1 below shows their response. From the table 81% of the respondents strongly disagreed that precipitation commence as expected, whereas 19% agreed that that the commencement of rainfall is reliable. The computed X^2= 138.6 df =1 p=0.00001 was statistically significant. This shows that, a good number of the respondents have lost hope in sowing before the commencement of rains and therefore preferred to wait until they receive the first rain drops before planting.

Table.4.1.Perception in Rainfall Reliability

Response	No. of Respondents.	%
Strongly agree	0	0
Agree	62	19
No opinion	0	0
Disagree	0	0
Strongly Disagree	261	81
Total	**323**	**100**

Source: Author.

4.6 Food Production Trends in Marani Sub-County.

4.6.1. Beans and Maize.

Figure 4.6 below shows beans and maize production as from 2009 to 2015. From the figures the lowest quantity harvested for maize was in 2009 whereas the largest quantity was in 2013. In addition, the highest quantity of beans was in 2012 while the lowest quantity was in 2013. The good harvest in 2013 for maize could be associated to the favourable conditions that prevailed during that year, even though the rainfall anomalies were dropping. However dismal yield of maize in 2014 can be associated with below normal rainfall during the year. On the other hand, a low yield of beans in 2013 is attributable to climate stresses linked to back to back failures in both boreal spring and boreal winter of 2012. (Ongoma *et al.,* 2015).

4.6.2. Production Trends for Sweet Potatoes and Bananas.

Figure 4.6 shows bananas yields in 2009 and 2015.The smallest quantity produced was captured in 2009 whereas the highest was in 2011. From the assessment of the amount of rainfall received the years, 2009 amount of precipitation was less than the long term mean (LTM) whereas 2011 annual rainfall amount received was higher.

This explains the discrepancy in yields considering that bananas may take eighteen months to fully develop, fruit and ripen (Tuo *et al*., 2016). Even though 2011 was one of the worst years in Kenya, seemingly bananas were not affected, may be due to the previous year's precipitation experienced in Kenya.

In the production of sweet potatoes, the lowest quantity produced was in 2013, whereas the highest was in 2015. The study attributed the low production to severe drought in 2012 that extended to 2013 (Funk, 2013). Even though 2015 was normal at the beginning, it later shifted to El Nino conditions towards its end. This explains the high performance in potatoes production in those years.

Figure 4.6 Showing Production trends for Maize, Beans, Banana and Sweet Potato in Marani Sub-County.

Source: Author.

4.6.3 Maize and Beans Prices

Figure 4.7 below shows the production trends of beans and maize prices in 2010 and 2015. From the figures within the last three years, the lowest price for maize was in 2015 while the lowest for beans was in 2014. The study associated the highest increase in price, both beans and maize to back to back dry conditions in 2011 and 2013 which may have led to a dismal harvest (Bahaga *et al.*, 2019). The poor harvest

led to a rise in demand for the available little stock, triggering a price hike. However, since 2015 was an El Niño year and precipitation was favourable, there was sufficient food harvested and the demand of maize and beans eased leading to the eventual price decline.

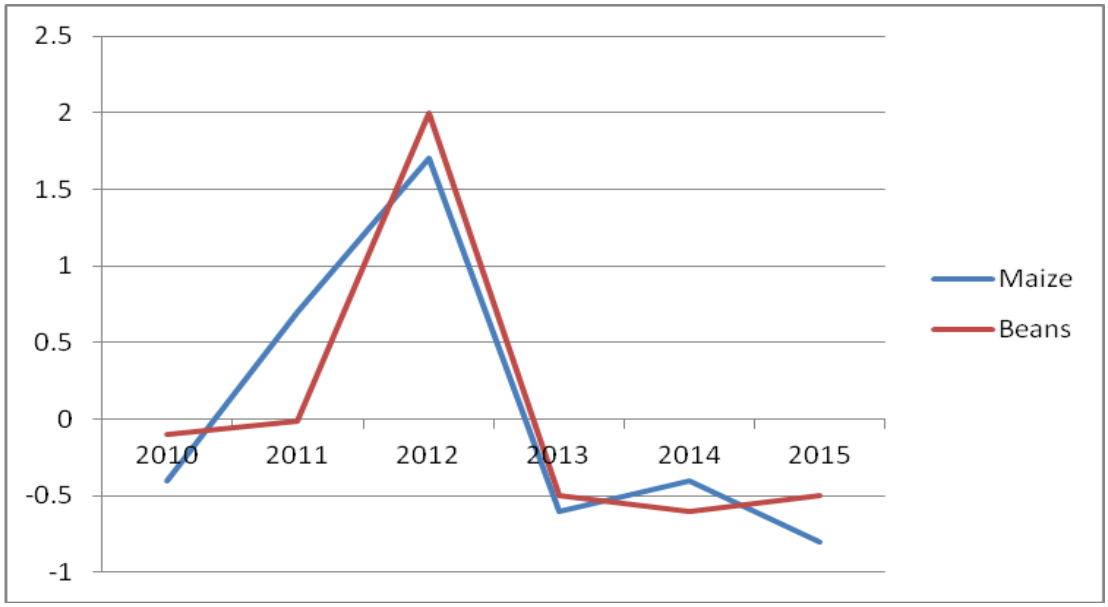


Figure 4.7 Showing trends in the prices of Beans and Maize in Marani Sub County.

Source; Author.

4.7. Food Crop Production in Bomachoge Chache Sub – County

4.7.1 Maize and Beans.

Figure 4.8 below shows the production of beans and maize in Bomachoge Chache between 2006 to 2015. From the figure, the biggest decrease in harvest of beans and maize was realized in 2012.This is attributable to climatic stresses connected to back to back failures in boreal spring and the boreal winter experienced in 2011 and 2012 (Uhe *et al*., 2017, Funk *et al* 2013, Ongoma *et al*., 2015). The highest maize production was recorded in 2006 and 2009 whereas the biggest increment in beans yield was realized in 2013.The good production in 2006 can be linked to the 2005 El Niño condition that spilt over to 2006, stretching to the long rains experienced in

March to May. The year 2009 experienced La Niña event as evidenced with the reduction of annual mean precipitation amount captured in 2009. Conspicuously, maize production in Bomachoge - Chache is on downward production trend whereas yield in beans was on upward production trend. We associated this, to may be precipitation in Bomachoge - Chache was on decreasing trend which adversely affected the production of maize whereas beans were not affected because they take shorter duration depending on type or variety and also require fewer other nutrients since they are able to fix some others on their own (Fenta *et al.*, 2019, Wiraguna 2016).

4.7.2. Bananas and Sweet potatoes.

Figure 4.8 below shows bananas and sweet potatoes production trends between 2009 to 2015. The highest drop in sweet potatoes and Bananas production was in 2012. Similarly this decline can be associated with consecutive dry conditions in 2011 and 2012 (Uhe *et al*., 2017, Ongoma *et al*., 2015). A good bananas production was captured in 2014 and 2015.This production can be linked to enhanced precipitation that commenced in 2013 evolving into a positive ENSO event in the last months of 2015. Generally Bananas yield in Bomachoge - chache has not been affected even though temperature had risen. Similar results were found by Ochieng (2016) that as climate variability and change, affects agricultural output, its effect vary from one crop to another. For instance, temperature may have adverse effects on crops such as maize, while other crops such as tea may have a positive one. In sweet potatoes, the highest production was in 2013.This high harvest can likewise be linked to the evolving positive ENSO event that year.

Figure 4.8 Showing Production trends in maize, beans, Banana and Sweet Potato production in Bomachoge Chache Sub County.

Source: Author.

4.7.3. Beans and Maize Price Trends.

Figure 4.9 shows the prices of maize and beans from 2006 to 2015 in Bomachoge - Chache. From the figure, the peak increase in the price of maize was in 2013 and 2014 while the lowest decrease in price of maize was in 2009. For beans the highest price was recorded in 2015 whereas the lowest price was captured in 2009 and in 2010. The price of beans and maize has steadily been rising since 2009 while it is quite explicable that, the price of maize has been rising, a fact that can be linked to the reduction in maize production all through the years, contrary the study discovered that, as the production of beans increased, also the demand for beans rose. The study attributed this scenario to situation where people may have replaced maize with rice hence the requirement for beans as an accompaniment enhanced its demand.

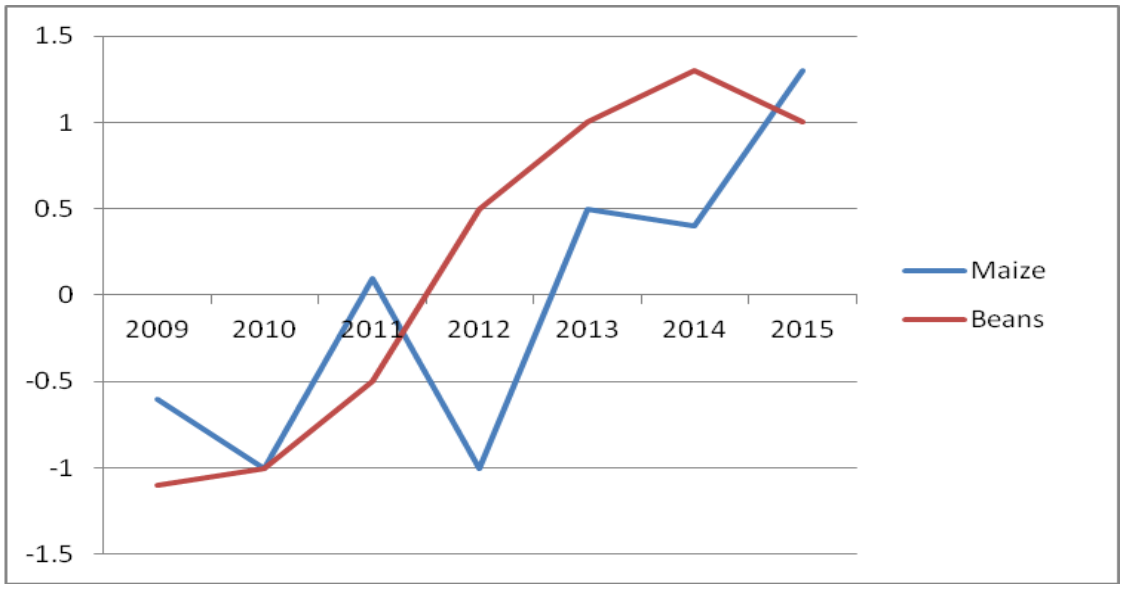


Figure 4.9 showing price trends in Beans and Maize in Bomachoge Chache.

Source: Author.

4.8. Size of Maize Farm.

Farmers were asked to indicate the size of their maize farm and figure 4.10 below shows the findings. Majority of the farmers at 54% had Maize farm sizes below one acre, followed by 33% who had farms ranging between 1 to 2 acres , 8% had 3 acres, 4% had 4 acres while 1% had a maize farm of more than 5 acres. The high number of maize farms that are below one acre may be attributed to competition from other sectors such cash crops and also demand for room for housing.

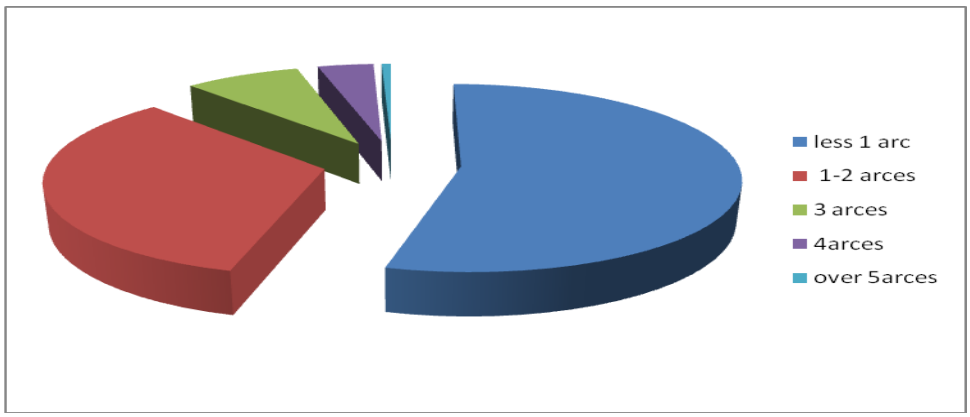


Figure 4.10 Showing sizes of maize farms.

Source :Author.

4.9. Fertilizer Application

Figure 4.11 below shows the application of fertilizers during maize growing. From the figure, majority of the farmers at 92% use fertilizer when planting maize seeds while only 8% do not use fertilizer. The study attributed this scenario where a large proportion of farmers use fertilizer in their maize farming may to due sensitization given by nearby extension officer from ministry of agriculture.

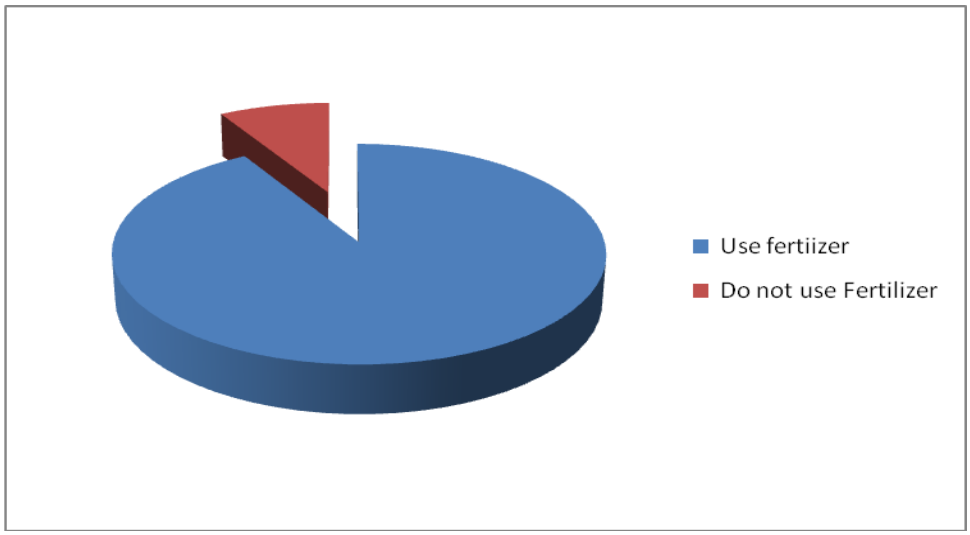


Figure 4.11 showing fertilizer use.

Source: Author.

4.10. Quantity of Maize Production per Season.

Farmers were asked to estimate the production of maize per an acre and figure 4.12 shows the result. From the figure, majority of the farmers at 43% produce 4 bags, 32% produce 5bags and 13% produce 3bags while 3% produce less than 2bags per an acre in one season. The high number of farmers producing 4 bags of maize preseason is attributable to the fact that majority of farmers in Kenya rely on rain fed agriculture that is prone to weather vagaries (Uhe *et al.*, 2017).

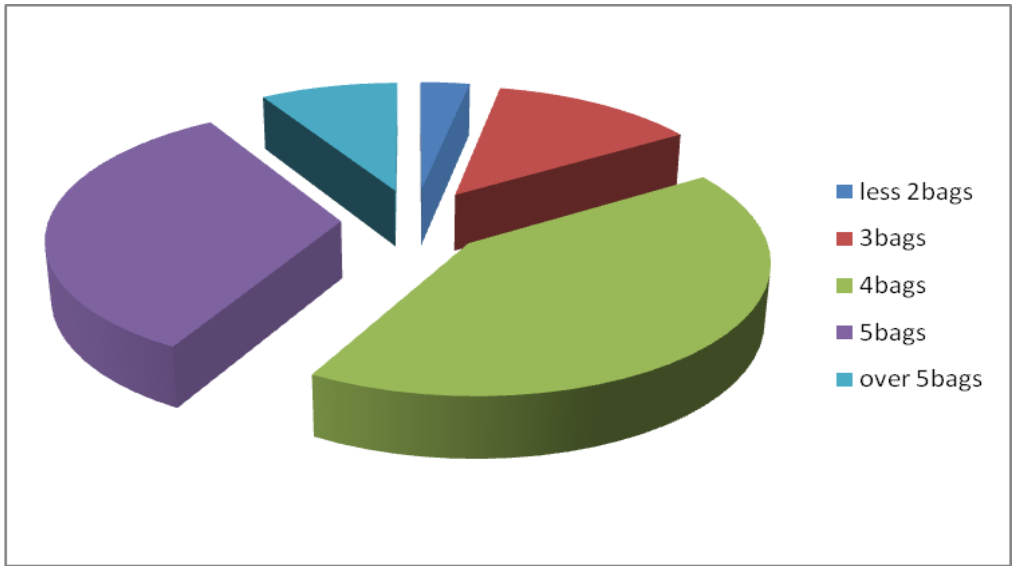


Figure 4.12 showing the production of maize Yields per season.

Source Author.

4.11. Preservation of Maize.

The interviewed farmers were asked to state whether they applied preservation measures after harvesting their maize and figure 4.13 shows the findings. Majority of the farmers at 82% indicated that they apply preservation methods while 14% do not apply any preservation technique as 4% give no opinion. The high numbers of farmers preserving their maize after harvest can be attributed to the fact that majority of the farmers are aware of methods of reducing some postharvest losses through the use of chemical insecticides (Peter *et al* 2019).

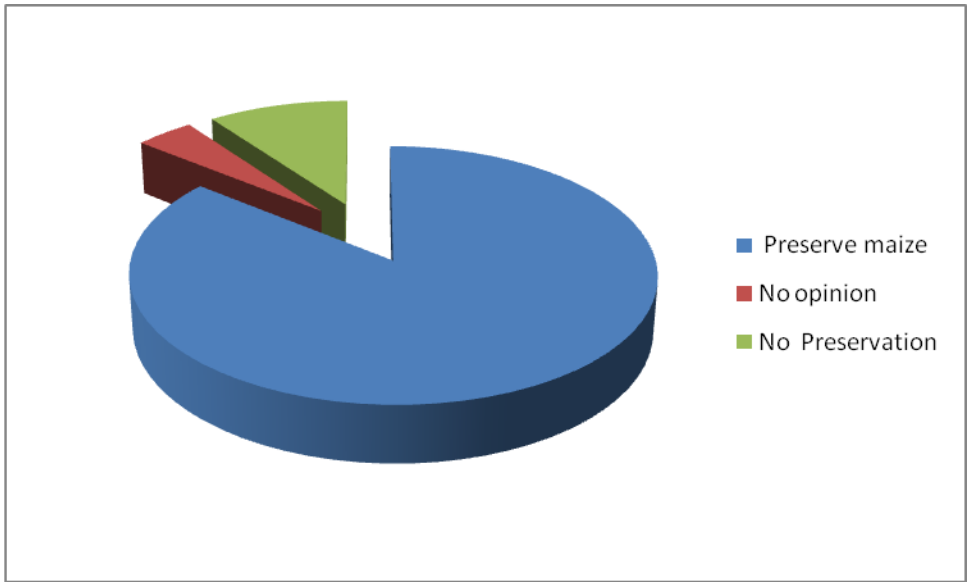


Figure 4.13 showing the preservation of Maize.

Source : Author.

4.12. Quantity of Food Harvested in the last 12 Months.

The interviewed farmers in Kisii County were also asked to state whether they had harvested enough food within the last 12 months of 2016. Table 4.2 shows their response; only 8.6 % of the interviewed agreed that the realized quantity sufficient to enable go through to another season whereas 91.4% of the respondents strongly disagreed that the harvested quantity was sufficient to sustain them all the way the next harvesting season. This finding is backed up by X^2= 248.6 df =1 p=0.00001. Similar results had been revealed by the African Women Centre (2014) who stated that Kisii County is not a food secure region due to urbanization and higher population density. Similar findings were revealed in Ethiopia by Sisha (2020) that a large proportion of households in a ratio of 1:4 were uncertain to obtain family food throughout the year.

Table 4.2 Showing the Quantity of Food harvested in the last 12 Months.

Response	No. of Respondents.	%
Strongly Agree	0	0
Agree	28	8.6
No opinion	0	0
Disagree	0	0
Strongly Disagree	295	91.4
Total	**323**	**100**

Source: Author

4.13. Food Security Coping Strategies.

Respondents were also asked on how they were bridging the gap on food shortages. Our findings shown in table 4.3 indicate that majority of those interviewed at 89.5%, purchased food from markets that may have been imported from other areas as 8.5% reached out to relatives for assistance whereas 2% depend on relief or donated food. Since most of those interviewed indicated that they bought food from nearby markets, they were further probed on the source of the funds that they use to purchase food stuffs and findings were as shown in table 4.4 below. Most of the respondents at 24.8% placed on sale some of their non food crops to access money for needed food stuffs whereas some of the residents at 23.1% turned to selling their property, a situation that placed them more in a vicious cycle of poverty. Similar revelations have been witnessed in Bungoma County (Wabwoba *et al.,* 2016).

Table 4.3 Showing Food Security Coping Strategies

		No. of Respondents.	%
Coping strategy	Buying from nearby Markets	289	89.5
	Food dependency from relatives	27	8.5
	Relief food from government and other agencies	7	2
	Total	**323**	**100**

Source: Author.

Table 4.4 showing source of funding during food shortages

		NO. of Respondents	%
Source of Funding	Selling property	67	23.1
	From employed children	67	23.1
	Cash crops	72	24.8
	Offering labor	45	15.5
	Borrow money	25	9.0
	Others	13	4.5
	Total	**289**	**100**

Source ;Author.

4.14. Planting Strategies.

Table 4.5 shows the sowing practice of the residents who were interviewed. Most of the respondents at 94% wait for rainfall to commence before they can plant crops. This could be due to the unpredictability in the commencement of rainfall which confirms the reason for the perception on the reliability of rainfall in Kisii County. In addition, 17% of the respondents indicated that they usually sow and wait for precipitation to commence whereas 5% went ahead planting and then applied irrigation techniques. The computed X^2= 45.45 df =2 p=0.00001 was significant, an implication that, a large number farmers wait for the commencement of rainfall before they plant. This finding is line with Rankoana (2017) who also found out that a large number of farmers in Limpopo province in Dikgale community in South Africa could also wait for rainfall to commence before planting their seeds.

Table 4.5. Showing Planting strategies of Farmers.

Response	**No. of Respondents.**	**%**
Wait for rainfall	304	94
Plant and wait for rainfall	16	5
Conduct irrigation	5	1
Total	**323**	**100**

Source: Author

4.15. Climate Variability Adaptation Methods.

Soil and water conservation methods at 51.1%, followed by cultivating different food crops at 33.1% as shown in 4.6 below. Those who could prefer shifting the planting dates were 11 % as those who chose to plant different crops were 5.5%. This agrees to

what was also observed in Ethiopia whereby farmers in Haraghe preferred to apply water conservation techniques to reduce the repercussions of climate variability (Lemma 2014).The computed X^2=191.38 df=3 p=0.00001 was significant.

Table 4.6 Showing Climate Variability Adaptation Methods.

Adaptation Methods.	**No. of Respondents.**	**Percentage**
Cultivating different types of food Crops.	106	33.1
Planting best yielding Maize and Beans varieties.	17	5.5
Soil and water conservation measures	164	51.1
Changing planting dates according to the arrival of rainfall	36	11.0
Total	**323**	**100**

Source: Author

4.17. Weather Forecast Response

Residents were asked whether they listened to weather forecasts and how they responded to the prediction. Our findings were that 84% of the respondents do not listen to weather prediction whereas only 16% of the respondents did as shown in table 4.7 below. The computed X^2= 164.4 df =1 p=0.00001 implied that most of Kisii County farmers never listen to weather prediction. On whether those who listen to weather prediction take heed, likewise the study found out that, most of the respondents at 85% did not pay attention to weather prediction while only 15% considered the weather information as shown in table 4.8 below. The computed X^2= 28.50 df= 1 p=0.00001 is statistically significant, an implication that a good number

of respondents in Kisii County do not pay attention to weather prediction or if they did, they do not incorporate weather prediction in their farming activities. This was associated with lack of confidence and perceptive of weather prediction in most farmers. Similar findings were also observed by Chengula and Nyambo (2016), whereby farmers in Tanzania along the slopes of Mt Kilimanjaro use their own native knowledge on weather forecasting methods which are anchored on biological, environmental, astronomical and mythical signs as opposed to modern scientific weather forecasting.

Table 4.7 showing Response to Weather Forecast

		No. of Respondents.	**%**
Listen to weather forecast	Strongly Agree	51	16
	Agree	0	0
	undecided	0	0
	Disagree	0	0
	Strongly Disagree	274	84
	Total	**323**	**100**

Source: Author.

Table 4.8. Showing Perception to Weather Forecasting.

		No. of Respondents	%
Heed to weather forecast	Strongly Agree	8	15
	Agree	0	0
	undecided	0	0
	Disagree	0	0
	Strongly Disagree	43	85
	Total	51	100

Source: Author

4.18. Summary of the Result.

The demographic information of the respondents was collected and analyzed. The gender of respondents was 78% female while 21.5% were male. The age brackets of famers were 18-27 years 6.1 %, 28-37 years was 14.6 % 38-47 years was 29 %, 48-57 years was 24.3% while over 57 years was 26%. The highest education level of the respondents was secondary education 67%, college education 41% while those who had primary education were 2%.

The average precipitation of the two weather station Karlo and Coffee substation was computed and Mann Kendell test was 0.950 ($p>0.05$). This indicated a trend in rainfall precipitation but it was not significant. On average minimum and maximum temperature, the computed Mann Kendell test was 0.001 ($p<0.05$). This revealed a significant trend in rising temperature over Kisii County.

In Marani sub County, the highest maize production was realized in 2013 while the

lowest was in 2009. In addition, the biggest quantity of Beans was harvested in 2013 whereas the lowest quantity was harvested during the course of 2013. The lowest quantity of bananas was harvested in 2009 whereas 2011 had the highest quantity harvested. The lowest quantity of sweet potatoes was harvested in 2013 while the highest quantity was harvested in 2015. The good performance of sweet potatoes in 2015 can be linked to El Niño conditions that were experienced towards the end of that year. The highest price for maize in Marani was in 2012 whereas 2015 had the lowest. We associated the highest maize price to dry conditions experienced in 2011 and 2012 leading to low yields. The low harvest triggered high demand of the maize and beans leading to higher prices. Low prices for both beans and maize in 2015 can be linked to higher harvests that were realized in 2015, hence reducing the demand leading to lower prices.

The study established that in Bomachoge - Chache sub-county, the highest maize production in number of bags was harvested in 2006 whereas 2012 had the lowest. On the other hand, the highest production of beans was harvested in 2013 whereas the lowest was captured in 2012. The lowest banana production was realized in 2012 while the highest was in 2014 and 2015. For sweet potato production, the highest production was realized in 2013 while the lowest was harvested in 2012. On market price, the highest price of maize was in 2013 and 2014 whereas the lowest was realized in 2009.The highest price of Beans was realized in 2015 while lowest was captured in 2009 and 2010. Generally the price of beans and maize has steadily risen since 2009.

On rainfall reliability, 81% of the respondents indicated that, rainfall had failed to commence as anticipated whilst 19% indicated that, rainfall commenced when

expected. The computed X^2= 138.6 df =1 p=0.00001 was statistically significant, hence most farmers wait for the onset of rainfall before planting. On sizes of maize farms, majority of the farmers at 54% had Maize farm sizes below one acre, followed by 33% who had farms ranging between 1 to 2 acres while 8% had 3 acres, 4% had 4 acres while 1% had a maize farm of more than 5 acres. On the production of maize per one acre per season, the study found out that, majority of the farmers at 43% produce 4 bags , 32% produce 5bags, 13% produce 3bags while 3% produce less than 2bags per an acre in one season. On the use of fertilizer, the study found out that, majority of the farmers at 92% use fertilizer when planting maize seeds while 8% do not. On ways of preserving the harvested yields, the highest number of the farmers at 82% indicated that they apply preservation techniques while 14% do not apply any preservation method as 4% give no opinion. The study also revealed that, in a span of 12 months, 91.4 % of the farmers did not harvest enough food to sustain their family needs; only 8.6 % of the farmers harvested enough food to sustain their family.

The X^2= 248.6 df =1 p=0.00001 was significant and therefore an indication that a large number of the respondents were experiencing food insecurity. This meant that, the food insufficient farmers had to find coping strategies. 89% of the respondents bought food from nearby markets, 8.5% begged from relatives while 2% depended on relief food. The X^2= 51.3 df =1 p=0.00001 was significant hence a high variation in coping strategies. In addition, to bridge the gap of food insufficiency, Majority of farmers buy food from markets while a few got food assistance from donors. The money used to purchase additional food emanated from different sources. For instance 24.8% got money from the sale of cash crops, 23.1% from selling property, 15.5% by offering labor, 23.1% obtained funds from their working children, 9% borrowed while

4.5% used other methods.

Famers in Kisii County have different planting techniques. For instance we found out that 94% of the farmers wait for rain before planting, 5% sow and wait for precipitation to commence whereas 1% plant and apply irrigation. The computed X^2= 457.45 df =1 p=0.00001. This means that the variation in planting habit is highly significant. In addition, farmers adopted different strategies to cope up with climate variability whereby 33.1 % preferred to cultivate different crops, 5.5 % plant different varieties, 51.1% prefer soil and water conservation methods and 11% prefer to wait until the commencement of rainfall. The X^2=191.38 df =1 p=0.00001 an indication that the observed variation in coping strategies was quite significant. The study a also found out that, very few farmers listened and considered weather services or information in their agricultural activities. Only 16% of the farmers listened to weather forecasting while 85% never listened. Out of the farmers who listen to weather information, only 15% of them took heed to weather predictions. From the X^2= 28.50 df =1 p=0.00001, it is quite clear that a significant number of respondents do not care about the weather forecasts. This could lead to poor food production that in turn leads to nutritional challenges such as malnutrition.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS.

5.1 Introduction.

This chapter has a summary of research findings, conclusions drawn based on the results, recommendations and lastly suggestions for further research.

5.2. Summary of the findings.

The research was done in Bomachoge Chache and Marani in Kisii County. It had three objectives namely; to examine rainfall and temperature trends for the last 31 years in Kisii County, to investigate the effect of rainfall variability on the production of food in Kisii County and finally to identify the coping techniques at house hold level adapted to reduce the impact of food shortages in Kisii County.

On precipitation variation in Kisii County, the p value computed using Mann Kendall test for the average rainfall totals from Karlo and coffee substation weather station was 0.590 ($p>0.05$). This implied a trend in the average precipitation from the two weather stations but it was not statistically significant. The computed Mann Kendall p value of 0.001 ($p<0.05$) of the average minimum and maximum temperatures revealed that, temperatures are rising over Kisii county at a significant pace, this is so because the p value is not greater than alpha level of 0.05.

In Marani sub County, the highest quantity of maize production was realized in 2013 while the lowest was in 2009. In addition, the biggest quantity of Beans was harvested in 2013 whereas the lowest quantity was harvested during the course of 2013. The lowest quantity of bananas was harvested in 2009 whereas 2011 had the highest quantity harvested. The lowest quantity of sweet potatoes was harvested in 2013 while

the highest quantity was harvested in 2015. The highest price for maize in Marani was in 2012 whereas 2015 had the lowest. Low prices for both beans and maize in 2015 can be linked to higher harvests that were realized in 2015, hence reducing the demand leading to lower prices.

The study established that in Bomachoge - Chache sub-county, the highest maize production in number of bags was harvested in 2006 whereas 2012 had the lowest. On the other hand, the highest production of beans was harvested in 2013 whereas the lowest was captured in 2012. The lowest banana production was realized in 2012 while the highest was in 2014 and 2015. For sweet potato production, the highest production was realized in 2013 while the lowest was harvested in 2012. On market price, the highest price of maize was in 2013 and 2014 whereas the lowest was realized in 2009.The highest price of Beans was realized in 2015 while lowest was captured in 2009 and 2010. Generally the price of beans and maize has steadily risen since 2009.

Farmers have devised different strategies to cope up with climate variability whereby 33.1 % preferred to cultivate different crops, 5.5 % plant different varieties, 51.1% prefer soil and water conservation methods and 11% prefer to wait until the commencement of rainfall.

Based on the above findings, the following conclusions can be drawn;

i) There was no significant trend in rainfall while minimum and maximum temperatures show a significant rising trend in Kisii County.

ii) The price of Maize and beans has been rising steadily since 2009.

iii) Kisii County is food insecure despite general perception that the County is a 'bread basket'

iv) Food security coping strategies in Kisii County include: Buying food from nearby markets, Reliance on relief donations from the government and other agencies.

v) Climate variability coping strategies include multi-cropping, soil and water conservation, change of sowing dates to coincide with the rains.

vi) The impact of climate variability can be reduced by soil and water conservation techniques, cultivation of different types of food crops, wait for the commencement of rain before planting and lastly plant crop varieties that have high resilience.

5.4 Recommendations

The following should be adopted in order to realize food security in Kisii County.

i) Civic education to sensitize the public on weather and climate information so that farmers can incorporate such information in their agricultural activities.

ii) Establish other sources of water such as creating large dams and constructing bore holes in order to provide water during prolonged drought periods.

iii) Encourage farmers to plant deep rooted crops such as Bananas to cushion them during prolonged droughts.

iv) Adopt fast growing food crops e.g vegetables, beans; diversify food production systems e.g aquaculture and apiculture, poultry; adopt irrigation

farming.

5.5 Suggestions for further study

The following are suggestions, the study wishes to propose for further investigation based on this research findings because, this study has only examined two climatic factors i.e rainfall and temperature, therefore, there is a need to undertake research on other facets in order to additionally contribute to national efforts towards realization of Vision 2030.

i) Study on other alternative crop varieties that can withstand prevailing climatic conditions in Kisii County.

ii) Evaluate the effect of land fragmentation in food production in Kisii County

REFERENCE

Abass Adebayo B., Nduguru Gabriel.,Mamiro Peter, Bimedele Alenkhe, Nicholas Mlingi, Mateete Sekunda (2013). Post harvest losses in a maize based farming system of Semi Arid savannah area of Tanzania. *Journal of Stored Products Research*. Doi.10.1016/j.jpr.

Abrha Misgina Gbrehiwot (2015). Local Climate Trends and Farmers' Perceptions in Southern Tigray, Northern Ethiopia. *International Journal of Environment and Sustainability*. Vol.4. Issue 11. PP267-277. Doi:10.24102/ijes.v4i3.563.

Adom Dickson, Hussein Emad Kamil and Joe Adu Agyem (2018). Theoretical and Conceptual Frame Work. Mandatory Ingredients of Quality Research. *International Journal of Scientific Research* 7.438-441.Pp 1-4.

African Institute for Development Policy (2012). Population Climate Change, and Sustainable Development in Kenya. *Bridging, Development Research Policy and Practice* pp 1-4.

Afful David B. (2016). Public Extension Agents Need For New Competences: Evidence from a Climate Variability Study in Limpopo province of South Africa. *Journal of Agricultural Extension* 44(2), Pp 59-70: ISSN 2413-3221. http://dx.doi.org/10.17159/2413-3221/2016/v44n2a387

Agwu Ekwe A., Ahmadu Festus O., Tedy, A. Mara M., Emmanuel, T. Woller, Leroy W. and Cegbe (2011). Agricultural Innovations for Climate Change Adaptation and Food Security in W. Africa, Case of Nigeria Sierra Leone and Liberia. African Technology Policy FrameWork.ISBN:978-9966 Pp 30-44.

Ahmad Ijaz, Deshan Tang, Tiang Wang Fang, Mei Wang and Bakhtawar Wegan (2015). Precipitation Trends over time Using Mann Kendall and Spearman rho Test in Swat River Basin, Pakistan. *Advances In Meteorology* vol.2015. https://doi.org/10.1155/2015/431860.

Ahmadi Davod, Sinclair Kate and Ebadi Narges (2017). Magic References for Learning About Healthy Eating. Differences Between Canadian Anglophone and Francophone men and women. *Sage Open.* pp1-10 doi: 10.1177/2.58244017707992

Anyah Richard O. and Semazzi Fredrick (2006). Climate variability over the Greater Horn of Africa based on NCAR AGCM ensemble. *Theor. Appl. Climatol.* **86,** 39–62 (2006). https://doi.org/10.1007/s00704-005-0203-7

Ayugi Brian, Wen Wang & Chepkemoi Daisy. (2016). Analysis of Spatial and Temporal Patterns of Rainfall Variations over Kenya. *Journal of Environmental Earth Sciences.* 6. 69-83.

African Women Studies Cemter (2014). Ensuring food security in Kisii County. University of Narobi press. African Women's studies centre.Pp.34-49.

Bahaga Titike K, Fink A. H. and Knippertz P. (2019), Revisiting Interannual to decadal teleconnections influencing seasonal rainfall in the greater horn of Africa deeming 20th century. *International Journal of Climatology* https://doi.org/10.1002/joc.5986.

Beddington John (2010). Global food and farming futures. Philosophical transactions of the Royal Society of London. Series B, Biological sciences. 365. 2767. 10.1098/rstb.2010.0181.

Cattani Elsa., Merino A. and Levizzani V. (2016). Evaluation of Monthly Satellite Derived Precipitation Products over E.Africa. *American Meteorological Society*.https://doi.org/10.1175/JHM-D-15-0042-1

Chauhan Nitin Mahendra (2017). Aflatoxins a risky menace for Africans Flood Commoditiesdoi:10.5772/intechopen.69302. https://www.intechopen.com/ books/aflatoxin-control-analysis-detection-and-health-risks/aflatoxin-a-risky-menace-for-african-s-food-commodities

Chase Sova, Kimberly Flowers and Christian Man (2019). Climate Change and Food security: A Test of U.S leadership in a Fragile world. Center for strategic and international studies. Brief Report). https://www.csis.org/analysis/climate-change-and-food-security-test-us-leadership-fragile-world.

Chengula Fasco and Nyambo B. (2016). The Significance of Indigenous Weather Forecast Knowledge and Practices under Weather Variability and Climate Change. A Case Study of Small Holder Farmers on the Slopes of Mt.Kilimanjaro. *International Journal of Agricultural Education*. Vol.2 (2), PP 031-043 2016.

Chouhan Goraknath, Suradkar D.D. and Anarase M. S. (2018). Farmers knowledge of climate change in Relation to crop management. *International Journal of Current Micro Biology and Applied Sciences*. ISSN: 2319-7692 Special issue 6 pp 2445-2451.

Darkwa Kwebana, Ambachew Daniel, Mohammed Hussein, Asfaw Asrat and Blair Mathew.W. (2016). Evaluation of Common Bean (*Phaseolus vulgaris L)* Genotype for Drought Stress Adaptation in Ethiopia. *Crop Journal* vol. 4, issue 5 pp 367-376 https://doi.org/10.1016/ j.c.j.2016.06.007

Dinko Hanaan Dinko (2017). Climate change and changing food security risk in Ghana. *African Journal of agriculture and food security*. ISSN 2375-1177Vol. 5(3) Pp 186-192.

Ebele Nebedum Ekene and Emondi Nnaemeka Vincent (2016): Climate change and its impacts on Nigerian economy. *Journal of Scientific Research and Reports* 10(6): 1-13, 2016; article no.JSRR.22162 ISSN: 2320-02227.

Ecker Olivier and Clemens Breisinger (2012). Food Security Systems: A New Conceptual Framework. IFPRI. Discussion paper 1166 Washington D.C. *International Food Policy Research Institute* (IFPRI). http:ebrary.ifpri.org/cdm/ref/collection/p15738 coll 2/id/126837.

Edame Greg E., Anam B. Ekepenyong ,William Fonta & Duru E.J.C. (2011).Climate Change, Food Security and Agricultural Productivity in Africa .Issues and Policy directions. *International Journal of Humanities and Social Sciences. Pp 208.*

Evans Wabwire Odhiambo, Mukhovi S. and Nyandega I A (2020). The Spatial and Temporal Characteristics of Rainfall over the Lake Victoria Basin of Kenya in 1987-2016. *Atmospheric and Earth Sciences* 10 (02); 240-257, doi:10.4236/acs.2020.102013

Eshetu Amongne Afaw and Tessema Wondifraw Workineh (2017). Effect of El nino induced drought on student' academic performance .A case study in Borena worenda of South wollo zone, Ethiopia . *International Journal of Academic Research in Education and Review.Vol. 5(2) pp 37-47.*

Escamilla Rafael Perez (2017). Food Security and the 2015-2030 Sustainable development Goals. From Human to Planetary Health: Perspectives and Opinions, Current Development in Nutrition vol.1 issue 7 2017, e ooo513, https//doi.org/10.3945/cdn. 117.000513.

FAO (2017). Extreme Drought and Floods Threaten Food Security in Sri Lanka. Food and Agriculture Organization of the United Nations 2017.www.fao.org/srilanka/news/detail-events/en/c/897464.

FAO (2018). Global Report on Food Crises (2018). Food Security Information Network 2018.

FAO (2018). The Future of Food and Agricultural Alternative Pathways to 2050. Food and Agricultural Organization of United Nations. Rome Italy n.228

FAO(2020a). Country Brief. http://www.fao.org/giews/ country brief/country. jsp?code =KEN.Date accessed 20/05/2020.

FAO (2020b). Low income food deficit countries list for 2018. FAO 2020

FAO, IFAD, UNICEF, WFP and WHO (2017). The State of Food Security and Nutrition in the world 2017. Building Resilience for Peace and Food Security. Rome. FAO 117 pp. ISBN 978-92-5-109888-2

FAO, ECA and NUC (2020). African Regional Overview of Food Security and Nutrition 2019. Accra https:/doi.org/10.4060/CA7343 EN

Famine Early Warning System (2010). A climate Trend Analysis of Kenya-August 2010.USGS Science for Changing World. Rolla Denvar Publishing Service Centres.

Fer Istem, Tetjen Brita, ChristianWolff and Florian Jeltsch (2017). The Influence of El-Niño- Southern Oscillation Regimes on Eastern African Vegetation and its Future Implications under the RCP8.5 Warming Scenario. *Biogeoscience* 14.4355-4374.10.5194/bg-14-4355-2017

Fenta Berhanu Amsalu, Beebe Stephen. E. and Kunert J Karl (2019). Role of Fixing Nitrogen in Common Bean South under Water Deficit Conditions. *Food and Energy Security.* https://doi.org/10.1002/fes 3.183

Finney Declan L., Marsham John H, Jauscson Lawrence S. and Kendon Elizabeth J. (2019). Implications of Improved Representation of Convection for the East Africa Water budget using a convection permitting model.AMS https://doi.org/10.1175/JCLI-D-18-03871

Funk Chris, Greg Husak, Joel Michaelsen, Shraddhanand Shukla, Andrew Hoell, Bradfield Lyon, Martin P. Hoerling, Brant Liebmann, Tao Zhang, James Verdin, Gideon Galu, Gary Eilerts, and James Rowland (2013). Attribution of 2012 and 2003–12 rainfall deficits in eastern kenya and southern Somalia [in "Explaining Extreme Events of 2012 from a Climate Perspective"]. *Bull. Amer. Meteor. Soc.*, **94** (9): S6–S9

Funk Chris (2013). Explaining Extreme Events of 2011 from a Climate Perspective. *Bulletin of the American Meteorological Society* (93): 1041-1067, doi: 10.1175/BAMS-D-11- 00021.1.

Funk Chris, Dettinger MD, Michaelsen J.C., Verdin J.P., Brown M.E., Barlow M., Hoell A. (2008) Warming of the Indian Ocean Threatens Eastern and Southern African Food Security but could be Mitigated by Agricultural Development. *Proc. Natl. Acad. Sci*. USA, 105: 11081–11086.

Gebrechorkos Solomon H., Hülsmann Stephen and Bernhofer Christian (2019). Long-Term Trends in Rainfall and Temperature using High-Resolution Climate Datasets in East Africa. *Sci Rep* **9,** 11376 (2019). https://doi.org/10.1038/s41598-019-47933-8.

Gichere K. Samuel, Geoffrey Olado, Douglas N. Anyona., Ally Said Matano, Gabreil O. Dida, Paul O Abuom.,… Ayub V.O afulla (2013). Effects of Drought and Floods on Crops and Animals Losses and Socio-Economic Status of Households in the Lake Basin Region of Kenya. *Journal of Emerging Trend in Economics and management Science.*ISSN 2141-7024. Pp 35-37.

Ghebrezgabher Mirhetab, Yang Taibao and Yang Xuemei (2016). Long Term Trend of Climate Change and Drought Assessment in the Horn of Africa. *Advances in Meteorology*. Vol. 2016 https://doi.org/10.1155/2016/8057641

Godden, Bill (2004). Sample size formulae. *Journal of statistics,* 3,66 https://www.alnap.org/help-library/sample-size-formulas

Government Of Kenya (2010). Short Rains Assessment Report. *Kenya food security steering Group* Pp 1-42.

Hirvonen Kalle & Sohnesen Thomas & Bundervoet Tom (2018). Impact of Ethiopia's 2015 Drought on Child Undernutrition. World Development 131(2020)104964. Pp 6-20.

Hox Joop & Boeije Hennie. (2005). Data collection, primary versus secondary.. Encyclopedia of Social Measurement. Elsevier Inc. Utrecht University. Utrecht. Netherlands.1. 10.1016/B0-12-369398-5/00041-4.

Indeje Matayo, Fredrick H.M Semazzi and Laban J. Ogallo (2000). ENSO Signals in E. African Rainfall seasons. *International Journal of Climatology*. https://doi.org/10.1002/(sici)1097-0088(200001)20:1<19::AID.JOC 449>3.0co:2-0. P 22.

The Intergovernmental Panel on Climate Change (2017). IPCC Fifth Assessment Report (ARS) Observed Climate Change Impacts Data Bases,Version 2.01.palisades NY:NASA Socio-Economic Data and Implications

Center(SEDAC(https://doi.org/10.7927/H4FT8JOX . 16/05/2020

Kpolovie Peter J. (2016). Single Subject Research Method: .The needed simplification. *British journal of Education* Vol.4:6 Pp 68-95.ISSN 2055-0227.

Kaitlin Patterson, Lea Barrang. F, Shuaib Lwasa, Didacus B Namanya, James Ford, Fortunate Twebeze, Sierra Clark, Blanaid Donelly and Sherilee L. Harper (2016). Seasonal Variation of Food Security among the Batwa of Kanungu, Uganda. Cambridge open. Doi:10.1017/s1368980016002494.

Kisii County Government (2013). The fFirst County Integrated Development Plan 2013-2017. Pp 14-126.

Kisii County Government (2018). County Integrated Development Plan 2018-2022. KCG 2018.

Kenya food security steering group (2017). The 2016 Short Rains Season Assessment Report. https://reliefweb.intelsites relief web.int/files/resources/Kenya 2016 SRA. National report date accessed 16/05/2020.

Kilonzi Titus M. and Ndungu C.Nderitu (2014). Challenges Affecting Implementation of Vision 2030 Strategic Decisions in Public Sector in Liakipia County. Kenya. *American Research Institute for Policy Development.*Vol.2:2 pp 77-93.ISSN- 2333-5823.

Kimberly Zeuli, Austin Nijhuis, Ronald Macfarlane and Taryn Ridsdale (2018). The impact of Climate Change on the Food System in Toronto. *International Journal of environmental research and public health*. 2018 Nov,15 (11)2314 doi 10.3390/ijerph 1511234.

Klocke Daniel, Brueck Mathias, Hohenegger Cathy…..(2017). Rediscovery of the Doldrums in Storm-Resolving Simulations over the Tropical Atlantic. *Nature Geosci* **10,** 891–896 (2017). https://doi.org/10.1038/s41561-017-0005-4.

Kumba Janepha K., Wegulo Francis and Otieno Joseph (2015). The Influence of Agricultural Land use on Household Food Security in Kisii Central Sub County. *Journal of Economics and Sustainable Development*. Vol. 6 no 6 (2015).

Kumar Deepak and Kalita Prasanta (2017). Reducing Post Harvest Losses during Storage of Grain Crops to Strengthen Food Security in Developing

Counties. *Foods 2017,6,8*

Kenya National Bureau of Statistics (2015). Kenya Demographic and Health survey 2015.

Kenya National Bureau of Statistics (2019). 2019 Kenya Population and Housing. 2019 vol.1.ISBN:9966-102-09-6.

Komlan Koudhahe, Koffi Djamana., Ansoumana Bodian, Suat.Imark., Mamadou Sall, Lamine Diop, Alpha Balde, and Daran R.Rudrick (2017). Trend Analysis in Rainfall, Reference Evapo-Transpiration and Aridity Index in Southern Senegal: Adaptation to the Vulnerability of Rainfall rice Cultivation to Climate Change. *Journal of Earth and Environmental Sciences. V.7 No.4.doi:10 4236/acs.2017.74035*,

Leidman Eva, Mich M. Lilian, Humphrey Alexa, Mil Leonie.T.V., Wilkinson Canline, Koech M.Chelangat, Sebuliba Henry, Siddique Mohammed Abu Bakr and Biluka Oleg (2020). Malnutrition Trends in Rohingya Children Aged 6-59 Months Residing in Informal Settlement in Cox's Bazar District, Bangladesh: An Analysis of Cross-Sectional, Population-Representative Surveys. *Plos Medicine* 2020. https://doi.org/10.137/journal .pmod.1003060

Lemma Zemedu (2014). Small holder's Vulnerability to Food Security and Coping Strategies. In the face of Climate Change East Hararghe- Ethiopia. *Journal of Economics and sustainable development*. P 93.

Lewis Kirty (2017). Understanding Climate as a Driver of Food Insecurity in Ethiopia. *Climate change* 144,317-328(2017) https:doi.org/10.1007/510584-017-2036-7.

Lopez Amparo Palacio, Christiaensen L.U. and Kilic Talip (2016). How much of the Labor Force in African Agriculture is Provided by Women. *Food Policy* Elsevier Ltd. Pp-53-57.

Lolemtum Joseph, John F. Obiri and Mugalavai M. Edward (2017).The Impact of Drought on Food Security in Weast Pokot County, Kenya. *International Journal of scientific Research publication* Vol.7:6.ISSN 2250-3153.

Louis Parker, Clement Bourgoin, Arrmando Martinez-Valle. and Peter L (2019). Vulnerability of the Agricultural Sector to Climate change. The development of a pan tropical climate risk vulnerability assessment to inform sub-national decision making. *Journal plos one*.v.14(3):2019

doi 10.137/journal pone 0213641

Lu Bo, Li-Ren Hang , Scaife Adam, Jic Wu Nick Dunstone, Deus Smith, Jiangua Wan,Rorie Eade,Craig Maclahlan and Margaret Gordon (2018). An Extreme Negative Indian Ocean Dipole event in 2016. Dynamics and predictability. Climate dynamics 51, 89-100(2018) https://doi.org/10.1007/s00382-017-3908-2

Magray Mudsir, Hussain Kurshid., Aijax Malik. Singh P and Nabi Ambreen. (2107). Post Harvest Management of Vegetable Crops: Introduction. *Journal of Pharmacology and Phytochemistry*. P. ISSN 2349-8234.

Margaret Grosman Rosso (2018). Climate Change and Individual. *American journal of comparative law*, vol.66 pp 345-378 https://doi.org/10.1093/lascc

Masese Clitson O., Nyabuti K. Ondimu, Mironga, John Momanyi (2016). Identification of weather Shocks Associated with Rainfall in Kisii Central, Kisii County. *Journal of Environmental Science Toxicology and Food Technology* ISSN: 12319-2399 vol:10, issue 7.

Masih Ilyas, Maskey Shreedhat, Mussa F. Firas and Trambauer Patricia (2014).A Review of Droughts in the African Continent: *A Geospatial and long – Term Perspective*. Pp 2681.

Marza Bogdan, Angelscu Carmen and Tindeleche Christina (2015). Agricultural Insurance and Food Security. The New Climate Challenges. *Procedia Economics and Finance* **27** (15) 594-599.Doi.org/10.1016/S2212-5671 (15)01038-2.

Mawenjje Joseph (2016). Food Prices, Energy and Climate Shocks in Uganda. *Agric econ* **4**, 4 (2016). https://doi.org/10.1186/ s40100-016-0049-6.

Marchant Rob & Mumbi, Cassian & Behera, Swadhin & Yamagata, Toshio. (2007). The Indian Ocean Dipole – the Unsung Driver of Climate Variability in East Africa. *African Journal of Ecology*. **45**. 4 - 16. 10.1111/j.1365-2028.2006.00707.x.

Makenzi Paul M., Ketiem P., Mranga E. and Wekesa C (2013). Trend Analysis of Climate Change and Its Impact on Crop Production in the Lower Tana River Basin, Kenya. *Octa Journals of Environmental Research*.Vol.1(4): 237-248.ISSN: 2321-3655.

Mendoza Rodgno J, Sabillon Luis, Martinez Campabadal C, Adams Heather and Blanchin Adams (2017). Traditional Maize Post Harvest Management

Practices Amongst Small Holder Farmer in Guatemala. *Journal of Stored Products Research*, **71** (2017) pp l4 doi10.1016/j.spr.2016.12.007

Majumder Bala S., B.K, Ashad M.M,, Hague M. A and Hossain M.A (2016). Food Security Through Increasing Technical Efficiency and Reducing Post Harvest Loss of Rice Production In Bangladesh. *Food Science* **8,** 361-374 (2016).

Madegwa Yvonne, Onwonga Richard, Shibairo S.Solomon and Karuku George (2016). Farmers Perception and Adaptation strategies in Climate Change in Lower Eastern Kenya. A case of finger millet (*Ebusine coracana* (L)) Gaertn production. *Journal of Agricultural Science*; vol. 8.no12 2016 ISSN 1916-9752 E-ISSN 1916-9760 doi;10.5539/jas.v 8n12p33

Marigi Samuel N. (2017). Climate Change Vulnerability and Impacts Analysis in Kenya. *American Journal of Climate Change* vol. 06 no.01 (2017), doi 10.4236/ajcc.2017.61004

Marigi Samwuel N, Njogu Alphxand Kaimba and Githunguro William (2016). Trends of Extreme Temperature and Rainfall Indicaters for Arid and Semi Arid Lands of South Eastern Kenya. *Journal of Geoscience and Environment Protection.*Vol.12 (2016). doi:10.4236/gop.2016.412012.

Mirzabaev Alisha (2013). Impact of Weather Variability and Climate Change on Agricultural Resources in Central Asia. *Quartery Journal of International Agriculture* 52:3:237-252.

Mohamed Abdulahi Abduselam (2017). Food Security Situation in Ethiopia. A review Study. *International Journal of Health Economics and Policy* vol.2 no.3. 2017 pp 86-96 doi:10.11648/ j hep.20170203.11.

Ministry Of Agriculture (2013). Food Security Assessment Report. *Department of crops* Pp 2-24.

Mugenda Abel Gitau. (2008). Social Sciences Research. Applied Research and Training Services: Kenya. Pp 193-196.

Mujib Rehman B., Nausahad K, and Inayatullah Jan (2007). Post Harvest Losses in Tomato Crop. A case of Peshawar valley. *Sarhad Journal of Agriculture* Vol 23.No 4 p 1281.

Murthy Vivek H. (2016) Food Insecurity Public Health Reports vol. 131(5) 2016 doi:10.1177/0033354916664154.

Nabil Ahmed, Hussainy F.M., Eid M.M. and Mahmoud MAlaa (2018). Studying the Movement of Inter Tropical Convergence Zone (ITCZ) over Africa Internal Equinox. Al-Azhar bulletin of science, basic science sector article 2 vol. 29 issue 2-B pp 7-15 doi:10.21608/ABSB.2018.60522.

Nyale E.H., & China S.S. & Makhanu, Ferdinand. (2019). Effects of Climate Smart Agriculture Technologies on Household Food Security in Makueni County, Kenya. *International Journal of Scientific and Research Publications* (IJSRP). 9. p9566. 10.29322/IJSRP.9.11.2019. p 9566.

Nyariki Ibrahim S., Kiprop Bett. K. Hillary, Patience Mshenga& Newton Nyairo. (2015). Analysis of Technical Efficiency among Smallholder Farmers in Kisii County, Kenya. *Journal of Agriculture and Veterinary Science*.Vol.8, issue 3 ver.1 pp 50-56.

Ndukhu Onwonga N., Onwonga, Wahome G., Kironchi R. G. and Jensen H.Henning (2016) Assessment of Organic Farming Knowledge and Adaptation Strategies to Climate Change and Variability in Central Kenya. *Journal of Applied Science and Technology* 17 (6):1-22,2016 ISSN 2231-0843 NLMID:10166454.

National Drought Management Authority (2017). National Drought Early Warning Bulletin. http.//www.ndma.go.ke/resource-center/send/39-drought-updates/4116-national drought-early warning bulletin-March 2017.Aceessed on 16/05/2020.

National Drought Management Authority (2020) Natural Drought Early Warning. February 2020.https://www.ndma.go.ke/index.php/resource-center/national-drought-bulletin/category/39-drought-updates

Nelson Gerald C., C, Mark W. Rosengrat, Jawa Koo., Richard Robertson., Timoty F., Tingju, Zhu.,... David Lee (2009) .Climate Change Impact on Agriculture and Cost of adaptation. Pp 2-30.

Nicholson, Sharon E.. (2016), The Turkana low level Jet: Mean Climatology and Association with regional aridity. *International Journal of Climatology*, **36** (6), 2598-2614 doi10:1002/joc.4515.

Nsubuga Francis Wasswa and Rantenbach Hannes (2018). Climate Change and Variability a Review of What is Known and out to be Known for Uganda. *International journal of climate change strategies and*

management, vol.10 no.5 pp 752-771 https//doi.org/10.1108/ijccsm-04-2017-0090.

Ochieng Justus, Karimi Lilian and Mathenge Mary (2016). Effects of Climate Variability and Change on Agricultural Production. The case of small scale farmers in Kenya. *Journal of Life Science, https://doi.org/10.1016/.njas.2016.03.005*

Ogechi Benard & Waithaka Edward (2014). Land Use Land Cover Changes and Implications for Food Production: A Case Study of Keumbu Region Kisii County, Kenya. *International Journal of Science and Research*. 3. 752-758.

Okal Harriete. A., Ngetich F. K., & Okeyo, J. M. (2019). Spatial Evaluation of Droughts Using Selected Satellite-based Indices in the Upper Tana River Watershed, Kenya. *International Journal of Plant & Soil Science*, *30*(1), 1-13. https://doi.org/10.9734/ijpss/2019/v30i130164

Okonya Joshua S., Saindikus Katja and Kroschel Jurgen (2013). Farmers' perception of and copping strategies to climate change: Evidence from Six Agro ecological Zones of Uganda.Journal of Agricultural Science; Vol 5, No. 8 ; 2013.ISSN 1916- 9752.Canadian Center of Science and Education.

Olajuyigbe Ayo Emmanuel, Rotowa Olukayode Olawumi and Durojaye E. (2012). An Assessment of Flood Hazard in Nigeria. A case of Mile 12 Lagos. *Mediterranean Journal of Social Science.* PP 1-9.

Ombuki Charles (2018). Factors influencing maize production to rural Kenya: Case of Kisii County . *International Journal of Arts and Commerce* vol. 7 no.6 (2018).Pp 50-55

Ongaro Kennedy (2018). Gender Dynamics in Participatory Fish Farming towards Sustainable Community Development in Kisii County, Kenya. *International Journal of Scientific and Technological Research* (IJSFER),1 (1) 16-26.

Onyango Kevin & Kirimi, Lilian. (2017). Post-Harvest Losses: a Key Contributor to Food Insecurity in Kenya.Tegemeo Institute of Policy and Agricultural Development.

Opijah Franklin J., N. J. Muthama, C Oludhe, G.O. Ouma and A.O. Opere (2015). Status of the 2015 El Niño Event in Kenya. University of Nairobi. Department of Meteorology. Pp 1-2

Omoyo Nyandiko N., Wakhungu J. & Oteng'I S. (2015). Effects of Climate Variability on Maize Yield in the Arid and Semi arid Lands of Lower Eastern Kenya. *Agric & Food Secur* **4,** 8 (2015). https://doi.org/10.1186/s40066-015-0028-2

Ongoma Victor, Guirong Ogwang T.B.and Nyarukinyimana J.P (2015). Diagnosis of Seasonal Rainfall Variability over E.Africa. A Case Study of 2010-2011 Drought over Kenya. *Pakistan Journal of Meterology.*Vol.11 Issue 22. Pp 13-21.

Otieno, Vincent O. and Anyah, R.O.(2013). CMIP5 Simulated Climate Conditions of the Greater Horn of Africa (GHA). Part 1: Contemporary Climate. *Clim Dyn* **41,** 2081–2097 (2013). https://doi.org/10.1007/s00382-012-1549-z

Owiti Zablone & Ogalo Laban (2008). Linkages between the Indian Ocean Dipole and East African Rainfall Anomalies. *Journal of Kenya Meteorological Society.* Vol2. 3 - 17.

Patel Prapati N., Grace M. Mbagaya. & Beatrice E. Imo (2012). Impact of Climate Change on Food and Nutrition Security in Kenya. *Global Food Security*. Pp 1-7.

Peter Koskei, Christine C. Bii, Protus Musotsi and Simion M. Karanja (2019). ''Postharvest Practices of Maize in Rift Valley and lower Eastern Regions of Kenya''. A Cross Sectional Study. *International journal of microbiology.*Vol.2020/Article ID 6109214/https://doi.org/10.1155/2020/6109214.

Saijad Ali, Ying Liu, Muhammad Ishaq, Tariq Shah, Abdullah, Aasir llyas, and Izhar A. (2017). Climate Change and its Impact on the Yield of Major Food Crops: Evidence from Pakistan. *Journal of Foods* V.6 (6) .doi 10.3390/f foods 6060039

Schmidt Daniel F and Grise M.Kevin (2017).The Response of Local Precipitation and Sea Level Pressure to Hadley Cell Expansion. *Geophysical Letters* https://doi.org/10.1002/2017 llo75380

Siderious Christian, Gannon K.Elizabeth, Ndiyoi M., Opere A., Batisani N., Olago D., Pardoe J. and Conway Declan (2018). Hydrological Response and Complex impact pathways of the 2015-2016 El Nino in Eastern and Southern Africa. *Earth' Future*. ISSN 2328-4277.Doi:10.1002/2017 EF 000680.Pp 5-19.

Simotwo Harrison K., Mikalitsa Stella M and Wambua Bonface.N (2016). Climate Change Adaptive Capacity and Smallholder Farming in Transmara East Sub county, Kenya. *Geo environ disasters* 5,5(2016) https:doi.org/10.1186/40677-018-0096-2

Sisha Teshanger Asseta (2020). Household Food Insecurity Assessment. Evidence from Panel Data Ethiopia. *Scientific African* vol.7 2020 https://doi.org/10.1016/j.sciaf.2019.e00262.

Smith Michael.D, Rabbit Matheu P. and Coleman-Jensen Alisha (2018). Who are the World's Food Insecure? New evidence from the World Food and Agriculture Organization's Food Insecurity Experience Scale. *World dev*. 2017;**93**.402-12.

Stevanovic Miodrag, Popp Alexander, Lotze-canpen Hermann, Dietrich Jan philipp, Muller Christoph, Bonsch Mark, et al (2016). The Impact of High end Climate Change on Agricultural Welfare. *Science Advan*ces 2016 el 501452.10.11.1126/sciadu.150.452

Sylvester Mpadeli, Dhesigen Naido, Tafadwanashe Mabhaudhi, Charles Nhemachenn, Luxon Nhamo,M. Stanley Liphadzi, Sithabile Hlahla and Albert T.Modi (2018). Climate Change Adaptation through the Water Energy Food Nexus in Southern Africa. *Journal of environmental Research and Public Health*. 2018. 15(10), doi 10.3390/ijerph15102306

Syed Md Abu and AL Amin M. (2016). Geospatial Modeling for Investigating Spatial Pattern and Change Trend of Temperature and Rainfall. *Climate* 2016, 4, 21; doi: 103390/c li4020021.

Taherdoost Hamed (2016a). Sampling Methods in Research Methodology; How to Choose a Sampling Technique for Research. *International Journal of Academic Research in Management.* 5. 18-27. 10.2139/ssrn.3205035.

Taherdoost Hamed. (2016b). Validity and Reliability of Research Instrument: How to test the validation of a Questionnire/survey Reserch.International journal of Academic Research in Management (IJARM)Vol.5 No3,2016 Pp 28-36,ISSSN:2

Taherdoost, Hamed (2018). How to Design and Create an Effective Survey/Questionnaire a SteP by Step guide. *International Journal of academic research in management* (IJAM), vol.5 no.4.2016, pp 37-4v ISSN:2296-1747.

Tajeda Enrique Moran, Bazo Juan, Moreno Juan I..Lopez, Aguller Enric, Morina Cezar.Azorin-Molina, Lorenzo Arturo Sancez, Martinez Rodney, Juan J. Nieto, Majia Raul (2016). Climate Trends and Variability in Ecuador (1966-2011). *International Journal of Climatology* https://doi.org/10.1002/joc 4597

Tavakol Mohsen & Reg Dennick (2011). Making Sense of Cronbach's Alpha. *International Journal of Medical Education.* Pp 53.

Tongco Maria (2006). Purposive Sampling as a Tool for Informant Selection. Ethnobotany Res Appl. 5. 10.17348/era.5.0.147-158.

Tuo Seydou, Amari L, Camara B. S, Sorho F, Ouedraogos A. and Kone D (2016). Assessment of Banana and Plantain Behavior under Natural Infestation

by *Mycosphaerella fijiensis*, Morclet in Southern Cote D Ivoire. *Journal of Agronomy*, **15**:151-164. Doi:10.3923/iq.2016.151.164.

Tranter Bruce (2017). It is only natural: conservatives and climate change in Australia, *Environmental sociology*, 3:3, 274-285, doi:10.1080/23251042.2017 1310966

Ray Deepak K, West Poul C., Clark Michael, Gerber S.Sames, Prischchepov V. Alexander and Chattejee Signidhnsu (2019). Climate Change has likely Affected Global Food Production. *Plos One* 14(5) e 0217148 https.//doi:org/10:i37/ *Journal pone* 0217148.

Ramakrishna Gollagari (2014). Impact of Floods on Food Security and Livelihoods of IDP Tribal Households: The case of Khammam Region of India. *International Journal of Development and Economics Sustainability.* 2. 11-24.

Rankoana Sejabaledi A. (2017). The Use of Indigenous Knowledge in Subsistence Farming. Implications for Sustainable Agricultural Production in Dikgale Community in Limpopo Province S. Africa. *International Journal of Climate Change Strategies and Management. Pp.64-69.*

Rembold Felix, R .Hodges, M. B. H Knips & Leo Oliver (2011). The Africa Postharvest Losses Information System . *JRC Scientific and Technical Reports*. Pp 11-17.

Rembold Felix, Leo Oliver., Negre Thiery and Hubbard Neil (2015).The 2015-2016 El Nino Event: Expected Impact on Food Security and main responses Scenarios in East and Southern Africa. EUR 27653 EN:doi:10.2788/80575.

Uhe Peter Sjoukje, Philip Sarah, Kew Shah, Joiyce Kimutai, Emmah Mwangi, Geert Jan Van Oldenbourgh, Roop Singh, Julie Arrighi, Eddie Jjemba, Heidi Culleni, Friederike Otto (2017). Attributing Drivers of the 2016 Kenyan Drought. *International Journal of Climatology* https://doi.org/10.1002/joc.5389.

UNICEF (2019). The State of Food Security and Nutrition in the World 2019: UNICEF 2019. https://data.unicef.org/resources/sofi-2019.

Vasanthi Sahanna C. and Sudheendra M. (2018). Economic Impact of Climate Change on the Farmers. *Journal of Pharmacognosy and Phyto Chemistry*. E-ISSN: 2278 -4136. Wang, Wen, Ertsen M. W, Svoboda Mark D. and Hefeez Mohsin (2016). Propagation of Drought. From

Meteorological drought to agricultural and hydrological drought. *Advances in Meteorology* (2016) article UD 6547209 https://doi.org/10.1155/2016/6547209.

Wabwoba, MaryStella, Wakhungu Jacob W. and Muterama Stanley (2016). Household Food Insecurity Coping Strategies in Bungoma County. *International Journal of Nutrition and Science*. p 715.

Wamalwa Isaac Wafula, Mburu Benson Kamau and Manguriu Daniel Gaturu (2016). Perception of Climate Change Effects And Influence on Uptake of Climate Smart Practices Among Small Scale Farmers in Kisii County Kenya. *International Journal of Information Research and Review*. ISSN:2349-9141.

Wambua Bonface Nzure (2013).The Status and Effect of Food Insecurity on the Livelihood Opportunities and Options in Semi Arid Parts of Makueni District Kenya. *Asian Journal of Agriculture and Food Sciences*.

Week Doodel A. and Wizor C.H (2020). Effects of Flood on Food Security, livelihood and Socio-Economic Characteristics in Flood Prone Areas of the Core Niger Delta, Nigeria. *Asian Journal of Geographical Research*. 3 (1):1-17, 2020 ISSN: 2582-2985.

WHO Expert Committee on Physical Status : the Use and Interpretation of Anthropometry (1993) : Geneva, Switzerland) & World Health Organization. (1995). Physical status: the use of and interpretation of anthropometry , report of a WHO expert committee. World Health Organization. https://apps.who.int/iris/handle/10665/37003

Wilgen Van Nicholas, Goodall Victoria, Holness Stephen, Chown L Steven, McGeoch Melodie. A. (2016). Rising Temperature and Changing Rainfall Patterns in S.Africans National Parks. *International Journal of Climatology.* vol.**36**:706-721(2016) doi:10.1002/joc 4377.

Wiraguna Edi (2016). Enhancement of Fixation of Nitrogen in Food Legumes. *Journal of Agricultural Studies* **4** (2):I 2016 doi:10.5296/jas.v4129065

Winkler Karina, Gessner Ursuhla and Volker Hochschild (2017). Identify Drought Affecting Agriculture in Africa. Based on Remote Sensing Time Senses Between 2000-2016. Rainfall Anomalies and Vegetation Conditions in the Context of ENSO. *Remote Sensing* 2017,9,831;doi:10.3390/rs 9080831.

World Bank (2017). Food Security:Annual Reports 2017. https://www.worldbank.org/en/topic/agriculture/brief/ensure-food security

Yimer Mohammed (2015).The Nexus between Agriculture, Food Security and Climate Change in Ethiopia. *Scientific Journal of Crop Science* 4 (2) 28-37.ISSN:2322-1690.Doi:10.14196/SJCS.V412.1880

APPENDICES

Appendix 1:Questionnaire for Kenya meteorological department

Part A. Background information.

1. What is yor name Mr/Mrs----------

Part B. Questions for objective one.

2. What were the readings per year of minimum temperature, Maximum temperature between 1983 and 2017?
3. What were the annual rainfall totals between 1983 and 2017 in various weather stations in Kisii County?

Appendix 2: Questionnaire for Key informant at Ministry of Agriculture at Sub County level.

Part A. Background Information.

1. What is your name; Mr/Mrs----------

Part B. Questions for Objective two.

2. Please provide the production totals for the following commodities in your sub county between 1983 and 2015.

Year	Maize (90 kg bags)	Beans (90kgbags)	Sweet Potatoes(Mt)	Bananas(mt)
1983				
1984				
1985				
1986				

-------				

5 Please provide the market prices of Maize and Beans between 1983 and 2017 in Kenya shilling.

Commodity	1983	1984	1985	1986	1987	1988	--	--	--
Maize									
Beans									

Appendix 3:Questionaire for Farmers.

Part A Background information.

1. What is your name (optional)----------
2. What is your gender Male[ ] Female[ ]
3. Which one of the following age bracket do belong

   18-27[ ], 28-37[ ], 38-47[ ], 48-57[ ], Over 57[ ]
4. What is your highest level of Education College [ ], Secondary [ ], Primary [

   Part B. Questions for Objective Three.
5. Rainfall has been commencing in your location when it is expectated in many occasions; Strongly Disagree [ ], Agree [ ] Undecided [ ], Disagree [ ], Strongly Agree.[ ].
6. Which of the following best suits your maize farm? Less 1 acre [ ], between 1-2 acres [ ], 3arces [ ], 4 acres [ ], 5 plus acres [ ].
7. When planting maize seeds, I apply planting fertilizer.

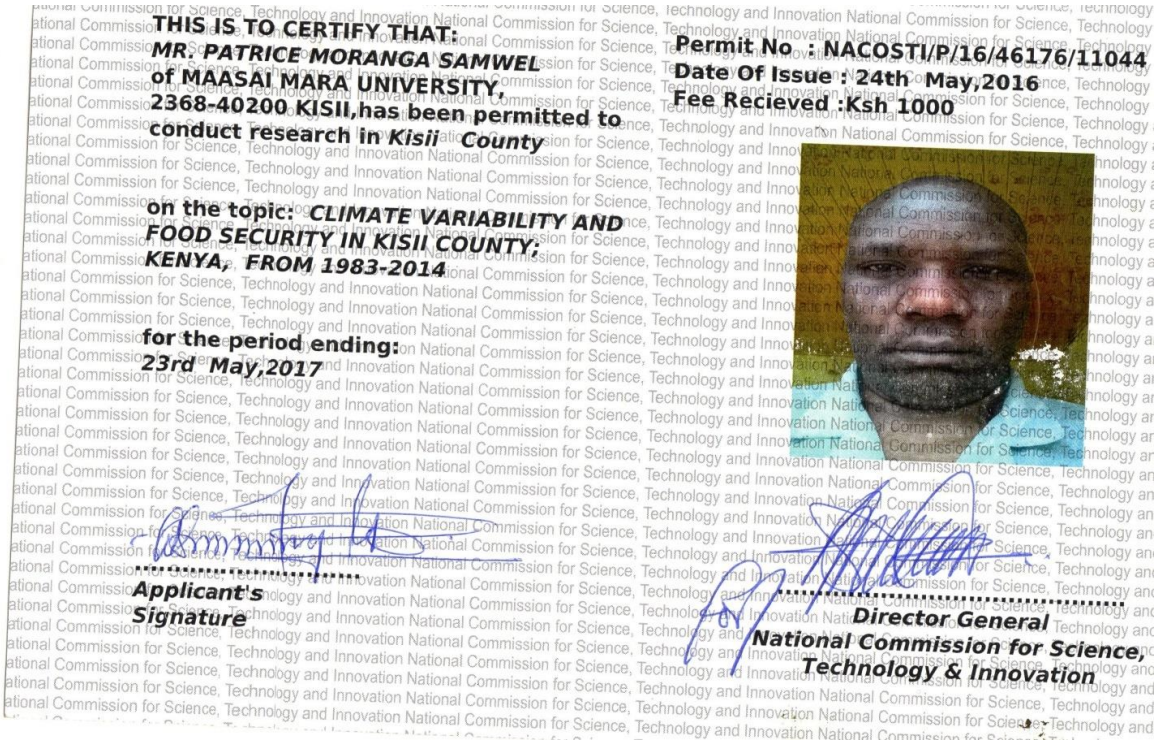
   Strongly Disagree [ ], Agree [ ], Undecided [ ], Disagree [ ] Strongly Agree [ ]
8. Which of the following best suits the maize yields per an arce?

   (i).Less than 2 bag [ ] (ii) 3 bags [ ] (iii) 4 bags [ ], (iv)5 bags [ ] (v) over 5 bags [ ]
9. After harvesting I apply preservation techniques.

   Strongly Disagree [ ], Agree [ ], Undecided [ ], Disagree [ ] Strongly Agree [ ].

10. You harvested enough maize in the last 12 months that were able to last the family till the next season. Strongly Disagree [ ], Agree [ ] Undecided [ ], Disagree [ ], strongly Agree.[ ]
11. Which one of the following ways do you often use to provide food whenever you have food shortages in the family; Buying from nearby market [ ], Depend on my Relatives for assistance [ ] Rely on food donors [ ] others [ ].
12. If you buy food from nearby markets, what is the source of your money; Selling my property [ ], from my employed Children [ ] from my cash crops [ ], Borrow money [ ] others [ ].
13. If you planned to sow your crops and rainfall delays, Which one of the following ways do you normally prefer; Wait for rainfall to commence[ ] Plant and wait for rainfall to commence[ ] Plant and apply irrigation[ ].
14. Which of the following techniques have you used over time to ensure food security in the family; Cultivating different types of food crops [ ], Planting the best yielding variety of Maize and beans [ ], Applying soil conservation measures [ ], Changing planting dates according to the arrival of rainfall [ ], others [ ].
15. Before planting my food crops, I always listen to weather forecasting ; Strongly Disagree [ ], Agree [ ], Undecided [ ], Disagree [ ] Strongly Agree [ ]
16. After listening to the weather forecasting, you normally to heed to the information given; Strongly Disagree [ ] Agree [ ], Undecided [ ], Disagree [ ] Strongly Agree [ ] .

Appendix 4: Research Permit



THIS IS TO CERTIFY THAT:
MR. PATRICE MORANGA SAMWEL
of MAASAI MARA UNIVERSITY,
2368-40200 KISII,has been permitted to
conduct research in Kisii County
on the topic: CLIMATE VARIABILITY AND FOOD SECURITY IN KISII COUNTY: KENYA, FROM 1983-2014
for the period ending:
23rd May,2017

Permit No : NACOSTI/P/16/46176/11044
Date Of Issue : 24th May,2016
Fee Recieved :Ksh 1000

Applicant's Signature

Director General
National Commission for Science,
Technology & Innovation

Appendix 5.: Research Authorization Letter

REPUBLIC OF KENYA

MINISTRY OF EDUCATION

Telegram: "EDUCATION"
Telephone: 058 – 30695
When replying please quote
E-mail: cdekisii@gmail.com

COUNTY DIRECTOR OF EDUCATION
KISII COUNTY
P.O. BOX 4499 - 40200
KISII.

Ref: CDE/KSI/RESECH/26

DATE: 23rd August, 2016.

STATE DEPARTMENT OF BASIC EDUCATION

Patrice Moranga Samwel
Maasai Mara University
P.O. Box 861-20500
NAROK.

RE: RESEARCH AUTHORIZATION.

Following your research Authorization vide your letter ***Ref. NACOSTI/ P/16/46176/11044,*** to carry out research in Kisii County, this letter refers.

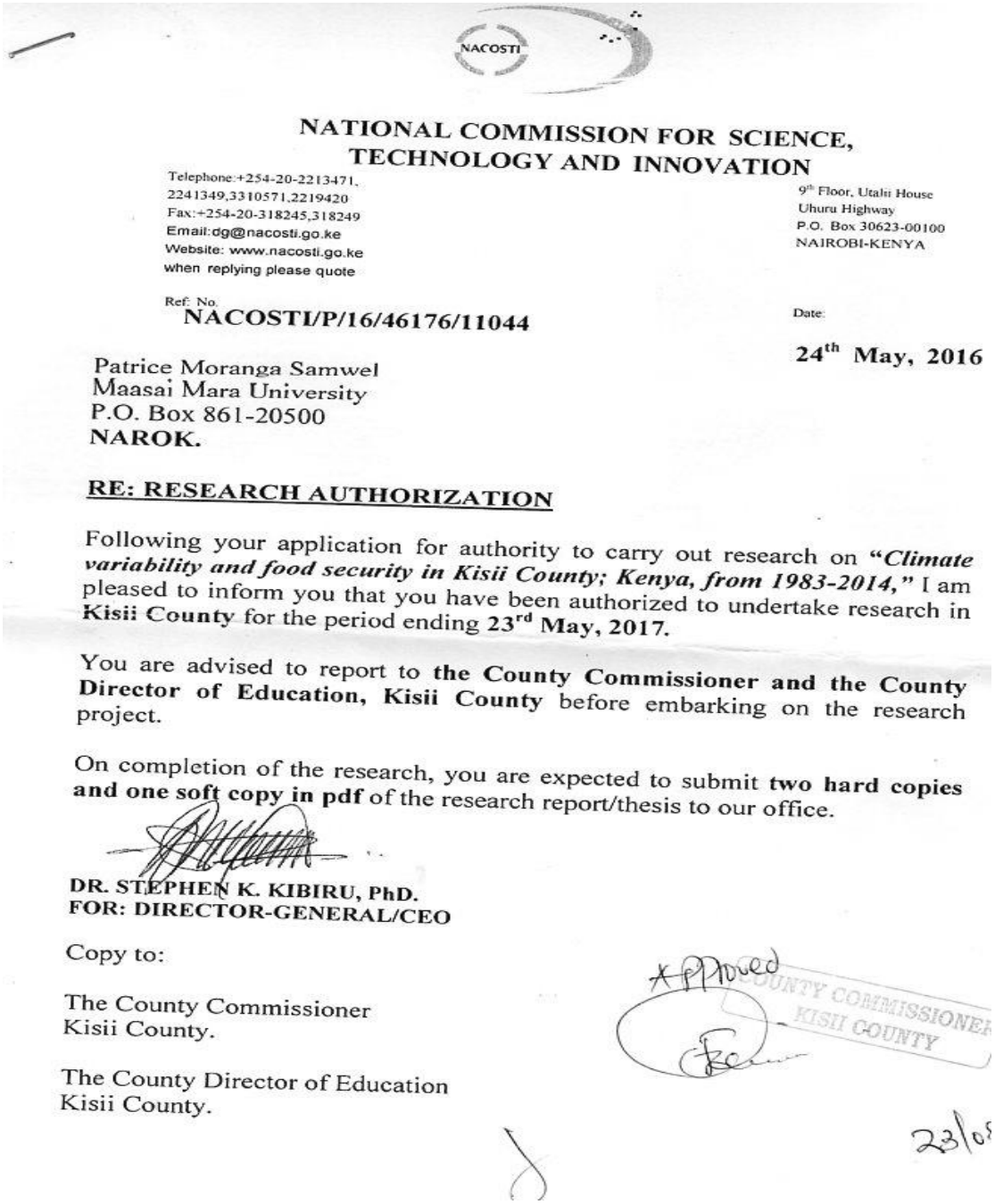
I am pleased to inform you that you can carry out your research in the County on "***Cimate variability and food security in Kisii County;Kenya, from 1983-2014,"*** For a period ending **23rd May , 2017.**

Wish you a successful research.

COUNTY DIRECTOR OF EDUCATION
KISII COUNTY
P. O. Box 4499 40200 KISII

RICHARD CHEPKAWAI
COUNTY DIRECTOR OF EDUCATION
KISII COUNTY.

Appendix 6: NACOSTI Authorization Letter



NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

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9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No.
NACOSTI/P/16/46176/11044

Date:
24th May, 2016

Patrice Moranga Samwel
Maasai Mara University
P.O. Box 861-20500
NAROK.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Climate variability and food security in Kisii County; Kenya, from 1983-2014,"*** I am pleased to inform you that you have been authorized to undertake research in **Kisii County** for the period ending **23rd May, 2017.**

You are advised to report to **the County Commissioner and the County Director of Education, Kisii County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

DR. STEPHEN K. KIBIRU, PhD.
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Kisii County.

The County Director of Education
Kisii County.

Approved
COUNTY COMMISSIONER
KISII COUNTY

23/05