EFFECTS OF CLIMATE VARIABILITY ON FOOD SECURITY IN OLOOLUA AREA OF KAJIADO COUNTY, KENYA

MAYAKA KWAMBOKA ELVINE (*BSc. Env.*)
Reg. No.: N50/25545/2013

A Thesis Submitted in Partial Fulfillment of the Requirements for the Award of the Degree of Master of Environmental Studies (Climate Change and Sustainability) in the School of Environmental Studies of Kenyatta University

NOVEMBER 2018

DECLARATION

Declaration by Candidate:

This thesis is my original work and has not been presented for a degree or award at any other University.

Mayaka Kwamboka Elvine
Reg. No.: - (N50/25545/2013)
Department of Environmental Education

Signature…………………… …………Date……………………………………………

Declaration by Supervisors:

This thesis has been submitted for the examination with our approval as the University Supervisors.

1. Prof. Amb. Michael K. Koech

Signature... Date..

Department of Environmental Education

2. Dr. James K. Koske

Signature.. Date...

Department of Environmental Education

DEDICATION

To my lovely parents Mr. Andrew Mayaka & Mrs. Robina Mayaka who have always believed in me and encouraged me to be the best that I could be.

ACKNOWLEDGEMENT

I would like to acknowledge the invaluable contribution of many individuals who made this possible. Firstly, I thank God for his grace, favour and sustenance all through this study.

Special thanks to my supervisors Dr. James Koske and Prof. Amb. Michael Koech for their scholarly guidance. Their constructive criticism and challenges sharpened my thinking. Despite their busy schedule they always found time to guide me and for discussions of this thesis. Our communication has been effective in enabling me to complete work on time. Their keen interest facilitated and contributed to this study.

My heartfelt appreciations go to my parents Mr. Andrew Mayaka and Robina Mayaka for being the source of inspiration behind this work. My husband Boaz Momanyi for the love, care and support, my son Ryan for his patience and my siblings for their encouragement.

Finally, I would like to appreciate the contributions of my peers particularly Wycliffe, Innocent, Juliet and Amos who have been a great source of support. Am indebted to Robert Nyaro (Crop Production Officer-Kajiado County), Christine Mahoga (Kenya Meteorological Department) for providing me data and Oloolua household heads for their generosity with time and knowledge. May God bless you all.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

AEZ	Agro-Ecological Zone
ASAL	Arid and Semiarid Land
CV	Climate Variability
ENSO	El Nino-Southern Oscillation
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Statistical Database
FS	Food Secure
FIS	Food Insecure
GDP	General Development Production
GHGs	Greenhouse gases
GoK	Government of Kenya
HFIAS	Household Food Insecurity Access Scale
IEBC	Independent Electoral Boundaries Commission
IFAD	International Fund for Agriculture Development
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
KMD	Kenya Meteorological Department
KNBS	Kenya National Bureau of Statistics
MoALF	Ministry of Agriculture Livestock and Fisheries
MEMR	Ministry of Environment and Mineral Resources
NEMA	National Environmental Management Authority

NGO	Non-Governmental Organization
SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan Africa
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VFIS	Vulnerability to Food Insecurity
WFP	World Food Programme

ABSTRACT

Climate variability is among major threats to food security in many agricultural based countries in Africa. In particular, it affects crop production due to temperature and rainfall changes, and more extreme weather events. Erratic rainfall and temperatures are said to reduce crop yields through shortening growing seasons, exaggeration of water stress and promote invasion and intensity of weeds, pests and diseases. Food security in Kenya is uncertain and communities in arid and semi-arid areas are relatively more affected. However, research into food security and enhanced understanding of the dynamics of climate variability effects is largely lacking. Using a descriptive survey, this study sought to examine the effects of climate variability on household food security in Oloolua area of Kajiado County. By use of questionnaires, primary data was collected from 311 randomly selected households. Interviews were also conducted among key purposely selected persons. Secondary data was obtained from physical libraries and electronic depositories and Government institutions. The climate data (rainfall and temperature) from 1980 to 2015 for Ngong' forest station (No.8005325) was sourced from the Kenya Meteorological Department. The data was statistically analyzed using SPSS with respect to the set hypotheses and objectives. The results of the study recorded a marginal increase in rainfall amounts of 78.08 mm with a significant inter-annual variability in the period 1980-2015 in Oloolua area. The study also indicated a rise in both maximum (0.1º C) and minimum (0.8º C) temperature in the period. Pearson's correlation test for rainfall against crop yields for the period 2008 to 2015 exhibited a positive correlation for maize (r=0.749) and beans (r=0.321). Maximum temperature revealed a weak positive correlation for both maize (r=0.27) and beans (r=0.398). Minimum temperature portrayed a negative correlation for maize (r=-0.35) and no correlation for beans (r=0.019). Further results from both household perception on their food security status 40.2 % and Household Food Security Assess Scale 85% indicated that majority of the households were in status food insecure and factors such as marital status (χ^2=32.566, df=6, p=0.000) education (χ^2=188.924, df=6, p=0.000) gender (χ^2=16.358, df=2, p=0.000) influenced household food security status. Majority of the households adopted drought resistant crops (216.6) however adaptation was reported to be constrained by lack of finances (257). The study concludes that Oloolua area is experiencing climate variability and this has affected food grain production and hence food security negatively in the area. The study recommends planned adaptation strategies that will enhance the resilience of small holder farmers to climate variability. There is need to invest in agricultural modernization including mechanization and construction of irrigation facilities. Small holder farmers to be encouraged to adopt modern agricultural production and productivity enhancing technologies

CHAPTER ONE: INTRODUCTION

1.1 Background Information

Climate variability is universally accepted as one of the complex and a major environmental problem facing human kind today globally (UNEP, 2014). Increased evidence in frequency of extreme climatological events is now more certain than ever (Hartmann *et al*., 2013; Adhikari *et al*., 2015). The expected climate variability impacts manifest in the form of long droughts, floods, storms, and high atmospheric temperatures (Naanyu, 2013). From the past historical records, global temperatures have risen since the late 19th century and the last three decades are reported to be warmer than the past decades. The 21st century in particular, is predicted to be the warmest of them all (IPCC, 2014).

Averagely, global temperatures have increased by 0.72°C since 1950 (Hartmann *et al*., 2013). According to studies carried out by Collins *et al*. (2013) and Kirtman *et al*. (2013), IPCC speculates a rise in temperature between 0.3°C and 0.7°C in the coming two decades and its projected to increase to a range above tolerance (Afenyo *et al*., 2015). Increase in temperature is additionally coupled with changes in hydrological cycle components, for instance rise in vapor, fluctuation in rainfall, changes in extreme events such as prolonged droughts, decrease in snow cover and melting of ice, and changes in soil moisture content and runoff (Hartmann *et al*., 2013). Rainfall greatly increased from 1900 to the 1950 between 30°N and 85°N latitude and also increased between 10°N to 30°N but has dropped after 1970 to present (Adhikari *et al.,* 2015).

Climate variability is the main driver of food security in the developing world, because it affects the productivity of the agriculture sector, its stability, and other components of the food system, including storage, access, and utilization (Ali *et al*., 2017). Insufficient food intake has detrimental effects on human health and well-being, growth and development, and labour productivity (Kirimi *et al*., 2013). Most of the losses are suffered in lower-income countries, such as the Africa region. The region engages in subsistence agriculture and is not technically sound or financially strong enough to abate the negative impacts of climate change. Moreover, they have low adaptive capacity (Kirby *et al*., 2016). A population of 842 million people are food insecure in Africa and the number in SSA was projected to rise to 300million people in 2010 where one in four people suffer chronic hunger (FAO, IFAD and WFP 2014).

Like many SSA nations, Kenya has encountered a number of food deficit incidences. About a third of Kenya's population is said to be food insecure (USAID, 2013). It is estimated that currently, 10 million Kenyans lack access to sufficient food and between two and four million people require emergency food with 3.2 million persons living in marginal areas, 850,000 school going kids, 150,000 displaced persons and 2.2 million people living with HIV/AIDS (Wambua *et al*., 2014; Owino *et al*., 2014). A relatively recent report by Ng'ang'a (2015) lists Kenya among the 15 countries prone to food insecurity according to Food Security Index of World Food Program. Furthermore, Wakibi *et al*. (2015) shows that 67 % of the Kenyan households are food secure, 30 percent are food insecure, which means they do not have access to sufficient food to sustain an active, healthy life for all members of their households.

Climate variability effects are global and local and will affect agricultural food systems all round. Studies carried out by Oxfam (2013), show that the changing climate is already jeopardizing gains in the fight against food insecurity and its set to escalate. Climate variability threatens the production and distribution of food, endangers food accessibility by destabilizing food prices and it harms people's health by affecting their nutrition and diets as well as the quality and quantity of food produced (FAO, 2013). Owing to the intensity and frequency in which the extreme events such as droughts, floods, storms and climate caused pests and plant diseases, among many other factors, continually occurs (Phiiri *et al*., 2016), food security continues to remain a far-fetched dream for many people. This is particularly so in the Sub-Saharan Africa where they are highly dependent on rain-fed agriculture (Adane *et al*., 2015).

Changes in rainfall activity and shifting temperature zones have devastating implications on food production (Mburu *et al*., 2015). These impacts can either increase or decrease crop production (Porter *et al*., 2014) and they can be separated into temporal and spatial trends at different regions (Nam *et al*., 2015). In high latitudes, warm temperatures lengthen the growing seasons as well as increases the potential agricultural land (Mueller *et al*., 2015). The latest report of IPCC (2014) indicates that, some areas have witnessed increased precipitation from 1900 to 2005 for example United States of America, northern and central Asia regions and northern parts of Europe. Others have recorded a decrease such as the Sahel, the Mediterranean, southern Africa and southern Asia. Africa will be worst hit especially the poor and vulnerable people in rural areas (Boru and Koske, 2014) due to high dependence on natural resource base and other stresses and this situation is likely to worsen when a 4 °C warmer climate is reached (World Bank, 2012; Connolly-Boutin and Smit, 2015).

Climate Variability impacts are projected to reduce the general produce of cereal crop by shortening of growing seasons, magnifying water stress and amplifying occurrence of pests, diseases and weed outbreak (Niang *et al*., 2014). Such assessments concentrate on the likely impacts of anticipated changes in average rainfall and temperature on crop production (World Bank, 2012). Studies carried out by Bita and Gerats (2013) show that heat stress during flowering and grain filling stages end up decreasing grain count and weight, leading to both low crop production and quality. Boko *et al*. (2007) further reports that total crop produce could come down by 90 % in the year 2100. A study by Teixeira *et al*. (2013) explains further that, even short length heat shock will scale back crop yields substantially, particularly if it coincides with the reproductive phase.

General crop production in many African countries by the year 2050 will decline by 10–20 percent owing to climate variability notably in Sub-Saharan Africa countries, (Omoyo *et al.*, 2015*).* Net crop revenues could fall by 90% by the year 2100 (Boko *et al*., 2007). Extreme rainfall varies with high intensity, few occurrences, and poor spatial and temporal distribution thus directly impacting on soil productivity which leads to low yields (Naanyu, 2013). Rainfall failure as well could mean loss of major livelihood source that always accentuate food shortage (Icheria, 2015).

Due to the aforementioned, there is need to encourage climate adaptation and mitigation synergy to improve food security (Icheria, 2015) as well as attempt and improve resilience to future and uncertain climate impacts on food production. This will enable the vulnerable to mitigate and cope with climate change effects generated by the interaction of food security and climate variability. Therefore, this study focuses on examining selected climate information (rainfall and temperature) and their effects on food security in the Oloolua area of Kajiado County.

1.2 Statement of the Problem

Ensuring food security amidst climate variability is at the top of the agenda in all developing nations and Kenya is no exception. Climate is anticipated to warm through all seasons in the country (Naanyu, 2013). Variability will lead to increased variation in weather patterns primarily between seasons and years. This evidence is backed up by data of over 50 years from Kenya Meteorological Department that shows the effects of variability in Kenya (GoK, 2010). Long-term shift in temperature and precipitations changes are expected to alter production seasons, the patterns of pests and diseases, increase water stress and also alter the set of crops thus affecting the yields (Amwata, 2013).

Increased climatic uncertainty means food production will change and become unpredictable and this will have severe consequences on food security status (FAO, 2010). According to Nga'ng'a (2015) extreme weather events in the country such as high temperatures and sporadic rainfall are already having significant effects on food production. As well increased temperature and change in precipitation that come as a result of climate variability are anticipated to further stress marginal areas that are already practicing agriculture (Bobadoye *et al.,* 2014).

Household food insecurity in Kenya's arid and semi-arid lands (ASALs) constitute 88 % of Kenya's total land area and are dominated with rain fed agriculture (Icheria *et al.*, 2015). Currently, it is estimated that 10 million Kenyans are food insecure and between two and four million people require emergency food (Wakibi *et al*., 2015). This number includes 3.2 million persons in ASAL parts of Kenya (Wambua, 2014) and Kajiado County falls within Kenya's arid and semi-arid region.

However, the contribution of climate variability to food insecurity in this area is not yet fully understood. Previous assessment of the impacts of climate variability on agriculture in the area concentrate more on pastoralism (Amwata *et al*., 2016). Studies (Amwata, 2013; Osano *et al*., 2013; Opiyo, 2014; Bobadoye *et al*., 2016) have analysed and documented climate variability and pastoralism at the household and community level. However, there is relatively little information in the literature available on climate variability impacts on crop productivity. More evidence on the topic is necessary in providing further understanding on the challenges of climate variability, crop production and its links to food security in ASALs. Thus, the study on the effects of climate variability (rainfall and temperature) on food security in Oloolua area, Kajiado County was deemed necessary.

1.3 Research Questions

The study sought to answer the following questions;

1. How has climate (temperature and rainfall) varied in Oloolua area of Kajiado County between 1980-2015?
2. How has climate variability affected food grain (maize and beans) production in Oloolua area of Kajiado County?
3. How is the state of food security among households of Oloolua area of Kajiado County?
4. Which are climate adaptation strategies practiced by households of Oloolua area, Kajiado County?

1.4 Objectives of the Study

1.3.1 General Objective

The general objective of the study was to determine the effects of climate variability on food security in Oloolua area, Kajiado County.

1.3.2 Specific Objectives

1. To examine climate variability trend in Oloolua area of Kajiado County between 1980-2015.
2. To determine the effect of climate variability on food production (maize and beans) in Oloolua area, Kajiado County.
3. To establish the state of food security among households of Oloolua area, Kajiado County.
4. To evaluate climate variability coping strategies practiced by households in Oloolua area, Kajiado County.

1.5 Hypotheses

1. Oloolua area of Kajiado County has not experienced climate variability between 1980 and 2015.

2. There is no relationship between climate variability (rainfall and temperature) and food grain (maize and beans) production in Oloolua area.

1.6 Significance of the Study

Climate variability introduces additional uncertainty to already constrained state of food security in Kajiado County. It manifests in change in seasonal characteristics for instance prolonged dry seasons, delayed rains and alternating dry and wet conditions. It's evident that climate variability and food security are inter-linked in Kajiado particularly due to increased change in seasonality. However, many climate studies in this area have focused more on Pastoralism, droughts, climate mitigation and adaptation but less has been done on food grain production. Studies close to this one have been done in other countries like Ethiopia, Zambia and Zimbabwe (Adane *et al*., 2015; Sianungu, 2015; Manyeruke *et al*., 2013) and even in different parts of Kenya (Mwaniki, 2014; Nga'ang'a, 2015) but due to geographical characteristics (agro-ecological zones), economic and social status their recommendations may not be applicable to Oloolua area. This study therefore sought to fill this gap.

Further, the study may increase an understanding of climate variability on food security from Oloolua area's point of view. This is essential to devising mitigation and adaptation practices that have positive outcome in this particular area. The study may also inform the households of Oloolua area on effectiveness of the already adopted strategies, inform the stakeholders of the climate trend and food security status in the area.

The study as well may be of significance to policy makers such as the Ministry of Agriculture, Livestock and Fisheries, Ministry of Environment and Mineral Resources, NGOs, local organizations and development agencies among other stakeholders working in the area by providing policy recommendations that may guide decisions that could bring change in agriculture and climate systems to enhance food security. The study findings will also contribute to the existing literature on the topic.

1.7 Conceptual Framework

The study aimed at examining climate variability trend, determining effects of climate variability of food production, establishing household food security status and evaluating effectiveness of coping strategies in the study area. The independent variable for the study was climate variability (rainfall and temperature). Food grain production and environmental change were dependent variables while natural and anthropogenic drivers, and mitigation and adaptation strategies were intervening variables.

Climate variability has far reaching effects on food grain production and thus food security. Food production will be affected by shortening of growing seasons, shift in planting seasons, increased crop pests and diseases, loss of soil fertility and decreasing moisture content. This can lead to seasonal crop failure and long-term production problem leading to low yields hence food insecurity. Climate variability as well can affect food access in a way that, as agricultural produce decreases, food prices shoot, and the purchasing power reduces. Natural and human (anthropogenic) drivers such as will accelerate climate variability (Rainfall and temperature) by changing weather patterns making production more unpredictable.

Environmental change in this case involves the extreme weather events such as droughts and floods. More intense and increased frequent extreme weather events and increasing abnormalities in seasonal rainfall changes are already having significant impacts on crop yields and thus food insecurity. Erratic and unpredictable rainfall will lead to changes in rainfall thus floods, high temperatures coupled with low rainfall can lead to droughts. Both natural and human drivers will accelerate the extreme events thus reducing food production. Appropriate climate adaptation and mitigation strategies will minimize the effects of natural and human drivers hence stabilizing the effect of climate variability on the environment and increase food production hence food security.

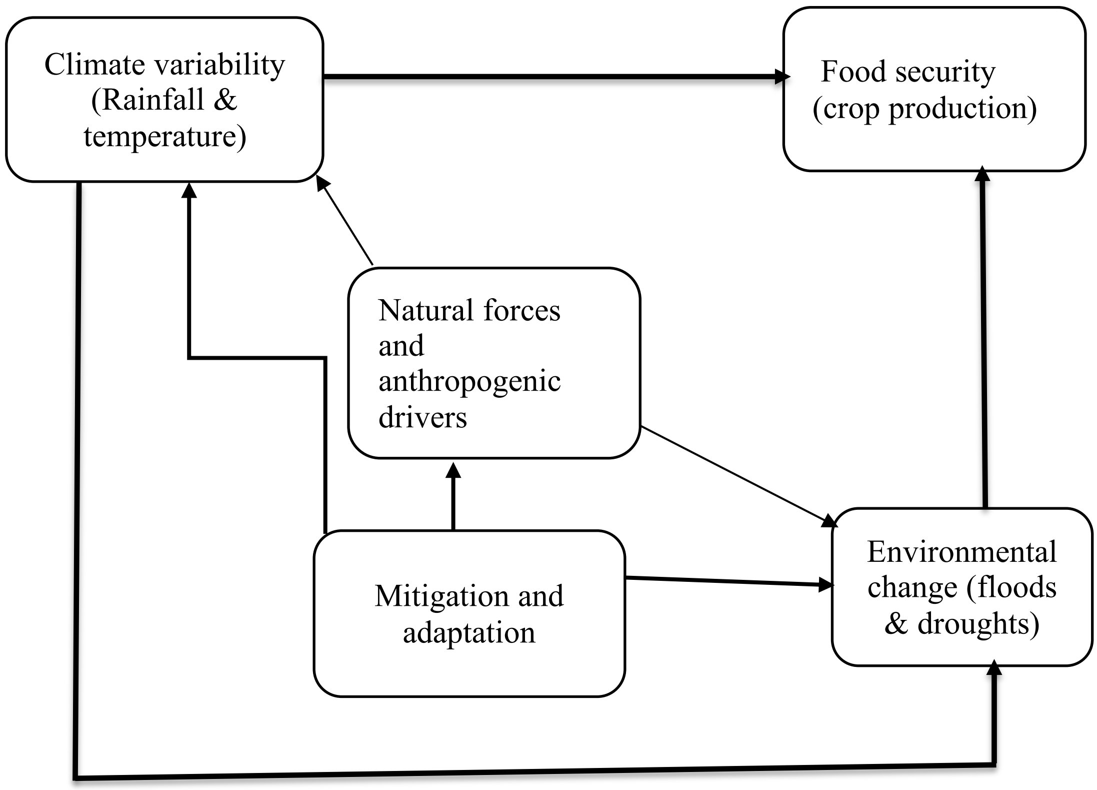

Figure 1.1: Conceptual framework, Adapted and modified from (FAO, 2008).

1.8 Definition of Operational Terms

Climate Variability: Variation in the mean state of the climate on all temporal and spatial scales beyond that of individual weather events attributed to natural or anthropogenic activities (IPCC, 2014).

Household: People living together and whose contribution in terms of labour, income and expenditure are considered part of the household (WFP, 2009).

Adaptation: Making an adjustment to the actual or anticipated climate stimuli to moderate the damage to cope with the outcome and exploits the benefits that come with it or the ability of people or a community to respond to changes in climate (IPCC, 2007).

Climate Change: Long-term change in weather patterns, mostly a decade or longer due to natural changes or as a result of human activities (UNEP, 2014).

Food Security: This is when *"all people at all times have both physical and economic access to sufficient, safe and nutritious food to meet their dietary needs"* (FAO, 2010).

Mitigation: A human intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC, 2007).

Vulnerability: The extent to which a system or a society is prone to, and not able to cope with, adverse effects of climate changes (IPCC, 2014).

CHAPTER TWO: LIRATURE REVIEW

2.0 Preview

This chapter presents a review of studies on climate variability and its effects on food security. It further discusses climate variability trend, effects of climate variability on crop production, household food security status and climate coping strategies.

2.1 Climate Variability Trend

There is no doubt that the earth is warming. Globally, surface temperature change is estimated to be 0.78°C since the 19th century with intervals of 0.72 to 0.85°C (Stocker *et al*., 2013). Precipitation on the other hand reported a small global annual mean with uncertain rising trend over the 20th century of about 1.1mm per decade (UNFCCC, 2007). Regions around mid to high level latitudes are said to experience more intense rainfall. These changes have received reasonable attention in the past years due to increased extreme events such as droughts, floods and hurricanes (Asadieh & Krakauer, 2015). According to IPCC (2007) it's never been this warm for the past 1000 years and precipitation events are anticipated to become significantly intense under warming.

In Africa, climate variability is aggravated by the interaction of different stresses and low capacity to adapt. The continent's climate is controlled by the interplay of both maritime and terrestrial activities that give diverse climate ranges in different regions (Boko *et al*., 2007; Mburu *et al*., 2015). In general, African continent temperatures are anticipated to increase by two to six degrees Celsius by 2100 (IFPRI, 2010). In the sub-Saharan African region, warming is also predicted to extend till the end of the century with temperatures hitting 5˚C by 2100 which is beyond the 1951 to 1980 baseline (Gebremedhin, 2018). In this case inland sub-tropics are said to warm the most (Serdeczny *et al*., 2016). These changes may seem homogenous, but they are not always. For example, the African tropical forests warming rate is 0.29°C, in South Africa a rate of 0.1 to 0.3°C has been noted (Sianungu, 2015). Eastern Africa has recorded declining trend in temperatures in areas nearing the coast and main inland lakes, they are also likely to increase more in the drier subtropical regions (Boko *et al*., 2007).

Unlike temperature changes, rainfall variability is a bit complex due to its complicated feedback mechanisms attributed to temporal and spatial variability. Nevertheless, inter-annual rainfall variability is conspicuous over most of Africa and for some regions, multi-decadal variability is also significant. For instance, Herrero *et al*. (2010) reports a likely increase in annual mean rainfall in East Africa which appears to be a relatively more stable albeit some evidence of long-term wetting and a decrease in both Mediterranean Africa and in the Northern Sahara regions. West Africa has also recorded a decrease in annual rainfall since 1960 by 20 to 40% (1PCC, 2007). Ziervogel *et al*. (2006) further reports that winter rains will reduce by 40% in the Southern Africa region with higher rainfall anomalies and more intense and widespread droughts reported.

In Kenya, climate ranges from a humid tropical climate along the coast to arid areas inlands while temperatures shift with change in altitude. GoK (2009) reports that temperatures in the country have increased by 1°C over the past 50 years and warming is set to escalate by almost 3°C by 2050 (IPCC, 2007). Temperature increase is normally higher in the months March, April and May which has attributed to experiencing hot days and nights around this time. The northern parts of Kenya experience high temperatures of up to 35°C and the western and central parts of the country experience the lowest of 10 °C and below (Naanyu, 2013).

Rainfall variability experiences regional rainfall differences. Long rains are less variable so inter-annual variability is as a result of short rains (Herrero *et al*., 2010). Rains are predicted to increase in some parts for instance around Lake Victoria region to the central highlands, east of the Rift Valley whereas the eastern and northern arid and semi-arid lands (ASAL) are anticipated to experience decrease in rainfall amounts (IPCC, 2007).

2.2 Food Security and its Vulnerability

Food security is referred as a state when: "*all people at all times, have both physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life*," (FAO, 2010). On the other hand, food insecurity is a state when food is not easily accessible to households and they are facing difficulties in securing sufficient and nutritious food (Wakibi *et al*., 2015). Food insecure households are those that do not have both economic and physical access to food and this may be due to inadequate food, low purchasing power and poor usage of food at household level (Icheria, 2015). The four components of food security are stipulated as: availability, access, utilization and stability as explained below:

2.2.1 Food Availability

Food availability plays a very important part in food security. It refers to the production, distribution, and exchange of food in appropriate quality for people to meet basic food needs and this can be supplied through household's own production or import (FAO, 2015). Food availability at household level can be described as the food's physical existence, either from markets or own production including food imports and aid (Bunyasi, 2012). In evaluating food availability factors such as sufficiency supply of energy, animal proteins and the numerical quantity of food production are considered (Oyiga *et al*., 2011).

Food supply per person in developing nations in the last two decades has grown faster than the population and quality of diet has improved (FAO, WFP and IFAD, 2013). For example, vegetables and fruits availability per person increased by 90 %, livestock products by 70 % and vegetable oils increased by 32 % since 1990–92 (FAO, 2015). This has changed into better diets, inclusive of increased protein of 20 % per person (Chauvin, 2012). Food availability in the SSA region has increased by nearly 12 % since (1990-92 and 2012-14) (FAO, 2010). In this period, countries such as Ethiopia experienced increase in food availability of 41 %, Mozambique 41 %, Cameroon 27 %, Sao Tome 23 % and Malawi 26 % (FAO, WFP and IFAD, 2013).

2.2.1.1 Climate Implication on Food Availability

The most notable effects of climate variability on food availability is through changes in production. Extreme weather events disrupt production cycles (Sianungu, 2015). Climate changes affect crop production directly through environmental changes and indirectly by affecting distribution of incomes and growth (Zewdie, 2014). Warming of over 3 °C will have negative effects on crop production. However, moderate warming of 1°C is anticipated to boost food crop and pasture growth in temperate regions, while it is likely to have negative effects in tropical and semi-arid regions, to cereal crops (Baldos and Hertel, 2014).

2.2.2 Food Accessibility

Food accessibility is referred as a household's capacity to access food of the needed quantity, quality, and nutritional type through production, purchase, gifts, borrowing or aid. Food access is directly associated with a household's financial ability to afford needed food for an active and healthy life (FAO, WFP and IFAD, 2015). The ability to acquire food is influenced by physical and financial resources (allocation, preferences and affordability) Zewdie (2014). Physical availability of food alone is not enough to a household or a person to have access to food. There may be adequate food in the market but due to the economic access aspect, some households may not be able to access it (Belloumi, 2014).

Food access is influenced by physical access which is determined by infrastructure and economic access. This is further determined by level of income, the cost of food and social access (Kabunga *et al*., 2014). Therefore, insufficient access to food could be due to high market prices or lack of capacity to acquire food and sociopolitical access for example traditional rights to common resources (USAID, 2013).

Access to food is often measured using entitlement proxies such as price, income, monitoring, consumption or assets. It reflects the demand, uneven food distribution side of food security as well as cultural values within a community. It accentuates challenges in response to severe shocks such as unemployment, hiked prices or loss of assets resource base (Poppy *et al*., 2014).

In the SSA nations, households are unable to access food for many reasons such as hiked food prices, markets inaccessibility, high poverty levels, employment status, level of education and rights to property. This will affect SSA communities that depend mainly on subsistence agriculture and markets as an important source of secondary food (Huppe et al., 2013; Zewdie, 2014). The effort to quantify food access is new and comes with a lot of challenges since households or individuals have many ways to react/respond to shock. Some of the indicators that have been put into consideration include; affordability or ability of consumers to buy food, money spent on food, market access, although a nearby market with plenty of food does not necessarily imply that households in the neighborhood are food secure (FAO, WFP and IFAD, 2014).

2.2.2.1 Climate Implication on Food Access

Climate variability is expected to place a strain on infrastructure. After production, food needs to be transported to the consumption point. How fast depends on the transport systems. Inefficient transport structures delay the delivery and increase food prices (Choufani *et al*., 2017). Increased exposure to weather extremes such as heavy floods and long droughts is said to reduce household's entitlement and hinder their food access. Entitlements in regard to households' access to food relies upon food allocation, affordability, and availability USAID (2013). Climate variability as well hinders food access through its effects on production. Limited production means scarcity in the market hence high prices (Porter *et al*., 2014).

2.2.3 Food Utilization

This is the ability or capacity of the household to utilize essential food nutrients from the food they consume or access (FAO, 2008). Utilization includes the nutrient content of the diet that is, how well food is utilized and whether the diet is well balanced with adequate nutrients (Chauvin, 2012). A house that has both physical and economic food access may be branded food insecure if it is not able to achieve a nutritious and balanced diet. These factors are influenced by preparation of food, knowledge on nutrition, access to clean drinking water and health care. These are particularly less if not lacking in most SSA nations where malnutrition is widely spread (Oyiga *et al*., 2011).

Utilization shows whether individuals and households use well the food that they have access to, whether they consume well balanced and nutritious foods they can easily afford or choose a nutritionally low diet. As well as if the foods they consume are safe and well-cooked so as to give their full nutritional value and substantive nutrients. Utilization is basically keen on dietary quality, especially intake of important minerals and vitamins (Poppy *et al.,* 2014).

Food utilization is reflected when there is adequate food intake and members of the household are in good health care to reach a state of nutritional well-being where all physiological needs are met. Food wasting can lead to inadequate food intake and this can cause repeated occurrence of illnesses or infections. This will further cause acute under nutrition (Li & Zheng, 2016). The number of undernourished and underweight children under five years has decreased in all developing regions since the year 1990, thus improved nutrition resulting from easy access to and availability of food. (FAO, IFAD and WFP, 2013).

2.2.3.1 Climate Implication on Food Utilization

Changes in climate affect the rate of production of different food types and this may hinder the dietary requirement of a household. Climate variability as well can affect the income levels and the ability of households/individuals to attain the required foods to meet a nutritious and well-balanced diet (Belloumi, 2014). On the other hand, when food is not available, the variety of food items normally decreases, and so the number of meals can decrease thus low balance of nutrients (Sianungu, 2015).

2.2.4 Food Stability

It is determined by the availability and access to food. Stability supports availability, access and utilization as well as captures the level of uncertainty or susceptibility to future commotions in food security. For instance, food chains, processing, storage, marketing and distribution constitutes the integral, methods that have preserved the food system from instability (Bunyasi, 2012). Risks to stability include climatic conditions, conflict, price shocks, production and supply, swing in food and input prices and disease, among other factors (FAO, WFP and IFAD, 2013).

Climate Implication on Food Stability: Increased extreme weather events will destabilize the local food system hence increased cases of food emergencies. Unpredictable weather can lead to unstable harvests hence instability of food production (FAO, 2008). The climatic variability produced by more frequent and intense weather events can upset the stability of individuals' and government food security strategies, creating fluctuations in food availability, access and utilization Weldearegay and Tedla (2018).

2.3 State of Food Security in Kenya

In Kenya the state of food security is directly associated to state of agriculture (USAID, 2013). The Kenyan Constitution of 2010, article 43, Section (1) (c) clearly states that: *"Every person has the right to be free from hunger, and to have adequate food of acceptable quality. To monitor progress and targeting interventions towards realization of this goal, an easy to- use, but scientifically sound measure of food security is required,"* (GoK, 2010) and yet the country has experienced cases of food insecurity for a long time in both potential and non-potential parts including urban and rural areas (Mwaniki, 2014).

About a third of Kenya's population is considered to be food insecure (USAID, 2013; Aden, 2017). Presently, an approximate 10 million persons are food insecure and between two and four million persons are in need of food aid (Wambua, 2014). World Food Program Food Security Index lists Kenya among the 15 countries most at risk of food insecurity. Appallingly it is ranked 11out of 163 with a food security score of only 1.22 (Ng'ang'a, 2015).

Results from a study carried out by Women's Studies Centre and KNBS (2014) shows that 9 % Kenyans suffer from chronic food insecurity, 24.4 % suffer from low food insecurity and 66.6 % are food secure. A relatively recent study by Wakibi *et al*. (2015) revealed that 67 % of Kenyan households are food secure, 30 % food insecure, which means that they do not have easy access to adequate food to sustain an active, healthy life for all members of their households. Coastal Counties mainly those in the coastal lowlands, inland lowlands and upper midlands agro-ecological zones have been found with higher rates of food insecurity than the national defined standards (USAID, 2013). Some of the counties suffering from chronic food insecurity include Turkana, Kisii and Migori with 23 %, 34 % and 42 % food insecure households respectively (Kassie, 2014). The most food secure counties are Kirinyaga and Baringo with 95 % food secure and 75 % food secure respectively (Wakibi *et al*., 2015).

Government of Kenya (2011) reports that food per person in Kenya, has drastically reduced by over 10 % in the last decade. The GoK report points out that food availability and access in Kenya are greatly determined by households/individuals' capacity to produce sufficient own food, earn income to buy food, availability of right infrastructure, good and efficient food distribution systems and finally fair food prices

According to USAID (2013), the average Kenyan household spends almost half of their household income on food which is a pointer of high level of poverty and food insecurity. This is attributed to elements like reduction in agricultural production which may result from continuous land fragmentation. Access to food is influenced by factors such as; poverty levels, population change, change in climate patterns, and shift in demographics affect (Bilham, 2011). Generally, Kenya as a country has not been able to meet her food needs and has continuously depended on food import/Aid, which contradicts the constitution. Among the foods that are imported include Maize, wheat and rice (Mwaniki, 2014).

2.4 Climate Variability and Food Security

Climate variability poses a serious threat to food security globally. It damages the resource base on which agriculture depends on and seriously affects crop production (Belloumi, 2014). Increased scientific evidence suggests that climate changes are set to magnify climatic variation, with significant changes in weather behavior, particularly seasonal changes and year to years variability (GoK, 2007). Climate variability may be affected by changes in climate related abiotic and biotic stresses and also changes in accumulation of atmospheric carbon dioxide, deposition of acid and the ground level ozone (Oyinbo *et al*., 2012). Food production will become more unpredictable globally and this calls for advanced understanding of the causes and effects, and dispersion of appropriate responses in regard to regional scale (Manyeruke *et al*., 2013). Yield changes and all other factors held constant, would reduce food consumption and production thus deteriorating food security conditions (Adane *et al*., 2015).

In regard to food systems, rainfall and temperatures are the most essential to measure (Comoe', 2013). The difference between highs and lows of rainfall and temperature extremes occur and the intensity of the incidences vary (Ziervogel *et al*., 2006). It's anticipated that low latitude countries mainly in the tropical and sub-tropical regions would mostly be at risk to decline crop productions. This will result in some areas in the tropical regions becoming undesirable for agriculture (Oyiga *et al*., 2011).

Rainfall fluctuation, together with extremes, can have intense impacts on agricultural production. The intensity of rain storms could increase, and precipitation could become more variable. Rainfall variability can affect both the intensity of soil erosion and soil moisture content which are crucial to crop yields (Oyiga *et al.,* 2011). Growing seasons are more sensitive to supply of water. According to Thornton *et al*. (2012), seasonal rains shortening decreases crop production, especially if the supply of water is insufficient towards the end of a growth-cycle when water demand is higher. This comes as a result of high temperatures gradient in high altitude. Water deficit/scarcity could lead to water limiting and raise the cost of water as well as reduce opportunities to expand agricultural lands by irrigation (Oyiga *et al*., 2011).

Africa is among the regions susceptible to climate variability (UNFCCC/IPCC, 2007) because it is already hot and dry, and the economy purely depends on rain-fed agriculture (FAO, 2010). Due to warming and drying, by 2050, total production in the African continent will decline by a percentage of 10–20 (Thornton *et al*., 2012). Anticipated decrease in yield in some countries could be up to 50 % by the year 2020, and overall crop produce could come down by a percentage of 90 by 2100, with small-holder farmers being the most affected (Barrett, 2014). SSA depends on rain-fed agriculture and changes in rainfall pattern would reduce crop yields and agricultural produce is projected to decrease from 9-21 % by 2080 (Belloumi, 2014) a rise in temperature and changes in rainfall are likely to reduce the production of stable foods by up to 50% as well (Zhao *et al*., 2017).

Climate variability may also bring with them new weeds, pests and diseases. Temperatures beyond optimum tolerated by crops will affect the biology of plants, leading to decrease in food production. The predicted losses in food crop add up to about 33 % by 2060 (Comoe', 2013). Prolonged droughts, unexpected changes in normal weather patterns in the past few years have jeopardized food security, particularly in vulnerable parts of Kenya (Naanyu, 2013) a consequence that has lead in the reduction of crop produce by 30 % (NEMA, 2007). The 2009 climate variability manifestation was seen in the general crop harvest failure (FAO, 2010). Kajiado County has also experienced a share of extreme events with great impacts on livelihoods (table 2.1.).

Table 2.1: Kajiado County Extreme climate events

Year	**Event**	**Impacts on livelihoods and people**
1980	Drought	People starved because there was no food to buy
1981	Drought	Starvation and loss of livestock and people looked for casual labour for the first time.
1983	Drought	Livestock had no enough grazing, and some died, and households did not have enough milk for their families.
1984	Drought	Outbreak of East Coast Fever which lead to livestock loss, Diversification from pastoralism to irrigation agriculture particularly maize and vegetables.
1990	Drought	Maasai women started small scale selling of agricultural products mainly beans and potatoes to add on income and other basic needs.
1991	Drought	Livestock had no enough sufficient grazing, and some died.
1994-96	Drought	Livestock moved to Nairobi area for the first time for pasture and water
1998	Heavy rains named *El nino*	Gullies were formed as a result of heavy rains, wheat was destroyed livestock suffered from bloat, and the area experienced bumper harvest in maize
2000	Drought and famine	Maasai community missed food and they were supplied food stuffs like yellow maize, beans and cooking oil in form of aid
2004/06	Drought	Low crop yields, death of many Livestock and wildlife
2005	Drought and famine	Livestock and wildlife died in large numbers Maasai moved with their cattle to Gilgil and Nakuru areas to graze.
2009	Drought	Lack of food for people and lack of pasture for livestock. Movement of people to Tanzania for a period of 6 months with livestock in search of food, water and pasture.

Source (Amwata, 2013)

2.5 Climate Variability Impacts on Food Grain Production

Crop yields global analysis between the year 1981 and 2002, shows that rise in temperature has had negative effects in wheat, maize, and barley with a total cost of around $5 billion yearly (Fei *et al*., 2017). Maize and soybean yields in the U.S under the IPCC scenario were predicted to decline by 30 % to 46 % with the slowest warming trend (Araya *et al*., 2017). In Europe low crop yields were recorded in the year 2003 when a heat wave was experienced, and temperatures ascended up by 6°C above average, and annual precipitation reduced by 50 % below average (Ainsworth and Ort, 2010). On the other hand, climate variability may increase production and set up new agricultural possibilities at high latitudes in areas of Canada and Russia, (Rosegrant *et al*., 2009).

Numerous reports have already revealed that a mix of increased rainfall changes and rise in temperatures will bring down production of stable crops (Alemaw and Simalenga, 2015). In 2010, cereal yields were 3563.538 kg/h globally and 1533.794 kg per hectare in Africa (Singh, 2018). A meta- analysis and a review by (Knox *et al.,* 2012). found out that the mean change in yields of maize, sorghum and millet were expected to be 5 %, 15 % and 10 % respectively by 2050 in Africa. It is anticipated that cereal production will come down by 3.2 % by the year 2050 due to climate variability (Ali *et al.,* 2017). Food prices is an important indicator of climate effects on food security; wheat, maize and rice prices in SSA are anticipated to increase by 15 %, 7 % and 4 % by 2050 respectively (Belloumi, 2014).

A recent analysis of over 20,000 historical maize trial yields of over eight-years revealed maize were cut down by 1 and 1.7 percent increase beyond 30°C under optimal and drought conditions respectively (Hellin *et al*., 2012). In some parts crop yields will decline for instance southern Sudan, northern parts of Uganda, and the semi-arid parts of Kenya and Tanzania while in some parts crops produce will rise for example southern Ethiopia highlands, western and central highlands of Kenya (Thornton *et al*., 2009).

Temperatures beyond optimum during the reproductive stages have far reaching effects beyond reducing the period of grain filling and photosynthesis. High-temperatures during the reproductive period may cause sterility (Teixeira *et al*., 2013), fertilization, and grain formation are affected, which is mostly associated with less yields (Ainsworth and Ort, 2010). Along with high temperatures, higher atmospheric CO_2, may harbor many pests and diseases that will affect agricultural produce (Ziska et *al.,* 2011). Temperature harbors insect development, survival and distribution. Insect population increase with increase in temperature and this is likely to diversify. For instance, recent warming in Canada and the U.S. have led to increased insect species such as mountain beetle (Ben-Ari *et al*., 2016)

Hedhly *et al*. (2008) studies show that high temperatures alter genetic frequencies, speed up the rate of pollen tube growth, stigma and ovule development, thus preserving the male-female relationship required for a complete seed set. Nevertheless, under intense-temperatures, this relation can be lost, causing low fertility and lower yield. Loss of relationship can also have consequences for insect-pollinated crops, where changes in annual temperature can destroy insect life cycles with crop-flowering physiology (Memmott *et al*., 2007; Ainsworth and Ort, 2010).

Ability to tolerate high temperatures depends upon the period and timing of heat levels together with the plant growth stage (Reynolds *et al*., 2010). Produce at low latitudes are speculated to reduce, with increase in temperature however global production is anticipated to go up (Easterling *et al*., 2007; Ray *et al*., 2015). Precisely, all major food grain yields are already going down (Fischer and Edmeades, 2010). Water on the other hand is very vital for plant development. Water scarcity during the reproductive period of food grain can be very destructive (Lobell and Gourdji, 2012)**,** because it is required for evapotranspiration and high physiological sensitivity when determining its main yield thus stress may mean low yields (Omoyo *et al.,* 2015).

2.5.1 *Maize Production*

Climate Variability is envisioned to cut back maize yields by 3 to 10 % by 2050 globally (Rosegrant *et al*., 2009; Ben-Ari *et al*., 2016). Maize is grown from latitude of 50°N to 40°S, and altitude of 4000 m above sea level. (Belfield and Brown, 2008). In SSA maize was cropped on about 25 million hectares, which represented 27 % of total land under cereal and 34 % of cereal production in the year 2005-2008 (Smale *et al*., 2011; Adhikari *et al*., 2015). Low produce in this region is widely linked with prolonged droughts, low soil fertility, weeds, pests, diseases, low input and unsuitable seed varieties (Hellin *et al*., 2012).

Maize in Kenya is a staple food and widely consumed food with an area under cultivation estimated at 1.6 million hectares (GoK, 2005). Within Kenya's ASAL, the possible average maize produce is a scrimpy 1.1 t ha^{-1} (Omoyo *et al.,* 2015). The optimum temperature for growing maize is reported to be 25°C. Temperatures beyond 30°C are said to reduce total maize yield by 1 % even under normal rain fed conditions (Fisher *et al*., 2015). Maize may grow with as low as 300 mm rainfall, but preferably 500 to 1200 mm for better results. Crop failure could occur if lower than 300 mm of rain were experienced depending also on soil type and stored soil moisture (Belfield and Brown, 2008). Thus, in low rainfall seasons (300mm) it appears that it is important for rainfall days to be spread out with rainfall events not concentrated for time periods nor should the daily rainfall events be strictly uniform (Duffy and Masere, 2015)

2.5.2 Beans Production

Beans are the second most important source of dietary and the most important source of calories after maize and cassava, with consumption surpassing 50 kg per individual annually (Adhikari *et al.,* 2015). They can be taken at different stages of their development for instance the leaves can be consumed as vegetables, fresh grain, green pods and as dry grains. Further, surplus can be sold to provide a steady source of income (Ainsworth and Ort, 2010). Beans are especially sensitive to high temperatures. When night temperatures stay beyond 18°C flowering is limited, thus reducing bean produce (Yadav *et al*., 2011).

Suitable lands are concentrated in cooler highlands and warmer mid- elevation regions with above 1000 m altitude above sea level. Studies carried out by Lobell and Field (2007) reported a likely reduction in bean yield per increase in temperature of 1°C. Higher daily temperatures increase disease incident (Eastburn *et al*., 2010). Beans are severely impacted by lack of moisture (Wortmann *et al*., 1998). When rainfall is less 300 mm during the growing season, yields decrease. Results from Adhikari *et al. (*2015) suggest that bean yields in East Africa are dependent and more sensitive to rainfall fluctuation than temperature fluctuation.

2.6 Mitigation and adaptation strategies

Climate variability mitigation and adaptation go hand in hand and their impacts are simultaneous so taking on an integrated approach can be the best way forward. Mitigation measures represent good options for adaptations in the climate systems.

2.6.1 Adaptation Strategies

Adaptation is a response that improves an outcome or alleviates adverse impacts or an adjustment in natural systems to deal with the consequences (IPCC, 2007). It involves taking practical actions to manage risks from climate impacts, protect communities and strengthen the resilience of the economy. Adaptation should be area specific because different locations are confronted with different climatic conditions. People depending on agriculture as a source of livelihood have devised ways to cope with climate variability (Alemaw and Simalenga, 2015).

Mexico and Argentina have adopted proactive adaptation such as; change of planting dates and variety of crops, diversified cropping and grazing, diversification of sources of income by keeping livestock, issuance of insurance for crops and establishment of local fund pools (IPCC, 2007). In Asia the Philippines have laid down effective adaptation practices such as a change to drought tolerant crops, construction of shallow tube wells, irrigation during droughts, water dams/ reservoirs construction, use of fire lines and contained burning, soil, water conservation measures application for elevated farms, harvesting rainwater and hydroponic farming (Manyeruke *et al*., 2013).

Adaptation is already being practiced in African agricultural systems. Some countries like Sudan have used adaptation practices such as rainwater harvesting and traditional water conserving measures (IPCC, 2007). In Ghana, adaptation practices in farming include intensification of crops, and experimentation with hybrid varieties, harvesting of crops early, and forming cooperatives with farmers to help in labor division (Connolly-Boutin and Smit, 2015). Drought management in Ethiopia, flood management in Mozambique, climate insurance in Malawi, and agriculture in Mali. Ethiopia has also put in place policies and planning for drought management, in order to manage the iterating droughts (Mugi-Ngenga *et al*., 2016). In Kenya Lobell *et al*. (2011) suggests transitioning from maize to sorghum farming because of the ability of sorghum to tolerate water scarcity and high temperatures (Bilham, 2011).

2.6.2 Mitigation Strategies

Mitigation is the changing of current practices to reduce the effects of human activity on the climate. Mitigation calls for actions to minimize the concentration of greenhouse gases and sink carbon in the short term, and long-term development choices that will reduce emissions (IPCC, 2007). Mitigation for many countries continues to be resource intensive due to its localized nature and fragmentation of agriculture. In many vulnerable regions, execution of mitigation measures is low, and people are most concerned about adaptation hence there is need to promote an integration climate adaptation and mitigation synergies to enhance food security (Chandra *et al*., 2016).

Long- term mitigation of climate variability impacts on agriculture can be achieved by use of improved crop type and range land management to increase carbon sinks by soil, restoring degraded lands, cultivating improved rice, manure and livestock management to minimize greenhouse gases in agricultural systems, advance of small scale irrigation schemes, science and technology, Agroforestry and water harvesting techniques can be put in place (Bryan *et al*.,2011; Adhikari *et al.,* 2015). FAO (2013) as well suggests use of animal manure (organic fertilizers), improved tillage management and restoration of degraded land.

CHAPTER THREE: MATERIALS AND METHODS

3.0 Preview

This chapter provides study areas specifications, target population, study design, sampling procedures, research instruments, data analysis and presentation.

3.1 Study Area

The study was carried out in Oloolua area of Kajiado County in Kenya. The area extends from longitude 1°22' 0" S to 1°8' 0" S and latitude of 36°38' 0" E to 36°42' 0" E. Oloolua area has an estimated population of 33,754 people with 9,801 households and it covers 19.3 Km^2 (IEBC, 2012). The area borders Ngong' location to the west and Karen location to the east. Oloolua area is made up of two administrative locations namely; Embulbul and Oloolua. Each location has two sub-locations respectively; Keraraponi, Bulbul, Olepolos and Oloolua. This area experiences a bimodal rainfall pattern with the average annual rainfall of 865mm and average annual temperatures of 16.7°C (Amwata, 2013). The area lies in agro-climatic zone IV classified as having a potential for rain fed cropping with an altitude of 1961m above sea-level. Long rainy season starts from March-May short raining season from October-December. Heavy rains occur along Ngong hills receiving an average of 1250mm per annum (Bobadoye *et al*., 2014). The main economic activities in the area are tourism, trade and small-scale farming (GoK, 2009).

The soils in Oloolua area vary from dark reddish brown sandy and clay. Normally, they are of medium potential thus support crops. Soils in the area range from clay in tow-lying areas to red loams and some regions have very light sandy and light textured soils (Makokha, 2006). The dominant form of vegetation is the Acacia trees and thorny thickets undergrowth and savanna acacia trees grow to a height of over 10m. The heights however vary with soil depth and aridity (GoK, 2013).

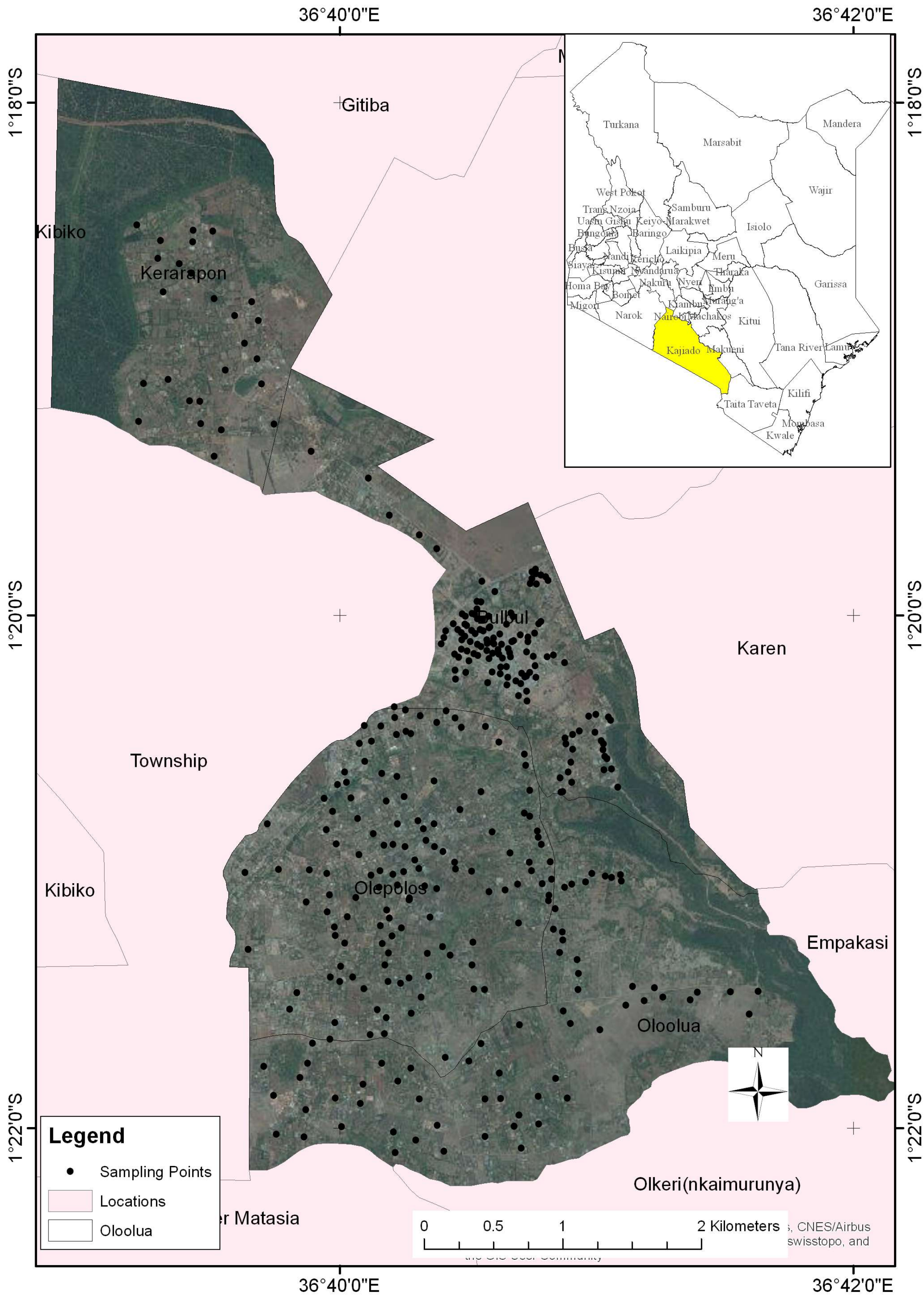

Figure 3.1: Oloolua area (redrawn from Environmental Systems Research Institute (ESRI) data, 2016)

3.2 Study Design

The study adopted a descriptive survey design, a process of collecting data in order to answer the questions the study sought to answer in regard to the subject**.** Both qualitative and quantitative forms of data were put into consideration so that the strength of the study could be more superior than using either of them (Creswell and Plano-Clark, 2007). Primary data collection methods entailed use of questionnaires, interview schedules and observation. Secondary data was collected from both electronic and non-electronic repositories.

3.3 Target Population

The target population comprised of households of Oloolua area in Kajiado County. According to IEBC (2012) the area has a population of 33,754 people with 9,801 households. The respondents of the study were household heads in Oloolua area. **3.4 Sample Size Determination**

The sample size was determined using the formula recommended by Yamane (1967) as follows:

$$n = \frac{\mathrm{N}}{1 + \mathrm{N}(e)^2}$$

Where *n*= Sample size
N= Population size
e=level of precision which is 0.05%
Since Oloolua area of Kajiado County had 9,801 households, the formula was applied as follows:

$$\mathrm{n} = \frac{9801}{1 + 9801(0.05)^2}$$

This gave a sample size 384 respondent. However, only 311(81 %) questionnaires were administered due to unavailability of household heads in their homesteads at the time of the study. Kelley *et al*. (2003) recommends 75% response rate as adequate for a study thus 311 was considered adequate.
The sample population was distributed among the four Sub-locations in the area as follows:

Table 3.1: Sampling frame

Sub-location	Population	No. of households	Proportion
Oloolua	8,549	2,231	87
Olepolos	8,564	2,419	95
Embulbul	13,637	4,321	169
Keraraponi	3004	830	33
Total	33,754	9,801	384

Source: Data from KNBS, 2010

3.5 Sampling Procedures

This is a process of selecting a number of people or objects from a population to represent the characteristics found in the entire group (Orodho and Kombo, 2002). The study employed the sampling procedures explained below:

1.4.1 Systematic Random Sampling

Systematic random sampling was used to select the households where closed ended questionnaires were administered. A starting point was randomly chosen, and thereafter the sample determined using a sampling interval. Every 8thhouse hold was visited with replacement. This was basically to avoid bias and give everyone an equal chance. The survey generated quantitative data on demographic characteristics, socio-economic status, and household food security status, climate variability on food production and mitigation and adaptation strategies on the 311 households.

1.4.2 Purposive Sampling

Purposive sampling was used to select key persons from relevant institutions for instance Ministry of Environment and Natural resources, Kenya Meteorological Department and Ministry of Agriculture, Livestock and Fisheries.

3.6 Instruments

Both quantitative and qualitative data was collected for this research.

3.6.1 Questionnaires

Structured questionnaires were used collect relevant data from households of the study area. The questions asked to all respondents were similar in order to acquire homogeneous data from all households. Information collected included, socio economic and demographic characteristics, information regarding climate variability in the area, information on food access, state of food security in the area and climate adaptation and mitigation strategies to climate variably effects on climate change.

3.6.2 Interview schedules

Face to face interviews with the key informants were carried out to gather firsthand information through use of interview schedule. The interviews followed a semi-structured format, with an in-depth focus in regard to the area of expertise of the informant. Views were elicited from a wider range of people including professionals in the relevant fields, market traders and community leaders.

3.6.3 Observations

Observation was used to supplement the information collected. The products from the observation included pictures and notes that were taken in the field.

3.7 Data Analysis

Both qualitative and quantitative data were analyzed. Quantitative data was analyzed by the use of Statistical Package for Social Scientists (SPSS). All questionnaires were examined for completeness and consistency. The collected data was numerically coded from the questionnaires based on the objectives for easy analysis. Analysis was descriptive in nature and tables; charts and graphs were used to present the findings. To determine the actual meteorological status, a 35-year rainfall and temperature (1980-2015) data was obtained from KMD for Ngong' Forest Station and analyzed for temperature and rainfall variability. Temperature and rainfall data were analyzed using Microsoft Office Excel to present patterns on trends in temperature and rainfall variations. The climate data was further correlated to crop production for the period 2008-2015 for which crop data was available to show any attribution of rainfall and temperature with crop production. Descriptive statistics (frequency, mean, standard deviation and percentage) and inferential statistics (chi-square, Pearson's correlation) were used to establish any relationships between assessed variables and all statistical tests were conducted at significance level of 0.05 %. Qualitative data were analyzed by use of qualitative techniques such as establishing connection and drawing conclusions in regard to the objectives.

According to Gliem & Gliem (2003) single-item questions due the way they are constructed are not reliable and should not be used in drawing conclusions. Multi-item scale was used in this study. The respondents were instructed to select one of the choices, the specific responses to the item were multiplied by the % of the frequency then summed up to get total weights. However, not all summated scales were created according to Likert's specifics, though they shared the basic logic associated with Likert scaling.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.0 Preview

This chapter presents the results of the study in regard to the objectives. It starts with (4.2) social-demographic characteristics and then results for the four objectives (4.3) climate variability trend of the area, (4.4) effects of climate variability on food availability, (4.5) households food security status and (4.6) climate coping strategies employed by households. The findings are presented as per each objective.

4.1 Demographic and Social Economic Characteristics of the Sampled Household Heads of Oloolua Area.

The variables under scrutiny were gender, age, education level, marital status, source of livelihood and type of house wall.

4.1.1 Age Distribution of the Sampled Household Heads

Different groups of ages are affected by climate variability and food insecurity differently. Age influences adaptation decisions to both climate variability and food insecurity. From the results majority 56.3 % of the respondents were found to be within the ages of 28-37years with a range of 43 years (Table 4.1.)

Table 4.1: Age and gender of the household heads

Age	Gender				Total	%
	male	%	female	%		
18-27 years	4	80	1	20	6	1.6
28-37 years	121	69.1	54	30.9	175	56.3
38-47 years	85	86.7	13	13.3	98	31.5
48-57 years	18	58.1	13	41.9	31	10
above 57 years	1	100	0	0	1	0.3
Total	229	73.9	81	26.1	311	100

This implies that household heads were dominated by fairly young population in the study area. The sampled age groups recorded a mean of 37.6 years with a standard deviation of 7.08. The likely explanation of these results is that the age of the respondents in this area was less variable (s=7.08). Age of the sampled households across gender and the chi-square results revealed that age did not differ significantly (χ^2=14.892, df=4, p= 0.005). Majority 73.9 % of the household heads were male headed with 26.1 % being female headed in the area. The implication of these findings is that the representation of male households in the study area was stronger in all age sets. A univariate chi- square test on gender confirmed this (χ^2=69.482, df= 1, p=0.000).

4.1.2: Education Level of the Household Heads

Education enables household heads to acquire important skills in adapting to climate change and food insecurity. The level education of the respondents in Oloolua area was found to be diverse as in table 4.2. Majority of the household heads had completed tertiary 104 (33.4 %) and secondary 103 (33.1 %) education. The remaining 22.5 % (70) had attained primary education and 10.9 %(34) had no formal education. It was therefore noted that majority of the caregivers were literate. Out of 311 respondents 207(66.5 %) had secondary and tertiary education whereas 104(33.5 %) respondents had primary and no formal education.

Table 4.2: Education level and gender of the household heads

	Gender				Total
	male	%	female	%	
No formal education	21	61.8	13	38.2	34
Primary education	43	61.4	27	38.6	70
Secondary education	81	78.6	22	21.4	103
Tertiary education	84	80.8	20	19.2	104
Total	229	73.6	82	26.	311

The likely explanation is that Oloolua area is more of an urban area which has access to social facilities including schools thus the influence on school enrolment is high. It may be partly explained to be as a result of expansion of Nairobi into its neighboring Counties. The area is well connected to the city center thus it's been inhabited by immigrants working in the city as professionals, entrepreneurs and government officials.

A chi square test revealed gender parity in education level in Oloolua area (χ^2=11.896, df=3, p=0.008). It can therefore be concluded that male household heads were more educated that female household heads. This can be explained from the experiences of Kenyan girls and women based on patriarchal values and practices that strengthens male privileges in societies. According to Munyao (2013) educational advancement in girls had been hindered by gender challenges such as early marriage, girl child school dropout due to male preference and financial constraints, female genital mutilation, sexual abuse and gender-based division of labour which affect school performance of girls and school retention rates. This study is in support of Munyao's work.

4.1.3: Source of Livelihood of Households Heads

Livelihood options available to households depend on diversity of resources. In the case of Oloolua area the source of livelihood was highly diversified as shown in table 4.3.

Table 4.3: Source of livelihood and type of house wall of the household

Source of livelihood	Type of house										Total	%
	mud	%	iron sheet	%	concrete	%	bricks	%	timber	%		
Formal employment	0	0	3	3.4	1	1.7	56	94.9	0	0	60	19
Casual laborer	6	7.8	55	71.4	1	1.3	0	0	15	19.5	77	24.8
Agriculture	0	0	8	36.4	0	0	12	54.5	2	9.1	22	7.4
Trading	0	0	37	24.3	1	0.7	113	74.3	1	0.7	152	48.9
Total	6	1.9	103	33.1	3	1	181	58.2	18	5.8	311	100

The main source of livelihood was found to be trading in the area 48.9 %. However, many households source of livelihood was from a combination of different sources. Source of livelihood was analyzed across type of house wall and the results showed that it had an influence on the type of house ($\chi^2 = 175.502$, df=16, p=0.000). The probable explanation to this is that the level of income determines the kind of house one is able to construct or rent. Majority of household heads with brick walled houses were engaged in trading (n=113) and formal employment (n=56) while those with highest number of iron sheet walled (n=55), timber (n=15) and mud (n=6) were involved in casual labour.

An analysis of type of house variation among sub locations revealed iron sheet walled houses, mud walled, and timber walled were common in Embulbul sub-location 64.2 % compared to other sub locations. This could be because Embulbul is a slum area and has probably attracted young and new people in the job market. Most of them work in the neighboring high-end estates, and middle-income earners estates as casual laborer and so their place of residence is determined by nearness to their place of work and affordability.

Further, source of livelihood was cross tabulated with age and it showed significant statistical difference (χ^2= 42.510, df=16, p=0.000). From the results, a great portion of respondents of the ages 28-37 were found to be engaging in casual labour (37.5 %) and trading (42 %). The involvement of younger people on casual labour and small businesses can be attributed to high level of unemployment in Kenya which is at 40 % as reported by KNBS, 2010.

4.1.4 Marital Status of the Household Heads

Overwhelming majority 67.5 % of the household heads were in marital status category married. This was followed by single (20.3 %), widowed (6.4 %) and divorced (8.5 %) as shown in table 4.4.

Table 4.4: Marital status and Gender of the household heads

Marital status	Gender				Total	%
	male	%	female	%		
Married	210	91.7	0	0	210	67.5
Single	17	7.4	46	56.1	63	20.3
Widowed	1	0.4	19	23.2	20	6.4
Divorced	1	0.4	17	20.7	18	5.8
Total	229	73.6	82	26.4	311	100

Marital status was analyzed across gender and results showed a significant relation (χ^2 =237.307, df=3, p=0.000). This could be due to gender differences in the experience of multiple roles demand within marriage. Most 91.7 % male household leads were married while female household heads were women either single (56.1 %), widowed (23.2 %) or divorced (20.7 %). Majority of them however were single.

4.2 Climate Variability Trend in Oloolua Area for the Duration 1980-2015

Climate variability determination in Oloolua area was based on two variables; rainfall and temperature for the period 1980 to 2015. The data was obtained from Kenya Meteorological Department for Ngong' forest station (No.8005325).

4.2.1 Rainfall variability in Oloolua area between 1980-2015

Rainfall variability and distribution are important climatological information. The analysis of inter-annual rainfall variability (figure 4.2) shows that rainfall trend fluctuated from year to year.

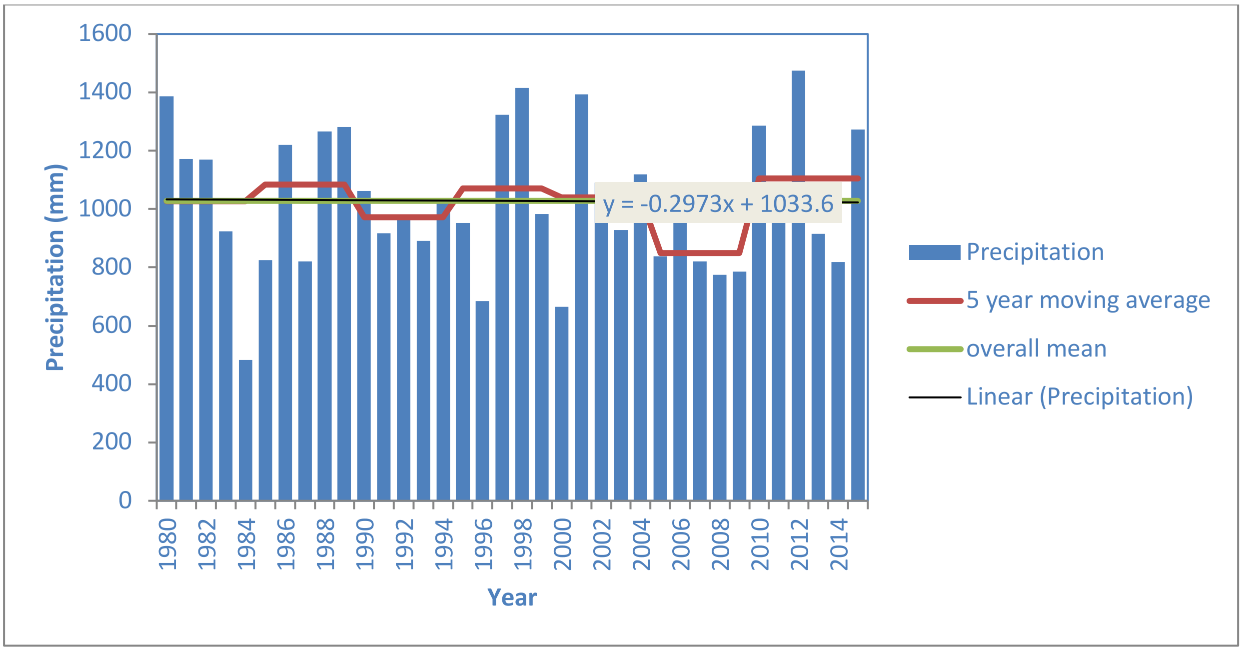

Figure 4.1: Inter-annual rainfall variation with 5year moving averages in Oloolua area for the period 1980-2015 (KMD data)

Rainfall amounts fluctuated between a maximum of 1475.5mm in 2012 and minimum of 482.7 mm in the year 1984. Oloolua had an average annual rainfall of 1028.1mm. The annual averages of 15 years were above average while the averages of 17 years period were below average annual rainfall and 2 years on the average. The year 1980 to 1990 experienced precipitation above average with changes in the years 1983, 1984, 1985 and 1987 that recorded below average. The year 1991-2015 recorded precipitation below average with breaks in the years 1997, 1998, 2001, 2002, 2004, 2010, 2012 and 2015. The year 1984 (482.7 mm) was the driest among them all, followed by the year 2000 (664.9mm) and 1996 (684.6mm). The years that experienced the highest amount of rainfall were 2012 (1475.5mm) followed by1998 (1415.4mm), 2001(1393.2mm) and 1980(1386.7mm). This confirms to the reports of Amwata, 2013 and Bobadoye *et al*., 2014 who mentioned some of the driest years to have been (1984, 2000, 1996) and wettest years (1998,1980 and 2012) in Kajiado County.

In addition to annual rainfall variation, rainfall anomalies characteristic for the period 1980-2015 clearly show deviation from the long-term mean as shown in figure 4.2. It shows a distinct view of the driest and wettest years as well as significant variability of average precipitation amounts recorded in the period.

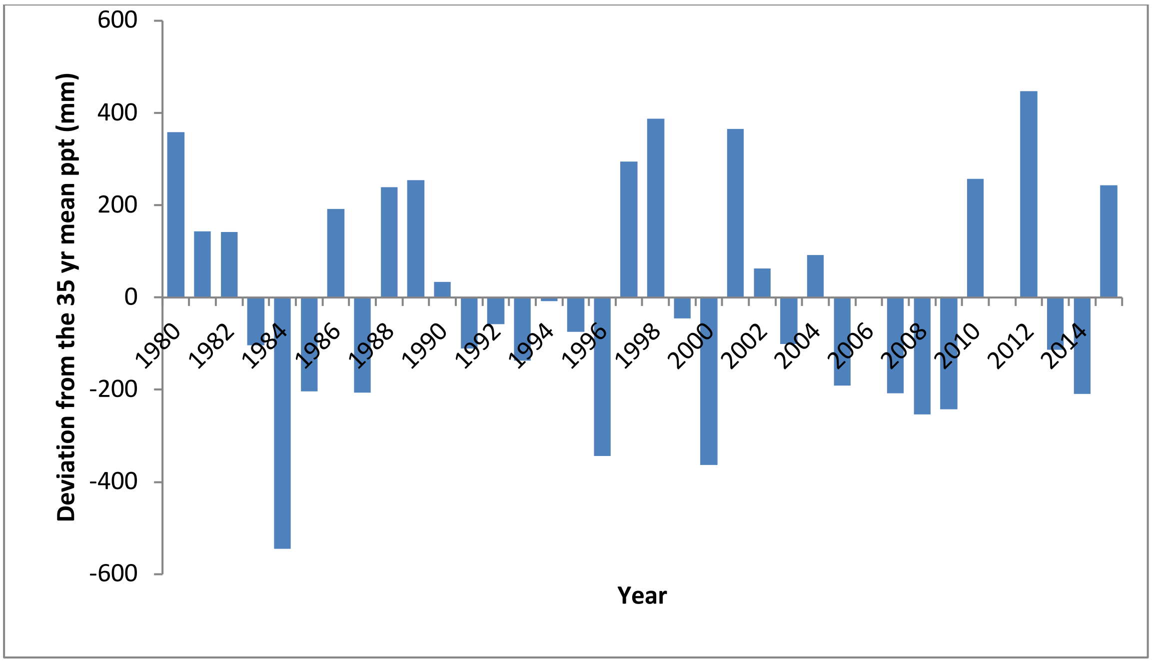

Figure 4.2: Inter-annual rainfall anomalies in Oloolua area for the period 1980-2015

Out of the 35 years, 15 years were above average while 19 years were below average and two years on average. This implies that the dry years in the period under analysis were more than wet years. The years that experienced noticeable droughts as shown in figure 4.2 were 1984, 1985, 1987, 1996, 2000, 2005, 2007, 2008, 2009 and 2014 and the year 1984 was the driest of them all. These findings are in line with those of Shisanya *et al*. (2011) who stated that in Kenya's wide spread droughts occurred in some of the mentioned years above. The years that experienced noticeable wetness in the period included 1980, 1988,1989, 1997, 1998, 2001, 2010, 2012 and 2015. The year 2012 was the wettest of them all. The 1990s had more dry years that the other two decades in the area only 3 years were above average. Followed closely by the 2000s that had 4 years above average and 6 below average. It can therefore be concluded that the 1990s was the driest decade among the 3 under analysis. From the graph, it is worth noting that the dry years were normally followed by years with heavy rains which is an indicator of rainfall variability.

Historically, flooding in Kenya occurred in these wet years and some were attributed to El Nino events (GoK, 2010) thus the role of ENSO cannot be ignored as much as some revealed climate variability. A study carried out by Mwaniki (2014) reported that years 1982, 1986, 1987, 1991, 1997 and 2000 were referred as El Nino years. Some of this years are reflected in the discussion above. Additional work by Kisaka *et al*. (2015) reported that high rainfall variability is normally attributed to La Nina and Elnino events although they are not of equal magnitude and they significantly contribute to unpredictable weather patterns. From the results (figure 4.2) these events continue to occur with increased severity and frequency in recent years. It can therefore be concluded that it's important to devise mechanisms that would help households of this area to adapt to these events of rainfall variability.

To further examine rainfall trends in Oloolua area, a five-years moving averages were analyzed to study the changes as reported in table 4.5 below. This 5-year periodic trend provided a better view of rainfall variability in Oloolua area than the anomalies from figure 4.2 above.

Table 4.5: 5-year moving average for precipitation amount (mm) in Oloolua area for the period 1980-2015

Period	Precipitation amount (mm)	Magnitude of increase mm	Trend
1980 - 1984	1027	-	
1985 - 1989	1083.16	56.16	Increased
1990 - 1994	972.42	-110.74	decreased
1995 - 1999	1071.7	99.28	increased
2000 - 2004	1039.52	-32.18	decreased
2005 - 2009	849.16	-190.36	decreased
2010 - 2014	1105.08	255.92	increased
Total ppt Increased		78.08	

Source: Data from KMD and MALF, 2016

Oloolua area recorded a marginal increase in precipitation amount of 78.08 mm between the years 1980 to 2015 but with a time series changes which clearly indicated rainfall variability. This may be attributed to rainfall distribution, rainfall for the period is not uniformly distributed. High rainfall variability exposes regions to rainfall extremes. Scientists (Susilo *et al.,* 2013; Avila *et al*., 2016) have pointed out that ASALs will experience more intense rainfall. It's likely that in a warmer climate heavy rainfall will increase and be produces by few introduce invest in agricultural modernization including mechanization and construction of irrigation facilities. However, linear regression analysis shows a steady decrease of rainfall in the period indicating that annual rainfall variance has been decreasing over the years. This is confirmed by the rate of change defined by the linear regression analysis that shows a descending slope (Y=-0.2973x +1033.6).

Small holder farmers to be encouraged to adopt modern agricultural production and productivity enhancing technologies more intense events. Susilo *et al.* (2013) further notes that change in rainfall trend due to El Nino and La-Nina has been discussed by many researchers worldwide suggesting that the ENSO is the most significant factor causing global hydroclimatic variability. This study therefore supports Susilo's work.

Another important indicator of climate variability was finally portrayed in seasonality trend analysis as shown in figure 4.3.

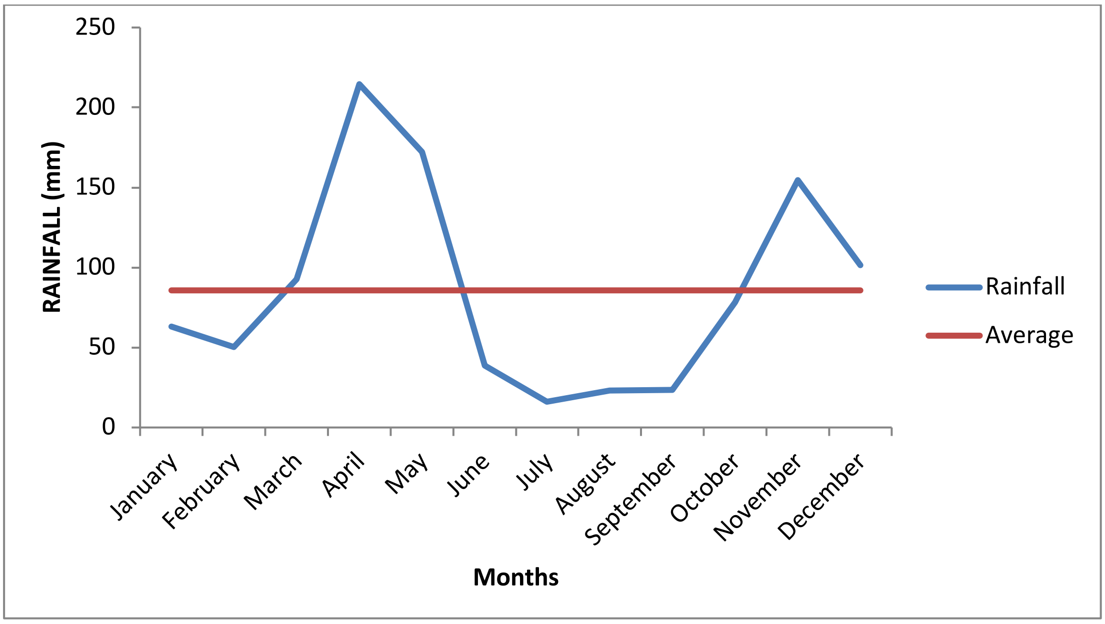

Figure 4.3: Monthly average rainfall variation in Oloolua area for the period 1980-2015

The analysis of monthly rainfall variation indicated that Oloolua area has 2 rainy seasons with the highest peak in April (214.6 mm) and the lowest peak in July (16.1mm). The monthly rainfall averages were 85.7 mm in the period under analysis. The year starts with 2 dry months (short dry season) January 62.9 mm and February 50.4 mm preceded by long rainy season. The long raining season runs for 3 months from March to May with 92.6 mm, 214.6.6 mm and 172.3 mm respectively. It is followed by the long dry season starting from June (38.5 mm), July (16.1mm), August (23 mm) and September (23.5 mm) and short raining season comes immediately after starting from October to December with 85.7 mm, 154.7 mm and 101.3mm respectively. These findings are in support of Ombogo (2013) in analysis of rainfall trend in Kajiado County and Bobadoye *et al*. (2014) in the influence of climate variability and change on land use found out that the area had bi modal rainfall pattern with four seasons.

To further investigate rainfall seasonality in the area, 11year moving seasonal trend was computed periodically as shown below in table 4.6.

Table 4.6: Seasonal precipitation trend in Oloolua area for the period 1980- 2015

Season	1980 - 1991	1992 - 2003	2004 - 2015	Trend
DJF	63.29	86.32	65	Increasing
MAM	179.58	144.83	155.14	Decreasing
JJA	20.0	25.79	30.81	Increasing
SON	84.2	85.23	86.92	Increasing

Note:
DJF = December-January-February
MAM =March-April- May
JJA =June-July-August
SON =September-October-November

Eleven-year analysis of the seasonal trend revealed that all the seasons increased except MAM season. The DJF dry season extended to the MAM rainy season. This implies that the MAM rains delayed and ended earlier. Generally, the MAM rainy season shortened due to the decrease of the season and extension of the DJF dry season that spilled over. The JJA season increased as well. This means it extended to the next SON rainy season thus delay of the onset of rains. The SON season as well increased spilling over to DJF dry season. This showed that the SON rains ended late and the DJF dry season delayed in the study area in the period under scrutiny.

Another noticeable change from table 4.6 is that JJA dry season recorded the lowest amount of precipitation than the DJF season. This implies that JJA is the driest season of the year. It can also be noted that SON experienced short rains while MAM experienced long rains from their total annual averages. These findings are in agreement with those of (GoK, 2010) which reported change in seasons in Kenya.

In regard to rainfall amount the responses were based on whether the amount had increased, decreased, remained the same or fluctuated. Out of 311 (100%) respondents 66.2 % (206) said rainfall amounts kept on fluctuating, 22.8 % (71) said it had decreased, 10.6 % (33) increased and only 0.4 % (1) said the amount remained the same. Further, 65.6% reported that the seasons fluctuated, 18.6 % narrowed, 15.5 %

widened with none responding on remaining the same. In line with rainfall spacing majority (65.3 %) reported that the seasons fluctuated, 18 % shortened, 16.7 % extended with none responding to remain the same. With regards to rainfall onset 25.1 % reported that the rains started earlier and ended late, 57.6 % the onset delayed & ends early and 17.3 % reported on frequent rain failure. The findings imply that Oloolua area is experiencing rainfall variability. The results are in agreement with those of Opiyo *et al*. (2014) and Bobadoye *et al*. (2016) who carried out research in the same ecosystem and reported that rainfall patterns highly varied in Arid and semi-arid parts of Kenya.

4.2.2 Temperature Changes in Oloolua area for the period 1980-2015

Temperature is also another important proxy indicator of climate variability.

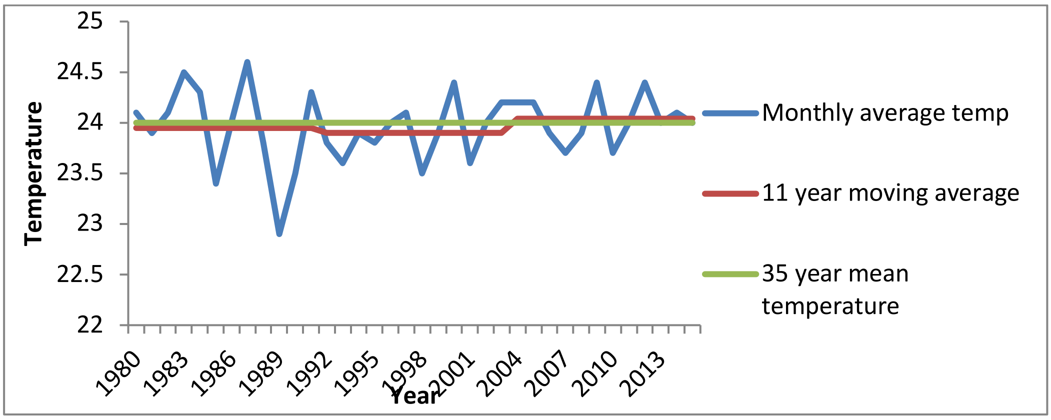

Figure 4.4: Mean average temperature variation in Oloolua area (1980-2015) (Ngong' forest station data, 2016)

The results showed that the area had experienced both a rise and fall in annual temperatures. The annual temperatures in the area ranged between 22.9°C (lowest) and 24.6ºC highest. Noticeable variability is observed from the year 1985-1991. Between 1985 and 1987 temperature rose steadily from 23.4-24.6°C and later declined sharply in 1989(22.9°C) and afterwards increased steeply to 24.3°C in 1991.

A time series of 11year monthly minimum and monthly maximum temperatures indicated the magnitude and rate of warming in the period under scrutiny as shown in table 4.7.

Table 4.7:11 year moving average for temperature in Oloolua area in the period 1980-2015

Period (yrs)	Maximum temp (°C)	Magnitude of increase (°C)	Minimum temp (°C)	Magnitude of increase (°C)
1980 - 1991	23.95	-	12.93	-
1992 - 2003	23.9	-0.05	13.32	0.39
2004 - 2015	24.04	0.14	13.675	0.355
Overall increase		0.09		0.745
Annual increase rate		0.0026		0.0213

From the results maximum temperature decreased from 1980-1991 to 1992-2003 by -0.05°C and it later rose from the year 1992-2003 to 2004-2015by 0.14°C. Minimum temperature in the period 1980-1991 to 1992-2003 rose by 0.39°C and that of the period 1992-2003 to 2004-2014 rose by 0.355°C. In general, maximum temperature increased by 0.09°C at the annual increase rate of 0.0026°C while the minimum temperature rose by 0.745°C at the annual increase rate of 0.0213.

This clearly indicated that minimum temperature increased more than the maximum temperature. These findings suggest that warming in the study area was due to diurnal temperature variation for instance difference between maximum and minimum temperatures. These findings are in support of Christy *et al*. (2009) who stated in the overview of climate change in Kenya that maximum temperature is not significantly different from zero and minimum temperature suggests an accelerating temperature rise. The study is also in support of GoK (2010) National Climate Change Response strategy report which indicated that minimum temperature increased more than maximum temperature in Kenya. The findings are also in agreement with the IPCC (2007) report which denoted with confidence that warming globally was as a result of a sharp incline in minimum temperatures. It can therefore be concluded that Oloolua area is slowly warming and it's due to diurnal temperature variation.

Views were further sought from the household heads on temperature changes in the study area. The responses were based on whether the temperature had increased, decreased, or remained the same. Out of 311 respondents 73.9 %(230) reported that temperature had increased, 23.8 % (74) said temperature had decreased with 2.3 % (7) reported that it remained the same. From the results, it may be concluded that the households were experiencing temperature changes in this area.

The results from both KMD data analysis and the household survey showed that temperature in the area had been increasing gradually in the period. These results correspond with UNEP, (2014) report which shows a rise in global temperature for the last 3 decades by about 0.6°C ± 0.2°C. Additionally, results of Brian *et al.* in (Boru and Koske, 2014) confirmed that temperature increased in 13 Arid and Semi-Arid divisions of Kenya from a survey carried out. Further, the study is also in tandem with GoK, (2009) which reported temperature rise in Kenya by 1°C over the past 50 years. There is therefore no doubt the earth is warming and so is Oloolua area.

4.2.3 Correlation Analysis between Temperature and Precipitation in the period 1980-2015

From the results, cooler years experienced more rainfall and vice versa. This is evident from the behavior of rainfall peaks and corresponding temperature peaks both maximum and minimum (figure 4.5).

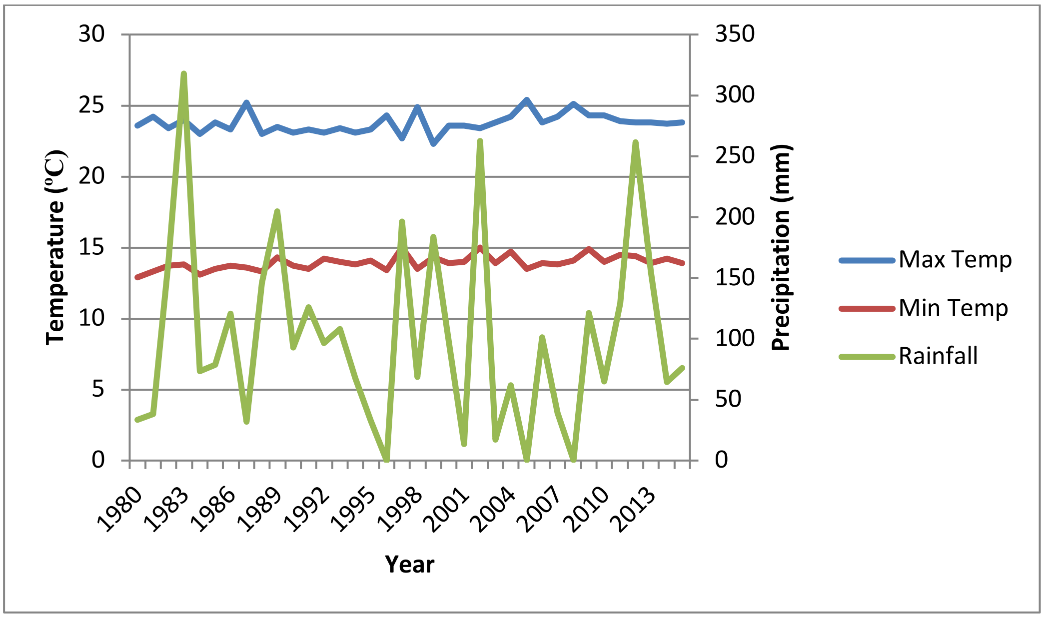

Figure 4.5: Inter-annual precipitation and annual temperatures in Oloolua area between 1980-2015

For instance, the year 1984, 1986, 1987, 1996, 1997, 1998, 1999, 2005, 2006, 2008 and 2012 have noticeable peaks. Temperature increase with decrease in rainfall revealed negative correlation between the two variables. When warm years were apparent, the resulting effect was decrease in precipitation amount. These study findings are line with those of Nkuna and Odiyo, (2016) who analyzed correlations between temperature and rainfall in South Africa. In their findings they reported that cold years were normally wet and warm years dry. They further suggested that, if temperature and rainfall of a given area remains static warmer years will be associated with decline in precipitation. It can therefore be concluded that increase in temperature resulted to low rainfall.

In addition, mean monthly maximum and mean monthly minimum temperatures were correlated with mean monthly precipitation to show any associations in seasons as in figure 4.6.

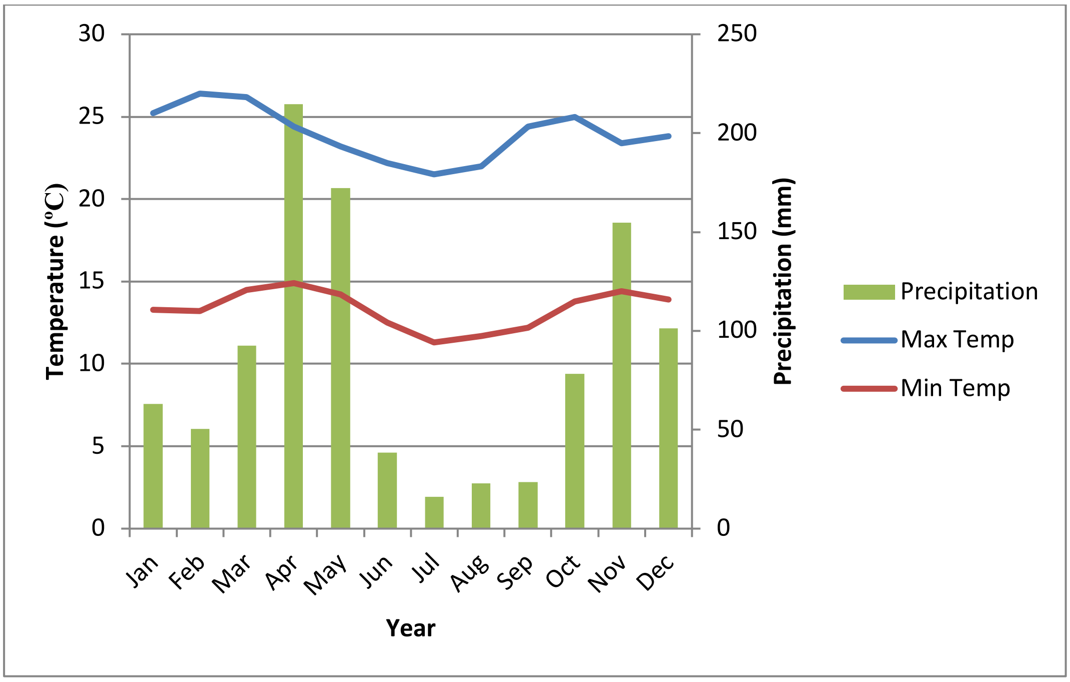

Figure 4.6: Mean monthly rainfall and, annual temperatures in the period 1980-2015

From figure 4.6, both maximum and minimum temperatures increase from September to October. The two months lie in the short rainy season of September to November. The likely explanation could be a result of temperatures being precursors of seasonal rains. They provide energy for connective activities that enhance rainfall in the area. Maximum temperature decreased in MAM rainy season, while minimum temperatures increased. This is a clear indicator of cold days and warm nights during this season. JJA dry season had low rainfall coupled with low temperatures which resulted to a dry period with cold days in the area. Their correlation was positive, and this can be explained from the fact that the trends behaved in the same way for instance the months of June, July and August when the lowest amount of rainfall was recorded lowest temperatures were recorded as well. This study is in support of Zhao *et al*. (2017) in his work on relationship between precipitation and temperature.

4.2.4 Perceived Causes of Climate Variability in Oloolua area

From the results, human drivers had the highest score of 430.9. It was then followed by natural forces and God's annoyance with the scores of 385.2 and 292.9 respectively.

Table 4.8: Perceived causes of climate variability in Oloolua area

Indicator	Strongly agree %	Agree %	Undecided %	Disagree %	Strongly Disagree%	Total weight
Human drivers	57.6	29.9	1.0	8.7	2.9	430.9
Natural Forces	35.4	38.9	2.6	21.6	1.6	385.2
God's annoyance	20.9	16.4	9.0	42.1	11.6	292.9

This implies that human activities were perceived as the major cause of climate variability in the area and thus households can have control over climate variability if they change their actions. These results were consistent with those of Oloo, 2013 who stated that households already related human activities to climate variability and not just being a natural phenomenon.

Based on the outcome of this section on rainfall variability and temperature changes it's evident that Oloolua area experienced climate variability thus the null hypothesis that Oloolua area is experiencing significant climate variability was accepted.

4.3 Effects of Climate Variability on Food Grain Production in Oloolua Area

A series of analyses were performed to test the hypothesis that climate variability has significant effects on crop production in Oloolua area for the period 2008-2015. The summary of the data set analyzed for the relevant variables are as shown in table 4.9. From table 4.9 it's clear that crop (maize and beans) yields and climate data portrayed year to year variability.

Table 4.9: Crop statistics and climate data for the period 2008-2015 in Oloolua area

Year	Total annual rainfall (mm)	Temperature (Max) °C	Temperature (Min) °C	Maize tonnes	beans tonnes
2008	775.0	25.1	14.1	223	67
2009	785.4	24.3	14.9	476	209
2010	1286.0	24.3	14.0	511	161.7
2011	1028.1	23.9	14.5	608	326
2012	1475.5	23.8	14.4	769.5	318
2013	915.2	23.8	13.8	315.54	324
2014	819.5	23.7	14.2	63.0	54
2015	1271.7	23.8	13.9	430.5	83

Source: KMD and MoALF data, 2016

The year 2012 produced high yields for both maize (769.5 tonnes) and beans (318 tonnes) for the period under analysis. This could be related to total rainfall volumes (1475.5mm) experienced in that year. The year 2014 gave the least yields; maize (63 tonnes) and beans (54 tonnes) in the period compared to 2008 (775 mm) and 2009 (785.4 mm) that had slightly lower amount of rainfall. This could be attributed to poor rainfall distribution throughout that year since rainfall amount and distribution is one of the most important determinants of inter-annual fluctuation on crop production.

4.3.1Correlation analysis of annual precipitation and crop production (maize and beans)

Rainfall is one of the most important climate variable that influences agricultural production.

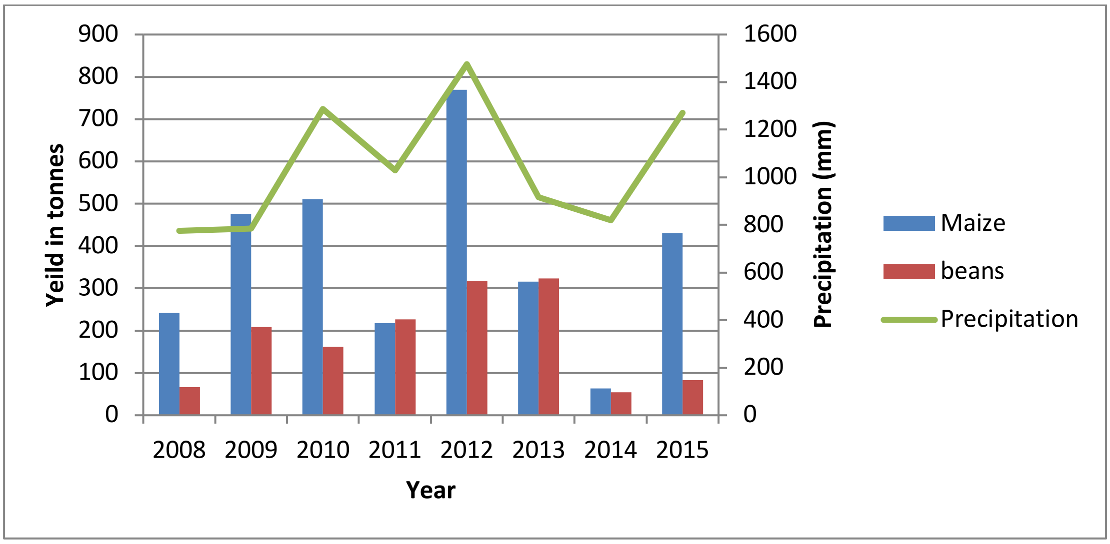

Figure 4.7: Crop (maize, beans) - precipitation correlation (2008-2015) KMD and MoALF data

From the results, it's quite remarkable that crop production and precipitation in the past 8 years varied from year to year. It's crystal clear that changes in rainfall impacted beans and maize production as depicted from the bars. High variable pattern of rainfall as portrayed in figure 4.7 reflects the uncertainty to which crop production is exposed in the area. The most noticeable year with high crop yields was 2012 which also recorded the highest rainfall amounts.

The year 2014 as well recorded the lowest crop yields in the period despite receiving relatively favorable rainfall amounts. This could be due to other related factors such as soil erosion, soil fertility and flooding. Too much water can leave the soil waterlogged.

Hatfield and Prueger, (2015) indicated in their literature that excess rainfall has detrimental effects to maize production particularly at the reproductive stage. They further noted that runoff water effects on soil fertility reduces crop yields.

Another significant correlation was depicted in running a Pearson's correlation test on precipitation-crop yields as illustrated in figure 4.8 and 4.9.

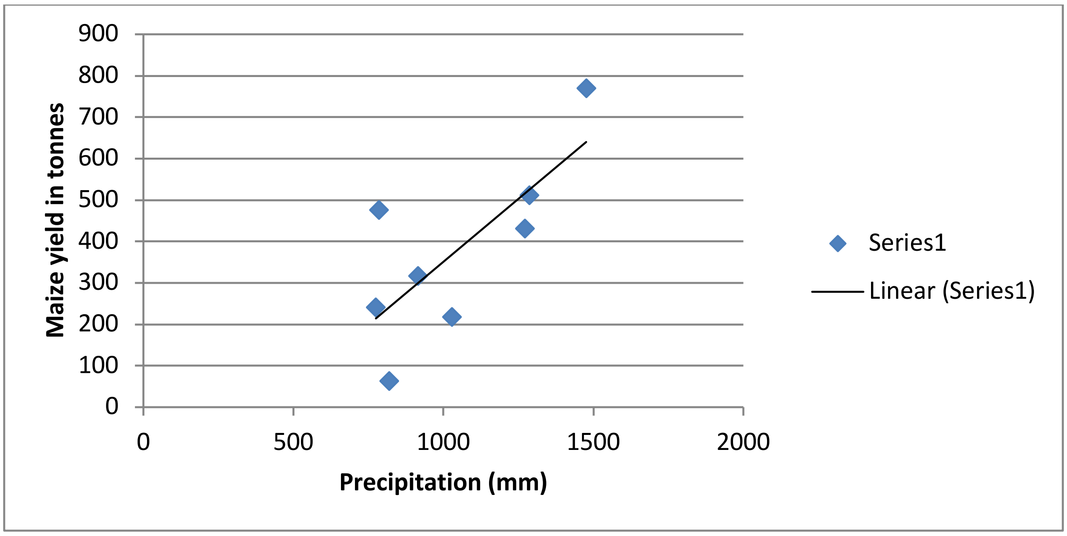

Figure 4.8: A scatter graph showing maize - precipitation correlation between 2008-2015

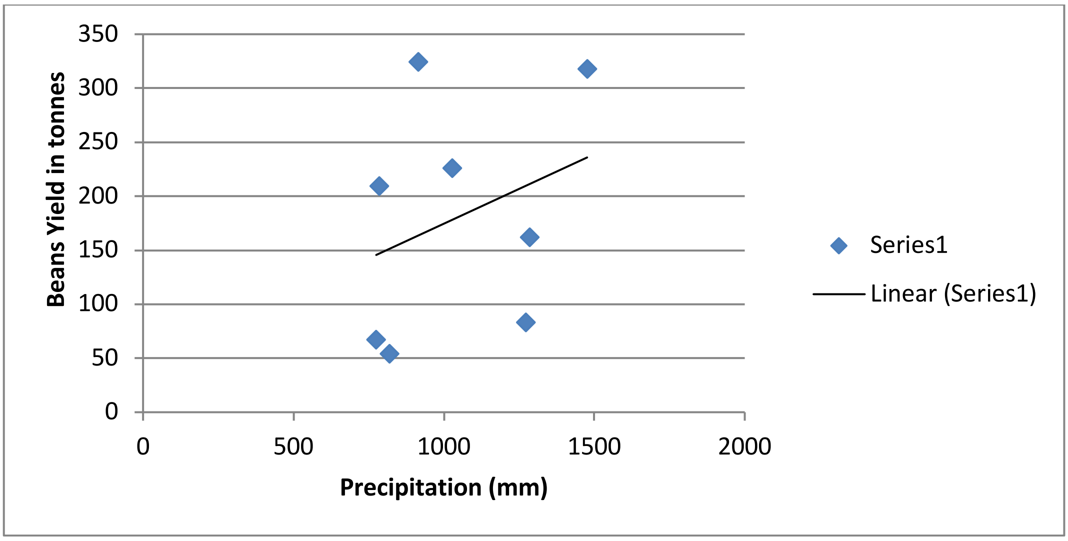

Figure 4.9: A scatter graph showing beans -precipitation correlation (2008-2015)

Pearson's correlation results exhibited a positive correlation for both maize and beans with values of r=0.749 (strong positive correlation) and r=0.321(weak positive correlation) respectively. This implies that the trend in rainfall variability was in unison with changes in maize and beans output despite their strength. These results are typical of rain-fed crops in semi-arid conditions where the study area falls. The likely explanation to this is that adequate water is more significant in determining yields as long as it's well distributed. According to Ndamani and Watanabe, (2014) water serves as a carrier of nutrients and energy exchange in crop development. This study conquers with him. Putting this into consideration poorly distributed rainfall can hamper crop growth thus resulting to low yields.

4.3.2Correlation analysis of maximum and minimum temperature and crop production (maize and beans)

Temperature is also another important variable that influences crop production. From the analysis maximum temperature did not show much activity on crop production. Minimum temperature however, portrayed significant effects on production. For instance, the year 2012 with the highest yields experienced the lowest minimum temperature 13.6°C in the period under analysis whereas the year 2014 with the highest minimum temperature of 14.1°C gave the lowest yields as portrayed in the graph.

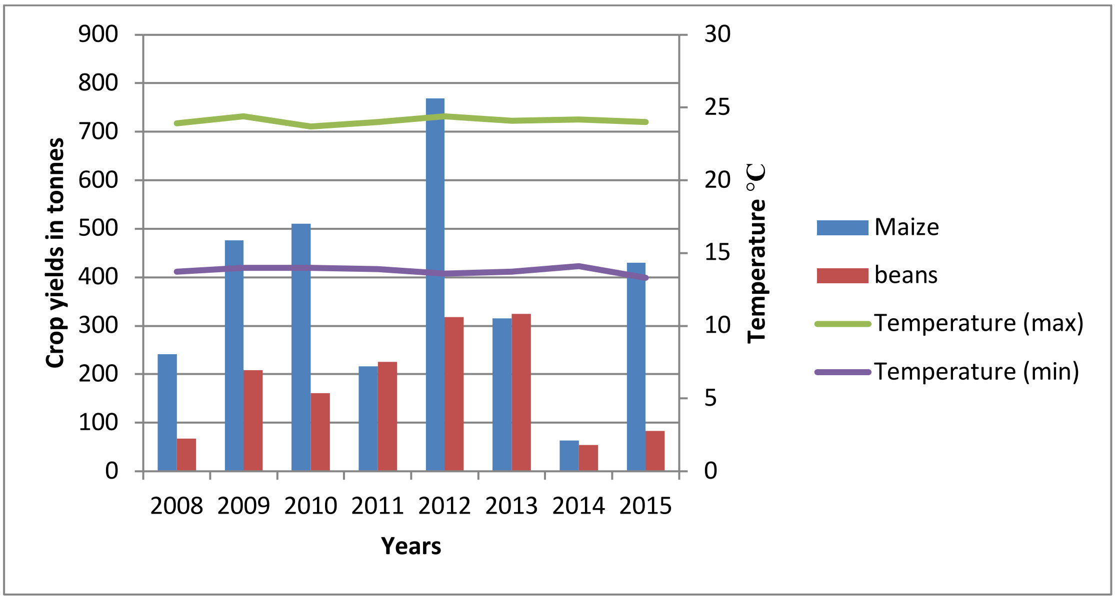

Figure 4.10: Crop yield (maize and beans) and temperature (max and min) correlation (KMD and MoALF data)

It is hypothesized that a rise in temperature translates to decrease in crop yields. According to Mark *et al*., 2008 high temperatures coupled with high seasonal variability could affect the availability of soil moisture for crop production due to high evaporation and evapotranspiration.

To further investigate the strength of association between crop yields and temperature, Pearson's correlation analysis was run, and results displayed as in figure 4.11, 4.12, 4.13 and 4.14.

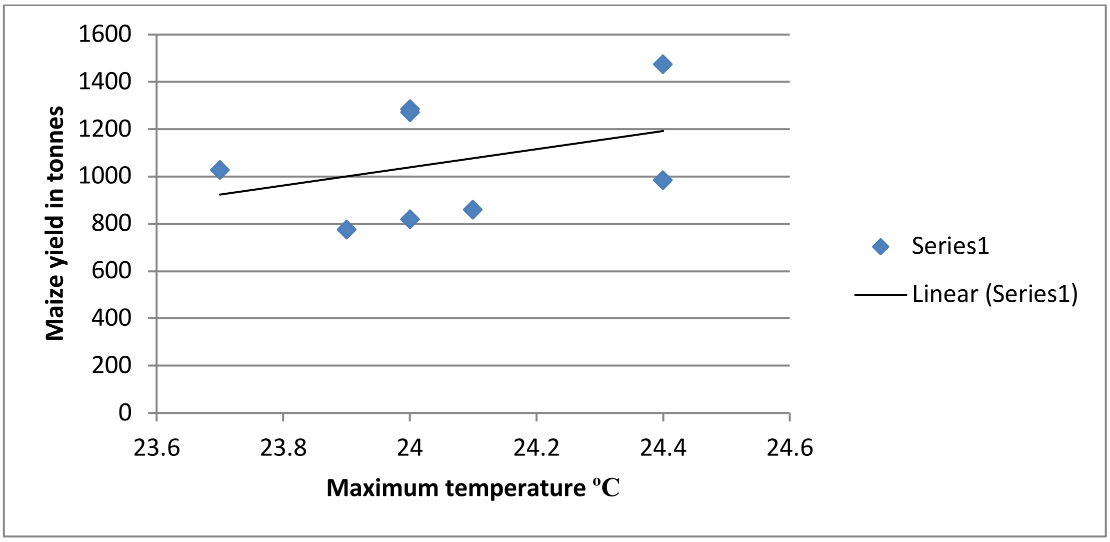

Figure 4.11: A scatter graph showing maize yield-maximum temperature correlation

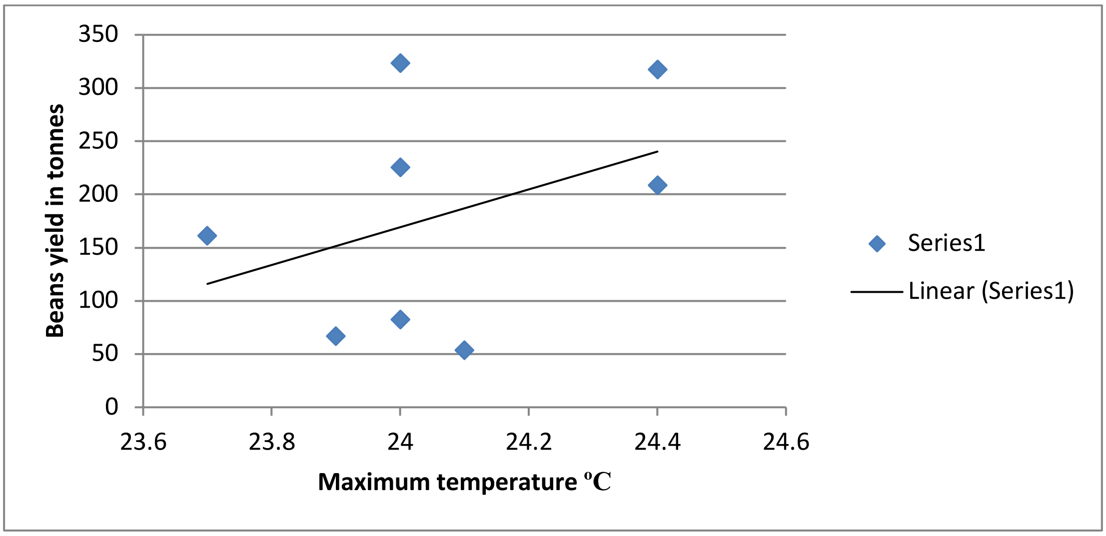

Figure 4.12: A scatter graph showing beans yield- maximum temperature correlation

The results of Pearson's correlation analysis for maximum temperature with maize (r=0.273) and beans (r=0.398) depicted a weak positive correlation. This implies that increased maximum temperature translated to increased production. According to Thornton *et al.* (2009) the area suitable for beans growth is likely to increase under medium to high warming. This explains why beans production is increasing with increase in temperature. The likely explanation is that beans production is still viable under warming and yields can be multiplied if effective mitigation is considered. The optimum beans growing maximum temperature is 23°C (Omoyo *et al*., 2015) and mean annual temperature in the area recorded 24.1°C. Further in the findings Omoyo suggests that beans are more sensitive to rainfall variations than temperature rise. This explains why the yields increased with increase in temperature. The optimum maize growing maximum temperature 25°C and the study area recorded a mean annual of 24.1°C which was below the threshold favoring maize growth.

Furthermore, minimum temperature was correlated with crop yield to determine any association as in figure 4.13 and 4.14.

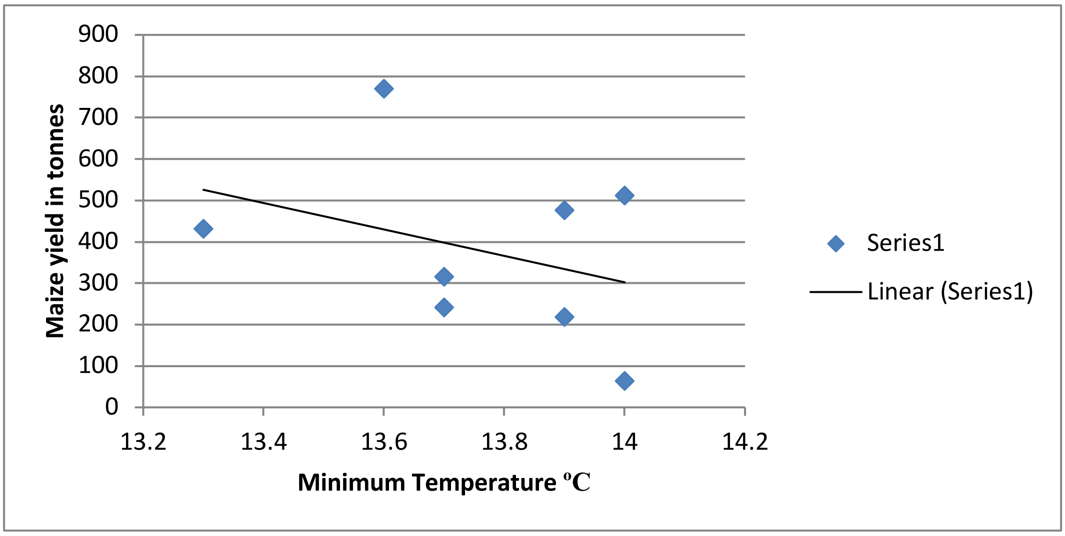

Figure 4.13: A scatter graph showing maize yield- minimum temperature correlation

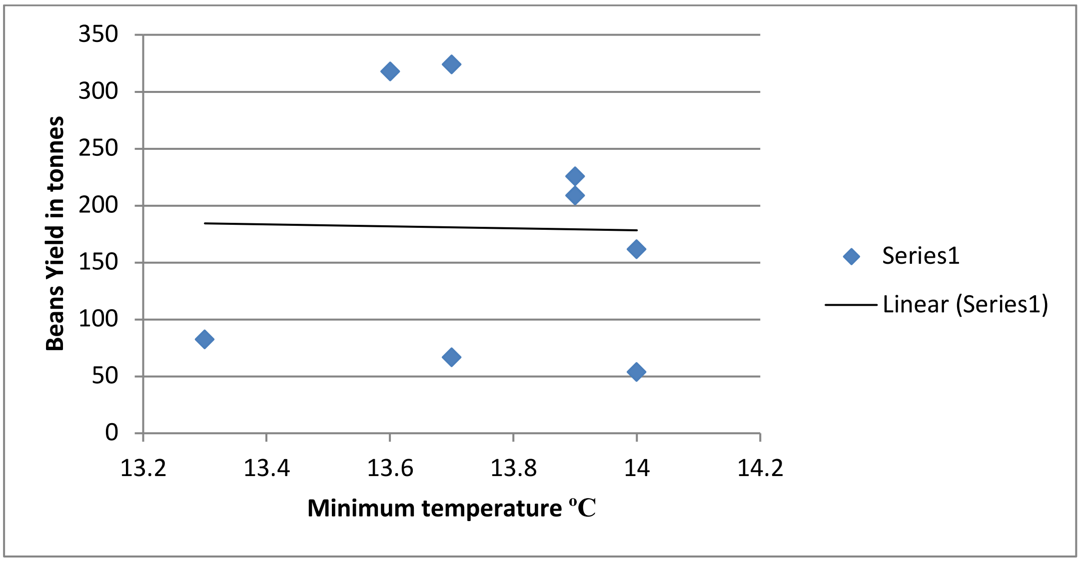

Figure 4.14: A scatter graph showing beans yield- minimum temperature correlation

Pearson's correlation revealed a weak positive correlation with maize(r=0.35) while beans revealed no correlation with minimum temperature (r=0.019). This implies that maize increased with increase in minimum temperature while it had no effect on beans production. These findings agree with those of Mwaura and Okoboi, (2014) who found out that temperature variations have observable effects on crop yields and beans production increased significantly with increase of lowest minimum temperature. Additional work by Yadav *et al*. (2011) reported that high minimum temperature can reduce fertility and pollination for beans. Higher temperatures on beans reduces nitrogen fixation and warming may promote invasion of pests and diseases resulting to low yields.

4.3.3 Perceived Climate Related Events that Hinder Food Production in Oloolua Area

The effects of climate variability on crop production is primarily attributed to increased frequency of extreme events (table 4.10).

Table 4.10: Climate variability related events experienced in Oloolua area in the period 1980-2015

Indicator	High	Moderate	Low	Total Weights
Droughts	67.2	25.4	7.4	259.8
Floods	37.3	52.7	10.0	227.3
Diseases and pests	23.5	45.7	30.9	192.8

From the results breakdown, droughts were reported to be the most frequent and widely spread in the study area with the score of 259.8 followed by floods with a score of 227.3. Occurrence of pests and diseases was the least experienced with the score of 192.8. According to Masekoameng and Maliwichi, (2014) recurred extreme weather events undermines food production. For instance, both rainfall extremes (droughts and floods) are detrimental to crop production under rain-fed conditions and altered weather patterns increases crop vulnerability to pest infestation. Droughts followed by intense rains reduces the capacity of water infiltration and leads to flooding. These events are likely to hinder food production in the area.

Action Aid, (2009) reported that in Kenya droughts were experienced once in every seven years in the 1970s, once in five years in the 1980s and 2-3 years in the 1990s but apparently droughts in Kenya occur yearly with great frequency. In the period under analysis in the study area (1980-2015) extreme weather events mainly (droughts and floods) have been reported in Oloolua area as shown in figure 4.2. However, some of them have been attributed to ENSO events. Some of the mentioned years such as 1996, 2009 and 2011 generally the country experienced food insecurity particularly in the ASALs (WFP, 2009). Droughts causes food shortage and it also triggers famine. It impacts crop yields and further triggers infestation of pests and diseases. Declined crop yields could lead to increased food prices in the markets thus food insecurity. These findings are in line with those of Enenkel *et al*. (2015) who reported that droughts affect food production hence food insecurity.

Based on the results presented in this segment 4.3 it was concluded that climate variability had great influence on crop production. In view of importance of the climate variables on crop production the hypothesis that climate variability (rainfall and temperature) has significant effects on crop (maize and beans) production in Oloolua area was accepted.

4.4 Household Food Security Status in Oloolua Area

FAO, 2010 describes household food security as "*having both physical, social and economic access to sufficient, safe and nutritious food at all times for a healthy life*". Categorical designations of household food security status were based on whether the household was food insecure, vulnerable to food insecure or food secure as shown in table 4.11.

Table 4.11: State of food security in household and main source of food in Oloolua households

	Source of food in household								Total	%
	Local market	%	Government reserve stock	%	Village farmer retailer	%	Own	%		
FS	39	48.8	29	36.2	5	6.2	7	8.8	80	25.7
VFIS	53	50.0	4	3.8	40	37.7	9	8.5	106	34.1
FIS	82	65.6	10	8.0	25	20.0	8	6.4	125	40.2
Total	174	56.0	43	13.8	70	22.5	24	7.7	311	100

FS-food secure, VFIS-vulnerable to being food insecure, FIS- food insecure.

From the results 40.2 % of the sampled households reported to be food insecure, 34.1 % were vulnerable to being food insecure and 25.7 % were food secure. Household food security status was then analyzed across household source of food to establish any interaction between the 2 variables. The chi-square test revealed that there was no statistical difference between food security status and source of food (χ^2=64.541, df=6, p=0.000). Most of the food secure households 48.8 % sourced their food grains from their local market. While 36.2 %, 8.8 % and 6.2 % sourced their food grains from government reserve stock, own production and village farmers' retailer respectively.

The respondents indicated that local markets 56 % were their main source of food in the area. Other sources of food were village farmers retailer 22.5 %, government reserve stocks 13.8 % and own production 7.7 %. These findings emphasized on the great role markets play in providing food for households in the study area. These similar trends have been reported in Makueni County by Scribd (2011) who in his findings reported that 64.5 % of households' main source of food was from local markets and in South Africa by Sakyi, (2012) who reported that food purchases from markets in many cases make up to 90 % of household food sources.

Further, household food security status in the area was based on Household Food insecurity Access Scale (HFIAS) generic questions responses. The scale provides a continuous measure of household food insecurity which can be categorized into 4 levels (food secured, mildly food insecure, moderately food insecure and severely food insecure) (table 4.12).

Table 4.12: Household Food insecurity Access Scale responses in Oloolua area

No	Food access statements	True	%	False	%
1	Worried would not have enough food	266	85.5	45	14.5
2	Not able to eat balanced meal	236	79.0	65	21.0
3	Worried that will run out of food	237	76.1	74	23.9
4	Ate non- preferred foods	229	73.6	82	26.4
5	Ate reduced size of meal	219	70.3	91	29.7
6	Ate fewer meals in a day	214	68.9	97	31.1
7	Went to sleep at night hungry	128	41.2	183	58.8
8	Did not eat for a whole day	124	39.9	187	60.1
9	Did not eat whole day and night	81	26.0	230	74.0

The first question (worry that your household did not have enough food) reflects anxiety and uncertainty, question 2, 3 and 4 reflects insufficient quality of food and question 5,6,7,8 and 9 indicates inadequate food intake and its physical consequences. Food secure households never experience any of the condition or occasionally experiences worry that the household did not have enough food. Mildly food insecure are not able to eat balanced meal, worried that your household will run out of food, ate non-preferred foods but do not reduce on quantity of food or experience the three severe conditions. A moderately food insecure forfeits quality and reduces on the food quantity by eating reduced size of meal, eating fewer meals in a day but the household does not experience any of the three severe conditions. A severely food insecure household experiences one or the three severe household conditions (Coates *et al*., 2007).

Majority 85.5 % of the household indicated a superior level of uncertainty about food security status meaning that only14.5 were food secure in the area. 79.0 % (n=236) could not eat balanced meals, 76.1 % (n=237) worried that the household would run out of food, 73.6 % (n=229) ate limited variety of food. This implies that an overwhelming majority were mildly food insecure. Majority 70.3 % (n=229) ate reduced size of meal and 68.9 % (n=214) reported that they ate fewer meals than they needed. This showed that they were moderately food insecure. Less number reported a severe form of food insecurity such as 41.2 % (n=128) went to sleep hungry because there was no enough food, 39.9% (n= 124) went a whole day without a meal and 26 % (n=81) and went the whole day and night without eating anything. This showed that the number of respondents declined towards a more severe condition of food insecurity.

The results of this study reinforce the earlier findings of Wakibi *et al*. (2015) in Kenya and those of Adane *et al*. (2015) in Ethiopia who reported that the number of households who worried of not having enough food was higher and it declined towards the severe conditions going day and night without a meal.
Further on household food security status the household heads were asked to indicate the months they experienced food shortage as in figure 4.15.

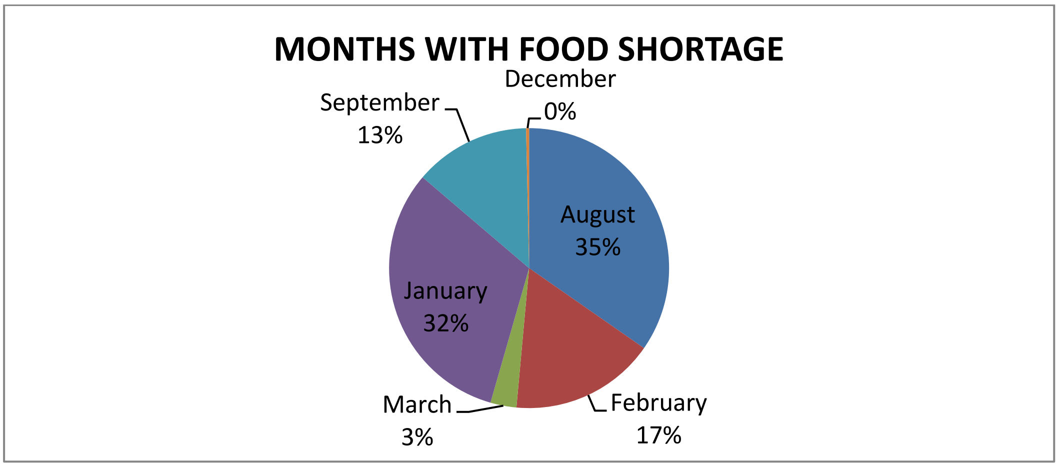

Figure 4.15: Months of food shortage in Oloolua area

From the results, most of the respondents experienced food shortages in the months of August 35 % and January 32 % followed by February 17 %, September 13 % and March

3 %. This could be attributed to the low rainfall especially in the month of January and August. All the five months fell in the dry seasons of the year (figure 4.7). It can therefore be concluded that households in this area experienced food shortage during the dry period and shift in seasonality may increase the number of months of food shortage in a year.

4.4.1 Causes of Food Shortage

From the results (table 4.13), reliance on rain-fed agriculture was the major cause of food shortage in Oloolua area with a weight of 275.9. It was followed with change in weather patterns with a score of 259.5. Insufficient harvests from previous seasons came third with a score of 262.4 then followed by pests and diseases, poor farming methods and land degradation and exhaustion with scores of 230.3, 229.2 and 225.2 respectively.

Table 4.13: Causes of food shortage in Oloolua area

Cause of food shortage	Often true %	sometimes true %	never true %	Total weight
Change in weather patterns	59.5	40.5	0	259.5
Poor farming methods	31.8	65.6	2.6	229.2
Land degradation and soil exhaustion	28.9	67.5	3.5	225.2
Pest and diseases	32.2	66.2	1.6	230.6
Reliance on the rain fed agriculture	78.1	19.6	2.3	275.9
Insufficient harvest from the past	69.8	24.1	6.1	262.4

According to Mburu *et al.* (2015), the ministry of agriculture noted most of these causes of food shortages. Agriculture in Kenya is rain-fed hence change in weather patterns limits production. The smallholders in the area reported that rainfall had become unpredictable consequently affecting planting seasons which further leads to low production. Rainfall extremes have long-term effects in reducing the economic base of households, thereby leading to chronic and acute food insecurity. Household's vulnerability to food insecurity increase during protracted drought through progressive depletion of food stocks and capital assets (Adane *et al.*, 2015).

4.4.2 Household Food Shortage Coping Strategies

To determine the extensiveness of the coping strategies entails measuring the frequency by the ascribed weights and then summing it up to get scores (Maxwell and Caldwell, 2008) as in table 4.14.

Table 4.14: Household food shortage coping strategies

Coping strategy in the last 7 days	often true %	sometimes true %	never true %	Total weight
Reliance on less expensive/preferred foods	64.2	35.8	0	164.2
Limit portion sizes	34.3	61.4	4.3	130
Reduced no of meals in a day	41.0	52.0	7	134
Reduced consumption by adults	22.6	56.4	21	101.6

Reliance on less expensive/ less preferred foods was the major food shortage coping strategy in the area with the highest score of 164.2. It was then followed by reduced number of meals in a day with a score of 134, limited portion sizes 130 and reduced consumption by adults with the lowest score of 101.6. The implication of these findings is that households of Oloolua area relied on various coping strategies to counter food shortage. Reliance on less preferred foods is an indicator of food insecurity. This study supports that of Icheria, (2015) on household food insecurity and coping strategies among small scale farmers in Tharaka Central Division. Icheria's study states that increased reliance on coping strategies is associated with lower food availability.

4.4.3 Distribution of Household Food Security Status by Household Socio-Demographic Factors

There are a set of socio-demographic characteristics set to determine state of food security such as gender, marital status, age, household size, income levels and education level of the household heads (Zhou, 2017). However, this study focuses more on gender, marital status and education level of the household heads as shown in table 4.15

Table 4.15: Socio-demographic characteristics and their influence on food security status in Oloolua area

	Food security status							
	FS	%	VFIS	%	FIS	%	total	%
Marital status	(χ^2=32.566, df=6, p=0.000)							
Married	64	80	90	72	56	52.8	210	67.5
Single	6	7.5	18	14.4	39	36.8	63	20.3
Widowed	3	3.8	9	7.2	8	7.5	20	6.4
Divorced	7	67.5	8	20.3	3	6.4	18	5.8
Education	(χ^2=188.924, df=6, p=0.000).							
No formal education	0	0	2	1.6	32	30.2	34	10.9
Primary education	2	2.5	18	14.4	50	47.2	70	22.5
Secondary education	19	23.8	64	51.2	20	18.9	103	33.1
Tertiary education	59	73.8	41	32.8	4	3.8	104	33.4
Gender	(χ^2=16.358, df=2, p=0.000)							
Male	70	87.5	94	75.2	65	61.3	229	73.6
Female	10	12.5	31	24.8	41	38.7	82	26.4

FS-food secure, VFIS-vulnerable to being food insecure, FIS- food insecure

Marital status is one of the important variables in determining household food security status. Household heads in marital status category- married were more food secure. In marriage both partners engage in income generating activities thus contributing to household income. The chi-square test results showed a statistical significant difference (χ^2=32.566, df=6, p=0.000). Both food secure and insecure households were in status married. The findings of this study are similar with those of Yusuf *et al*., (2015), who concluded that married household heads are likely to be more food secure than divorced, separated, widowed and single individual.

Education level is also another important variable in determining food security status of a household. It shades light into distribution and utilization of food. It enables people to acquire information on nutrition, balanced diet, hygiene and how to cope with food insecurity. People with little education normally secure low paying jobs thus food insecurity. Majority of the household heads were literate. A chi-square test was done to establish any relationship between education level and food security status. The results revealed that the level of education significantly influenced food security status (χ^2=188.924, df=6, p=0.000). These findings are in line with a study carried out by Icheria, (2015) who reported that the years spent in school is one of the determinants of increased household food production. However, the findings contradict Ndobo and Sekhampu, 2013 who reported that education did not significantly influence household food security status in South African township.

In regard to gender, food insecurity was more dominant in female headed households than male headed households. This could be due to the fact that female headed households are more likely to be single parents who take care of the household needs single handedly thus increased burden. The chi-square test which showed significant difference between gender and food security status in the study area (χ^2=16.358, df=2, p=0.000). The findings of this study are similar to those of Adane *et al*. (2015), who argues that most female headed homesteads are food insecure because they are constrained with resources such as land and due to their social roles in the society. It can therefore be concluded that women need to be enlightened and be included not because they are vulnerable but because they also have different experiences and perspectives to contribute to food security status.

Based on the findings of this section it was concluded that the area was food insecure and gender, marital status and education significantly influenced the state of food security in the area.

4.5 Climate Variability Coping Strategies Adopted by Households in Oloolua Area

Insights from Guloba, (2014) point out that adaptation capacity of households depends on how they can draw from their resources to increase their outcomes. If the climate trend plays out as expected, food insecurity is likely to become worse. Faced with a myriad of unpredictable climate variation, Oloolua households probably adopted to different strategies to offset the effects of climate variability. Findings are presented in able 4.16 below:

Table 4.16: Climate variability coping strategies in Oloolua area

Indicator	Never %	Sometimes %	Often %	Always %	Total weight
Agroforestry	1.6	60.1	32.8	5.5	162.1
Application of organic fertilizer	3.9	60.8	33.1	2.1	133.3
Rain water harvesting	1.9	22.2	58.2	17.7	191.7
Irrigation farming	46.3	45.7	7.7	0.3	62.0
Soil water conservation	1.6	40.2	52.7	5.5	142.2
Introduction of new seeds	12.2	74.9	12.5	0.3	100.8
Drought tolerant crops	0.3	17.7	51.1	30.9	212.6
Greenhouses farming	66.2	30.5	2.8	0.3	37.0

From the findings, majority 212.6 of the households in the area adopted drought resistant crops. The low adoption of greenhouse farming and irrigation could be due to the high cost required to purchase, install and maintain irrigation systems and greenhouse structures. The area was seen to practice autonomous adaptation practices which were more of risk management or production enhancement triggered by ecological and welfare changes. This implies that if widely adopted they have the capacity to offset climate variability effects. However, the current rate of climate variability may change known patterns subjecting households to a situation they are not well equipped to handle thus need for planned adaptation to improve resilience for future uncertainty.

This study is in support of Mburu *et al*. (2015) who reported similar strategies and further emphasized that drought tolerant crops could leads to reasonable production even with little rainfall. Soil and water conservation could improve nutrients and water uptake and reduce soil erosion thus increased production. As water stress becomes more intense especially during the dry periods most households try to cope by harvesting rainwater (Adane *et al*. (2015). Some respondents suggested that they had diversified their crop (sorghum, millet) as well moved from farming to non-farming (trading, handcraft) activities as a form of adaptation. Some of these strategies are also similar with those mentioned by Coulibaly *et al*. (2015) and Chandra *et al*. (2016). It can therefore be concluded that Oloolua households relied on a number of coping strategies to counter food insecurity and climate variability and they preferred multiple options that were used in combination.

4.5.1 Socio-Demographic Factors that Influence Climate Variability Coping Strategies

Below *et al*. (2010) pin points that age, gender, education, assets, household size are among household adaptation characteristics. In this study, attention was given to age, gender and education of the household heads.

4.5.1.1: Planting Drought Tolerant Crops

Drought is a major factor that limits food security. With increase in temperatures due to global warming droughts are likely to become a severe problem. In this sense drought tolerant plants play a vital role in ensuring food security.

Table 4.17: Age, gender and education level influence on drought resistant crops in Oloolua area

Age in years	Drought resistant crops										Chi-square statistics
	Never	%	sometimes	%	often	%	always	%	Total	%	
18-27	0	0	3	60	1	20	1	20	5	100	$x^2 = 20.418$
28- 37	7	4	113	64.2	56	31.8	0	0	176	100	
38 - 47	4	3.8	62	59	35	33.3	4	3.8	105	100	
48 - 57	1	4.2	11	45.8	10	41.7	2	8.3	24	100	df=12
57 >	0	0	0	0	1	100	0	0	1	100	p=0.060
Total	12	3.9	189	60.8	103	33.1	7	2.3	311	100	
Gender											
Male	11	4.8	143	62.4	71	31	4	1.7	229	100	$x^2 = 4.563$
Female	1	1.2	46	56.1	32	39	3	3.7	82	100	
Total	12	3.9	189	60.8	103	33.1	7	2.3	311	100	df=3 p= 0.207
Education level											
No formal education	2	5.9	24	70.6	8	23.5	0	0	34	100	$x^2 = 8.192$
Primary education	3	4.3	47	67.1	19	27.1	1	1.4	70	100	df=9 p= 0.005
Secondary education	2	1.9	62	60.2	37	35.9	2	1.9	103	100	
Tertiary education	5	4.8	56	53.8	39	37.5	4	3.8	104	100	
Total	12	3.9	189	60.8	103	33.1	7	2.3	311	100	

The findings of this study revealed that majority (212.6) of the household planted drought tolerant crops. The results showed that the ages of 28-37 (n=176) adopted more to planting drought tolerant plants. This could be due to the fact that majority of the household heads fall within this age set. However, Chi-square test results proved that age had no influence (χ^2=20.418, df=12, p=0.060) on planting drought resistant crops in Oloolua area. This means that household heads of all ages are likely to adopt drought tolerant crops.

These findings contradict those of Oloo, (2013) who found out that aged household heads were most likely to adopt planting drought tolerant crops. Further, gender had no influence on planting drought tolerant crops in the area (χ^2=4.563, df=3, p=0.207) though a look at the results showed that Male (n=229) adopted to drought resistant crops. This could be attributed to the fact that male headed households were more that female headed in the study area. Additionally, the level of education had significant positive influence on adoption of drought resistant crops (χ^2=8.192, df=9, p=0.005). A quick scan on the results shows that households heads with tertiary (n=104) and secondary education (n=103) adopted drought tolerant crops more than their counterparts with primary (n=70) and no formal education (n=34). This means that household heads with high education levels are likely to plant drought resistant crops. The argument here could be that education increases the probability of adaptation.

4.5.1.2 Rain Water Harvesting

Rain water harvesting is basically the diversion, collecting, storage and usage of rainwater for various purposes for instance collecting rainwater from roof tops. Rain water harvesting was the second adopted coping strategy in the study area with a score of 191.7. It means households are harvesting water to abate droughts and water stress seasons. Rain water harvesting was analyzed across gender, education and age to establish any connections in the study area. The chi-square statistics revealed that age had an influence on rainwater harvesting (χ^2=35.290, df=12, p=0.0001).

A scan on the results showed that rain water harvesting was more popular where household heads aged between 28-37 years (n=176). The possible explanation to this is that household heads in this age set are assumed to be young and informed and thus have a good understanding of the importance of water harvesting technique. The findings of this study however disagree with those of Aroko (2010) who found out that older household heads adopted more than the young household heads. He argued in his findings that this was attributed to the experience gained over time.

Additionally, rainwater harvesting was analyzed across gender to establish any gender differences in adoption of the practice and the results (χ^2=3.760, df=3, p=0.289) revealed no significant influence. Further the chi-square test was run to test for any association between the level of education and rainwater harvesting and it showed a significant positive influence (χ^2=37.546, df=9, p=0.001). This implies that heads with high level of education are more likely to adapt than less educated. These results are in support of Recha *et al*. (2015) who reported that educated household heads adopted to rain water harvesting more than less educated.

Table 4.18: Age, gender and education level influence on rain water harvesting in Oloolua Area

Age in years	Rain water harvesting									%	Chi-square statistics
	Never	%	some times	%	often	%	always	%	Total		
18-27	0	0	1	20	3	60	1	20	5	100	x^2
28-37	2	1.1	40	22.7	114	64.8	20	11.4	176	100	$= 35.290$
38-47	3	2.9	26	24.8	56	53.3	20	19	105	100	df=12
48-57	1	4.2	2	8.3	8	33.3	13	54.2	24	100	p=0.0001
57>	0	0	0	0	0	0	1	100	1	100	
Total	6	1.9	69	22.2	181	58.2	55	17.7	311	100	
Gender											
Male	5	2.2	51	22.3	138	60.3	35	15.3	229	100	x^2
Female	1	1.2	18	22	43	52.4	20	24.4	82	100	$= 3.760$
Total	6	1.9	69	22.2	181	58.2	55	17.7	311	100	df=3 p= 0.289
Education											
No formal education	1	2.9	9	26.5	21	61.8	3	8.8	34	100	x^2 $= 37.546$
Primary education	1	1.4	14	20	49	70	6	8.6	70	100	df=9 p=0.0001
Secondary education	3	2.9	20	19.4	70	68	10	9.7	103	100	
Tertiary education	1	1	26	25	41	39.4	36	34.6	104	100	
Total	6	1.9	69	22.2	181	58.2	55	17.7	311	100	

UNEP (2002) report classified Kenya as a water scarcity country with annual volume of below 1000 m^3 per an individual. IPCC, (2007) report further indicated that water scarcity affects every aspect of life including development and food security status.

Thus, rain water harvesting comes in handy to provide sufficient supply during the scarcity tenure. This could as well go a long way in slaking water stress seasons.

4.5.1.3 Agroforestry Practices

With increased threats of climate variability and food insecurity, interest in agroforestry has been acknowledged for its multiple benefits. Agroforestry practices was the third preferred adopted strategy with a score of 162.1 in the study area. It was then analyzed across gender, age and education level to establish any possible connections as in table 4.19.

Table 4.19: Age, gender and education level influence on agroforestry in Oloolua area

Age	Agroforestry								Total	%	Chi-square statistics
	Never	%	Some times	%	often	%	always	%			
18-27	0	0	4	80	1	20	0	0	5	100	$x^2 = 11.887$
28-37	3	1.7	110	62.5	54	30.7	9	5.1	176	100	
38-47	2	1.9	63	60	36	34.3	4	3.8	105	100	
48-57	0	0	9	37.5	11	45.8	4	16.7	24	100	df=12
57>	0	0	1	100	0	0	0	0	1	100	p=0.455
Total	5	1.6	187	60.1	102	32.8	17	5.5	311	100	
Gender											
male	3	1.3	142	62	74	32.2	10	4.4	229	100	$x^2 = 2.972$
female	2	2.4	45	54.9	28	34.1	7	8.5	82	100	df=3
Total	5	1.6	187	60.1	102	32.8	17	5.5	311	100	p= 0. 035
Education											
No formal education	0	0	25	73.5	6	17.6	3	8.8	34	100	$x^2 = 9.706$ df=9
Primary education	2	2.9	40	57.1	27	38.6	1	1.4	70	100	p= 0.001
Secondary education	2	1.9	62	60.2	34	33	5	4.9	103	100	
Tertiary education	1	1	60	57.7	35	33.7	8	7.7	104	100	
Total	5	1.6	187	60.1	102	32.8	17	5.5	311	100	

Age had no significant (χ^2=11.887, df=12, p=0.455) influence on adoption of agroforestry practice in Oloolua area. This implies that the likely to adapt to agroforestry was inversely significant to age. Increase in age had no influence the chances to adopt agroforestry in the study area.

According to Mutambara *et al*. (2012) young household heads are more likely to adapt to agroforestry practices while elderly could be reluctant due to risks attached to new adaptations that come with increased age. These findings are in line with Mutambara's work. The probable explanation is that aged heads tend to prefer less labour demanding activities unlike agroforestry. In addition, it was crucial to derive statistical significance of agroforestry on either gender. It is hypothesized that men and women due to gender social roles adapt to different practices differently. The chi-square test results revealed that gender had no significant (χ^2=2.972, df=3, p=0.035) influence on adoption of agroforestry in Oloolua area. This means that the decision to adopt agroforestry did not depended the gender of the household head. A quick scan on the results showed that majority (n=229) of the male respondents adopted agroforestry in the area. The rationale here is that agroforestry is gender intensive like the planting of trees and cutting or pruning them down thus female heads tend to shy away from them.

Education is key in enhancing adaptive capacity. Education had a statistical influence on agroforestry (χ^2=9.706, df=9, p=0.001). This implies that the more educated the more likely to adapt to agroforestry practices. This is tandem with Boateng, (2008) who found out that the literacy levels influenced adaptation in Ghana. However, the study contradicts Jera and Ajayi, (2008) who found that the level of education of a household head not being a significant determinant of adopting agroforestry in Zimbabwe.

4.5.2 Challenges that Hinder Devisal of Coping Strategies

Despite the benefits of climate variability coping strategies, there are a number of challenges that work against their wide use as shown in table 4.20.

Table 4.20: Challenges that devisal of coping strategies in Oloolua area

Indicator	Often true	%	Sometime true	%	Never true	%	Total weight
Financial constraints	183	58.8	125	40.2	3	1	257.8
Poor infrastructure	32	10.1	256	82.3	23	7.5	202.4
Lack of information	67	21.5	239	76.8	5	1.6	219.7
Lack of relevant skills	62	19.9	243	78.1	6	1.9	217.8
Lack of technology	67	18.5	231	74.3	23	7.3	211.2

From the results, the major challenge households were facing in the study area is lack of finances. Coping strategies are costly. Even with knowledge and skills there is little that can be done without resources to implement the practices. Lack of information could be greatly due to the fact that research in climate variability coping strategies have not been strengthened in Oloolua area. These findings echo those of Mbah *et al.*

(2016) who state in their work that the capacity of the community to mitigate and cope to climate effects depends on the resources available.

Based on the findings presented on this section it was concluded that coping strategies used in the study area were autonomous hence there is need for planned adaptations to improve climate resilience for future climate uncertainty.

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of the Findings

The study found out that rainfall amount increased in Oloolua area by 78.08 mm in the period 1980-2015 with significant year to year variability which was depicted from deviation from the mean. Seasonality trend analysis revealed an increase in DJF, JJA and SON seasons while MAM recorded a decrease in the season. Maximum temperature recorded an increase of 0.09º C with the annual increase rate of 0.0026º C while minimum temperature recorded rise in temperature of 0.745º C with the annual increase rate of 0.0213º C. Correlation analysis on inter-annual precipitation and maximum and minimum annual temperatures showed that cold years were wet and warm years dry. The results from Meteorological station were consistent with the perception of households on rainfall and temperature changes.

The findings also confirmed that climate variability had significant effects on crop production in Oloolua area. Both climate data and crop production portrayed year to year variability. Pearson's correlation analysis for crop production (maize and beans) against precipitation revealed a strong positive correlation for maize (r=0.749) and a weak positive correlation for beans (r=0.1321). Maximum temperature against production depicted weak positive correlation for both maize and beans with values of r=0.273 and r=0.398 respectively while minimum temperature exhibited weak negative correlation for (maize r= -0.35) production and no correlation for beans production(r=-0.01). Responses on perceived climate related events revealed that droughts with the highest score of 259.8 was the most experienced climate event that hindered crop production in the area.

The results further revealed that majority 40.2 % of the households were food insecure and they described the amount of food consumed in their households as low. The chi-square results of food security status and source of food showed no significant relationship (χ^2=64.541, df=6, p=0.000). The major cause of food shortage in the area was reliance on rain fed agriculture with the highest score of 275.9 and their main coping strategy was reliance on less expensive/less preferred foods 164.2. Marital status, level of education and gender significantly influenced food security status in Oloolua area (χ^2=32.566, df=6, p=0.000), (χ^2=188.924, df=6, p=0.000) and (χ^2=16.358, df=2, p=0.000) respectively.

Furthermore, the findings revealed that planting drought tolerant crops 212.6 and rain water harvesting 191.7 were the most commonly used coping strategies in the area. Irrigation and greenhouse farming were the least adopted practices in Oloolua area due to their expensive nature in buying, installing and maintaining the structures. Age, level of education and gender showed some degree of influence on adopting mitigation and adaptation strategies. Lack of finances was the major challenge that hindered adoption of coping strategies in the area with the highest score of 257.8.

5.2 Conclusions

Based on the findings of this research, the following conclusions can be drawn.

1. Oloolua area experienced climate variability. Variance is observable from inter and intra annual rainfall changes and increase in both minimum and maximum temperature. From the findings rainfall anomalies depicted a distinct view of rainfall variability. Unpredictable onset and ending of rains showed shift in rainfall trend. Minimum temperature significantly increased while maximum temperatures increased by a very tinny margin. This meant that warming in the area was accelerated by diurnal temperatures. Therefore, minimizing human based greenhouse gas emission would be a successful way to fight climate variability in the area.
2. The study also confirmed that the effects of rainfall and temperature adversely affect to maize and beans production in Oloolua area. The effects are significant and positive for all crops. Generally, there is better correlation of production with precipitation than temperature. From the findings Pearson's correlation showed positive correlation for crop yields against climate data except for minimum temperature that exhibited weak negative correlation for maize and no correlation for beans. This shows plainly that "business as usual" food grain growth is altered by changes in climate. These changes could alter growing seasons, planting and harvesting calendars or even invasion of pests, weeds and diseases. Some years that experienced relatively higher rainfall gave the lowest yields. This is likely to be caused by poor distribution of rains across seasons. Therefore, there is need to devise proper adaptation practices to curb climate variability to improve food production.
3. Oloolua area was food insecure. This could be attributed to climate variability that has contributed to low food production in the study area eventually causing food insecurity.

4. It can also be concluded that, the households employed some coping strategies in the area though the effort was still low. This could be due to the challenges they faced such as inadequate resources to implement the practices. Lack of finances hampered any effort to embrace this practices that require heavy investment upfront such as irrigation and use of greenhouse structures. Mitigation practices such as agroforestry should be supported due to their multi-benefits since they modify temperatures, attract rainfall and give other benefits like soil and water conservation as well as act as source of food and fuel.

5.3 Recommendations

Based on the findings of this research, the following recommendations can be made.

1. The study recommends planned adaptation strategies that will enhance the resilience of small holder farmers to climate variability. Various stakeholders such as the government, communities, development partners and the private sector all have important roles to play in enhancing the adaptive capacity of the community to climate variability.

2. The study recommends Ministry of Agriculture, livestock and Fisheries together with other stakeholders to introduce invest in agricultural modernization including mechanization and construction of irrigation facilities. Small holder farmers to be encouraged to adopt modern agricultural production and productivity enhancing technologies.
3. The study recommends KMD to provide farming households climate information and forecasts of onset and cessation of growing season. The information should be understandable, reliable and easily accessible. This will give them proper guidance on devising appropriate coping strategies to enhance drop yields and enhance food security in Kenya
4. The study recommends adoption of other food grains that may do well under this current climatic condition. Crops such as millet and sorghum are encouraged due to their high tolerance to droughts, soil infertility and high temperatures. Households also to be guided on how to monitor crop-climate relationship so as to achieve improved crop production drought resistant modern seed varieties are very important to the population of the

5.4 Suggestions for Further Research

1. There is need for further research on how food waste management can improve food security and counter climate variability in Oloolua area.
2. Climate modeling should be undertaken to determine the potential effects of further climate variability on crop production in the study area.
3. A study could be done on the same topic covering a wider scope in a different agro-ecological zone.

REFERENCES

.

Action Aid (2009). Floods follow drought in Kenya and there is worse to come. www.actionaid.ogr.uk/102148.

Adane, D. M., Atnafe, A. D., and Ahmed, H. M. (2015). The status of food availability in the face of climate change and variability in Choke Mountain Watersheds,Central Ethiopia. *Journal of Development and Agricultural Economics*, Vol. 7(10): 358-372.

Aden, H. (2017). Persistent Food Insecurity in Kenya: Examining the Potential Challenge of Horizontal Public Policy Inequalities (HPPIs). Master's thesis, Lund University.

Adhikari, U., Nejadhashemi, P. A., and Woznicki, S. A. (2015). Climate change and eastern Africa: a review of impact on major crops. *Food and Energy Security*, 4(2):110–132.

Afenyo, S. J. (2015). A review of food security implications of climate change in sub-Saharan Africa. Africa Intelligence's Africa Enviro. Available from: http://www.consultancyafrica.com/index.php?option=com_content&view=article&id=993: Accessed in Feb,2016.

African Women 's Studies Centre and Kenya National Bureau of Statistics (2014), *Status Report on Kenya National Food Security,* Nairobi; University of Nairobi Press.

Ainsworth, E. A., and Ort, D. (2010). How do we improve crop production in a Warming World? *Future Perspectives in Plant Biology*, 154: 526–530.

Alemaw, B. F., and Simalenga, T. (2015). Climate Change Impacts and Adaptation in Rain-fed Farming Systems: A Modeling Framework for Scaling-Out Climate Smart Agriculture in Sub-Saharan Africa. *American Journal of Climate Change*, 4(04), 313.

Ali, S., Liu, Y., Ishaq, M., Shah, T., Ilyas, A., & Din, I. U. (2017). Climate change and its impact on the yield of major food crops: Evidence from Pakistan. *Foods*, *6*(6), 39.

Amwata, D. A. (2013). The influence of climate variability and change on land-use and livelihoods in Kenya's southern rangelands, Kenya. Unpublished PhD thesis, University of Nairobi.

Amwata, D. A., Nyariki, D. M., & Musimba, N. R. (2016). Factors influencing pastoral and agropastoral household vulnerability to food insecurity in the drylands of Kenya: a case study of Kajiado and Makueni Counties. *Journal of International Development*, *28*(5), 771-787.

Araya, A., Kisekka, I., Lin, X., Prasad, P. V., Gowda, P. H., Rice, C., & Andales, A. (2017). Evaluating the impact of future climate change on irrigated maize production in Kansas. *Climate Risk Management*, *17*, 139-154.

Aroka, N. (2010). Rainwater Harvesting in Rural Kenya: Reliability in a variable and changing climate. Master's thesis, Stockholm University.

Asadieh, B., & Krakauer, N. Y. (2015). Global trends in extreme precipitation: climate models versus observations. *Hydrology and Earth System Sciences*, *19*(2), 877-891.

Baldos, U. L. C., and Hertel, T. W. (2014). Global food security in 2050: The role of agricultural productivity and climate change. *Australian Journal of Agricultural and Resource Economics*, 58(4), 554-570.

Barrett, C. B. (2014). The impact of changing rainfall variability on resource-dependent wealth dynamics. *Ecological Economics*, 6:1-25.

Belfield, S., and Brown, C. (2008). *Field Crop Manual: Maize A Guide to Upland Production in Cambodia*. NSW Department of Primary Industries, Cambodia.

Belloumi, M. (2014). Investigating the Linkage between Climate Variables and Food Security in ESA Countries. *Regional Environmental Change,* 42: 172-186.

Below, T., Artner, A., Siebert, R. and Sieber, S. (2010). "Micro-level Practices to Adapt to Climate Change for African small scale farmers: A review of selected literature", IFPRI Discussion Paper 00953.

Ben-Ari, T., Adrian, J., Klein, T., Calanca, P., Van der Velde, M., and Makowski, D. (2016). Identifying indicators for extreme wheat and maize yield losses. *Agricultural and Forest Meteorology*, *220*, 130-140.

Bilham, J. (2011). Climate Change Impacts upon crop yields in Kenya: learning from the past. *Earth &Environment,* 6(3): 1-45.

Bita, C. E., and Gerats, T. (2013). Plant tolerance to high temperature in a changing environment: scientific fundamentals and production of heat stress- tolerant crops. *Frontier in Plant Science,* 4: 273.

Boateng, I. (2008). The impact of agro forestry on the livelihood of rural farming households: A case study of selected communities of Offinso, Afigya,Sekyere and Atwima Districts: Kumasi : Unpublished. Msc. thesis, Kwame Nkrumah University of Science and Technology.

Bobadoye, A. O., Ogara, W. O., Ouma, G. O., and Onono, J. O. (2014). Comparative Analysis of Rainfall Trends in Different Sub Counties in Kajiado County Kenya. *International Journal of InnovativeResearch & Studies*. 3 (12), 180-195.

Bobadoye, A.O., Ogara, W.O., Ouma, G.O. and Onono, J.O. (2016), "Pastoralist perceptions on climate change and variability in Kajiado in relation to meteorology evidence", Academic Journal of Interdisciplinary Studies, Vol. 5 No. 1, doi: 10.5901/ajis. 2016.v5n1p37.

Boko, M., Niang, I., Nyong, A. (2007). In: Parry, M.L., Canziani, O.F, Palutikof, J.P., vanderLinden, P.J. and Hanson, C.E. (Eds.), Climate Change 2007: *Impacts, Adaptation and Vulnerability*. Cambridge University Press, UK: 433–467.

Boru, H. J., and Koske, J. K. (2014). Climate Variability and Response Strategies among the Gadamoji Agro-Pastoralists of Marsabit County, Kenya. *International Journal of Humanities and Social Science*, 4:11.

Bryan, E., Ringler, C., Okoba, B., Koo, J., Herrero, M., and Silvestri, S. (2011). *Agricultural management for climate change adaptation, greenhouse gas mitigation, and agricultural productivity: Insights from Kenya* (No. 1098). International Food Policy Research Institute (IFPRI).

Bunyasi, P. A. (2012). Kenya: Food Security Brief. *Available at SSRN 1992451*.

Chandra, A., Dargusch, P., and McNamara, K. E. (2016). How might adaptation to climate change by smallholder farming communities contribute to climate change mitigation outcomes? A case study from Timor-Leste, Southeast Asia. *Sustainability Science*, *11*(3), 477-492.

Choufani, J., Davis, C., McLaren, R., & Fanzo, J. (2017). *Climate change and variability: What are the risks for nutrition, diets, and food systems?* (Vol. 1645). Intl Food Policy Res Inst.

Chauvin, N. D., Mulangu, F., & Porto, G. (2012). Food production and consumption trends in sub-Saharan Africa: Prospects for the transformation of the agricultural sector. *UNDP Regional Bureau for Africa: New York, NY, USA*.

Christy, J. R., Norris, W. B., and McNider, R. T. (2009). Surface temperature variations in East Africa and possible causes. *Journal of Climate*, *22*(12), 3342-3356

Coates, J., Swindale, A., and Bilinsky, P. (2007). Household Food Insecurity Access Scale (HFIAS) for measurement of food access: indicator guide. *Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development*.

Collins, M., Knutti, R., Arblaster, J., Dufresne, J.-L., Fichefet, T., and Friedlingstein, P. (2013). *Long-term climate change: projections, commitments and irreversibility*: 1029–1136 United Kingdom, Cambridge University Press.

Comoe', H. D. (2013). Contribution to food security by improving farmers' responses to climate change in Nothern and central areas of Côte D'ivoire. Unpublished PhD Thesis,Eth Zurich University.

Connolly-Boutin, L., and Smit, B. (2015). Climate change, food security, and livelihoods in sub-Saharan Africa. *Reg Environ Change*, 4:89-96 DOI 10.1007/s10113-015-0761-x.

Coulibaly, J. Y., Gbetibouo, G. A., Kundhlande, G., Sileshi, G. W., and Beedy, T. L. (2015). Responding to crop failure: Understanding farmers' coping strategies in Southern Malawi. *Sustainability*, *7*(2), 1620-1636.

Creswell, J. W., and Plano-Clark, V. L. (2007). *Designing and conducting mixed methods research*, Thousand Oaks, CA: Sage Publications.

Duffy, K. J., & Masere, T. P. (2015). Effect of within-season daily rainfall distribution on maize crop yields. *Outlook on AGRICULTURE*, *44*(4), 267-271.

Eastburn, D. M., Degennaro, M. M., Delucia, E. H., Dermody, O., and Mcelrone, A. J. (2010). Elevated atmospheric carbon dioxide and ozone alter soybean diseases at Soyface. *Global Change Biol*., 16: 320 – 330.

Easterling, W.E., Aggarwal, P.K., Batima, P., Brander, K.M., Erda, L., Howden, S.M., Kirilenko, A., Morton, J., Soussana, J.F., and Schmidhuber, J. (2007). Food, fibre and forest products. In, Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M., and Miller,H.L. (Eds.), *Climate Change 2007: The Physical Science Basis.* UK, Cambridge University Press: 273–313

Enenkel, M., See, L., Bonifacio, R., Boken, V., Chaney, N., Vinck, P., and Anderson, M. (2015). Drought and food security–Improving decision-support via new technologies and innovative collaboration. *Global Food Security*, *4*, 51-55.

FAO (2015), Climate Change and Food Systems: Global Assessments and Implications for Food Security and Trade, Food Agriculture Organization of the United Nations (FAO), Rome.

FAO, (2013) Food security and agricultural mitigation in developing countries: options for capturing synergies. FAO, Rome.

FAO, (2008). *Climate change and food security: A framework document. Summary*. Interdepartmental working group on climate change: 1-107. Rome, Italy.

FAO, (2010). *Analysis of Climate Change and Variability Risks in the Smallholder Sector*.Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO, IFAD and WFP. (2013). The State of Food Insecurity in the World 2013. *The Multiple Dimensions of Food Security*. Rome, FAO.

FAO, IFAD and WFP. (2014). The State of Food Insecurity in the World 2014. Strengthening the enabling environment for food security and nutrition. Rome, FAO. Retrieved from:http://www.fao.org/publications/sofi/en/.

Fei, C. J., McCarl, B. A., & Thayer, A. W. (2017). Estimating the impacts of climate change and potential adaptation strategies on cereal grains in the United States. *Frontiers in Ecology and Evolution*, *5*, 62.

Fischer, R.A., and Edmeades, G.O. (2010). Breeding and cereal yield progress. *Crop Science,* 50: 85–98

Fisher, M., Abate, T., Lunduka, R., Asnake, W., Alemayehu, Y., and Madulu, R. (2015). Drought tolerant maize for farmer adaptation to drought in sub-Saharan Africa: Determinantsof adoption in eastern and southern Africa. *Climatic Change*, 87:91 DOI 10.1007/s10584-015-1459-2.

Gebremedhin, G. G. (2018). A Review of Impact Of Climate Change On Food Availability And Adaptation At Farm Level In Sub-Saharan Africa.

Gliem, J., & Gliem, R. (2003). Calculating, interpret- 22 ing, and reporting Cronbach's Alpha Reliability Coefficient for Likert-type scales. Midwest Research-to-Practice Conference in Adult, Con- tinuing, and Community Education. Retrieved October 6, 2010, from http://hdl.handle. net/1805/ 344.

GoK, (2013). County Integrated Development Plan 2013-2017, County Government of Kajiado.

GoK, (2007). *National Draft Policy on the sustainable development of ASALs*. Government printer, Nairobi.

GoK, (2010). *National Climate Change Response Strategy*; Ministry of Environment and Mineral Resource Development; Nairobi, Kenya.

GoK, (2012). National Environment Policy, 2012. Revised Draft number 5.

GoK, (2009). Kenya national climate variability and change strategy. Ministry of Environment and Natural Resources, Nairobi, Kenya.

GoK, (2010). The Constitution of Kenya, 2010. National Council for Law Reporting, Milimani Commercial Courts, Nairobi, Kenya. http://www.kenyalaw.org. Accessed in Dec 2015.

GoK, (2005). *Grain production in kenya.* Nairobi, PKF Consulting Ltd. Export Processing Zones Authority,

GoK/ NEMA, (2005). Kenya 's Climate Change Technology Needs and Needs Assessment Report under the United Nations Framework Convention on Climate Change.

Guloba, M. (2014). *Adaptation to climate variability and change in Uganda: Are there gender differences across households?* (No. 2014/107). WIDER Working Paper.

Hartmann, D. L., KleinTank, A. G., Rusticucci, M., Alexander, L. V., Bronnimann, S., and Charab,Y. (2013). Observations: atmosphere and surface. Pp. 159–254. In:Stocker, T. F., Qin, D., Platter, G.K., Tignor, M., Allen, S. K. & Boschung, J. (Eds.), *Climate change 2013: the physical science basis*. Cambridge Univ. Press, United Kingdom.

Hatfield, J. L., & Prueger, J. H. (2015). Temperature extremes: Effect on plant growth and development. *Weather and climate extremes*, *10*, 4-10.

Hedhly, A., Hormaza, J.I., and Herrero, M. (2008). Global warming and sexual plant reproduction. *Trends Plant Science* 14: 30–36

Hellin, J., Shiferaw, B., Cairns, J., Reynolds, M., Ortiz-Monasterio, I., Banziger, M.,and Rovere, R. (2012). Climate change and food security in the developing world: Potential of maize and wheat research to expand options for adaptation and mitigation. *Journal of Development and Agricultural Economics,* 4(12):3-14

Herrero, M., Ringler, C., Steeg, J., Thornton, P. K., Zhu, T., Bryan, E., ... & Notenbaert, A. (2010). Climate variability and climate change and their impacts on Kenya's agricultural sector.

Huppé, G. A., Shaw, S., Dion, J., & Voora, V. (2013). Food Price Inflation and Food Security: A Morocco case study L'inflation des prix des aliments et la sécurité alimentaire: une étude de cas du Maroc.

Icheria, B. K. (2015). Household food insecurity and coping strategies among small scale farmers in Tharaka central division, Kenya. *International Journal of Humanities Social Sciences and Education (IJHSSE)* (2) 2, 63-76.

IEBC, (2012). Report on Constituencies & Wards. Nairobi. Independent Electoral Boundaries Commission.

IFPRI, (2010). Micro-level Practices to Adapt to Climate Change for African Small-scale Farmers. Discussion Paper 00953.

IPCC, (2007). *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the IPCC. Cambridge, Cambridge University Press: 869-883.

IPCC, (2014). Climate Change 2007: Impacts, adaptation and vulnerability. Contribution of working group II, final draft.

Jera, R., and Ajayi, O. C. (2008). Logistic modelling of smallholder livestock farmer's adoption of tree-based fodder technology in Zimbabwe. *Agrekon Journal*, volume 47, 386- 389.

Kabunga, N. S., Dubois, T., and Qaim, M. (2014). Impact of tissue culture banana technology on farm household income and food security in Kenya. *Food Policy*, 45, 25-34.

Kassie, M. W., and Stage, J. (2014)." What Determines Gender Inequality in Household Food Security in Kenya? Application of Exogenous Switching Treatment Regression. *World Development*, *56*, 153-171.

Kelley, K., Clark, B., Brown, Vivienne, B. and Sitzia, J. (2003). Good practice in the conduct and reporting of survey research. *Int. Journal for Quality in Health Care*, vol. 15(3), pp. 261-266.

Kirby, J.M.; Mainuddin, M.; Mpelasoka, F.; Ahmad, M.D.; Palash, W.; Quadir, M.E.; Shah-Newaz, S.M.; Hossain, M.M. (2016). The impact of climate change on regional water balances in Bangladesh. Clim. Chang. 135, 481–491.

Kirimi, L., Gitau, R., and Olunga, M. (2013, April). Household food security and commercialization among smallholder farmers in Kenya. In *The 4th International Conference of the African Association of Agricultural Economists,* Hammamet, Tunisia.

Kirtman, B., Power, S. B., Adedoyin, J. A., Boer, G. J., Bojariu, R.,and Camilloni, I. (2013). Near-term climate change: projections and predictability. Pp. 953–1028, In:Stocker, T. F., Qin D., Plattner, G. K., Tignor, M., Allen, S. K., Boschung, J., (Eds.), *Climate change 2013: the physical science basis*. Cambridge Univ. Press, United Kingdom.

Kisaka, M. O., Mucheru-Muna, M., Ngetich, F. K., Mugwe, J. N., Mugendi, D., and Mairura, F. (2015). Rainfall Variability, Drought Characterization, and Efficacy of Rainfall Data Reconstruction: Case of Eastern Kenya. *Advances in Meteorology* 1-16.

KNBS. (2010). Population and Housing Census. Nairobi: Kenya Central Bureau of Statistics.

Knox, J., Hess, T., Daccache, A., and Wheeler, T. (2012). Climate change impacts on crop productivity in Africa and South Asia. *Environmental Research Letters*, *7*(3), 034032.

Li, M., & Zheng, K. (2016). A Study of a Dynamic Early Warning Model to Determine Grain Security in China. In *Proceedings of 2015 2nd International Conference on Industrial Economics System and Industrial Security Engineering* (pp. 107-118). Springer, Singapore.

Lobell, D. B., and Field, C. B. (2007). Global scale climate– crop yield relationships and the impacts of recent warming. *Environ. Res. Lett*., 2: 142.

Lobell, D.B., Bänziger, M., Magorokosho, C., and Vivek, B. (2011). Nonlinear heat effects on African maize as evidenced by historical yield trials. *Nat. Climate Chang*. 1:42-45

Lobell, D., & Gourdji, S. (2012). The influence of climate change on global crop productivity. *Plant physiology*, pp-112.

Makokha, W. E. (2006). Settlements on the Management of Selected Dry Land Natural Resources; a Case of Ngong Division, Kajiado District.Master's thesis, University of Nairobi

Manyeruke, C., Hamauswa, S., and Mhandara, L. (2013). The Effects of Climate Change and Variability on Food Security in Zimbabwe: A Socio-Economic and Political Analysis.*International Journal of Humanities and Social Science*, 3:6.

Mark, W., Mandy, E., Gary, Y., Lan, B., Saleemul, H., and Rowena, V. (2008). Climate Change Crop production and Agriculture: Threats and Opportunities. Federal Ministry for Economic Cooperation and Development, Germany.

Masekoameng, M., and Maliwichi, L. L. (2014). Determinants of Food Accessibility of the Rural Households in Sekhukhune District Limpopo Province, South Africa. *J Hum Ecol*, *47*(3), 275-283.

Maxwell, D. & Caldwell, R. (2008). The Coping Strategies Index Field Methods Manual (2nd Ed). Cooperative for Assistance and Relief Everywhere Inc. Care USA

Mbah, E. N., Nwunuji, R., and Amah, N. E. (2016). Factors Limiting Adaptation to Climate Change among Farmers in Taraba State, Nigeria. *Asian online journal* Vol. 1 (1); 1-5.

Mbow, C., Smith, P., Skole, D., Duguma, L., and Bustamante, M. (2014). Achieving mitigation and adaptation to climate change through sustainable agroforestry practices in Africa. *Current Opinion in Environmental Sustainability*, *6*, 8-14.

Mburu, B. K., Kung'u, J. B., and Muriuki, J. N. (2015). Climate change adaptation strategies by small-scale farmers in Yatta District, Kenya. *African Journal of Environmental Science and Technology*, *9*(9), 712-722.

Memmott, J., Craze, P.G., Waser, N.M., and Price, M.V. (2007). Global warming and the disruption of plant-pollinator interactions. *Ecol Lett* 10: 710–717

Mueller, B., Hauser, M., Iles, C., Rimi, R. H., Zwiers, F. W.,and Wan, H. (2015). Lengthening of the growing season in wheat and maize producing regions. *Weather and Climate Extremes*, 9:47–56.

Mugi-Ngenga, E. W., Mucheru-Muna, M. W., Mugwe, J. N., Ngetich, F. K., Mairura, F. S., and Mugendi, D. N. (2016). Household's socio-economic factors influencing the level of adaptation to climate variability in the dry zones of Eastern Kenya. *Journal of Rural Studies*, *43*, 49-60.

Munyao, W, L. (2013). Gender issues affecting the girl child in Kenya. *International Journal of Humanities and Social Sciences.* Vol. 3 No. 4, pp. 125-129.

Mutambara, J., Dube, I. V., and Mvumi, B. M. (2012). Agroforestry technologies involving fodder production and implication on livelihood of smallholder livestock farmers in Zimbabwe. A case study of Goromonzi District. *Livestock Research for Rural Development*, *24*(11).

Mwaniki, P. I. (2014). Impact of Climate Variability on Food Security in Gachoka Constituency in Mbeere District, Embu County, Kenya. Doctoral Thesis, Kenyatta University.

Mwaura, F. M., and Okoboi, G. (2014). Climate variability and crop production in Uganda. *Journal of Sustainable Development*, *7*(2), 159.

Naanyu, M. (2013). Integration of indigenous knowledge with information and communication technologies in coping with effects of climate change and variability on agriculture in Kajiado County, Kenya. Unpublished Master Thesis, the University of Nairobi.

Nam, W.H., Hong, E.M.,and Choi, J.Y. (2015). Has climate change already affected the spatial distribution and temporal trends of reference evapotranspiration in South Korea? *Agric. Water Manage*. 150: 129–138, Doi: 10.1016/j.agwat.2014.11.019.

Ndamani, F., and Watanabe, T. (2014). Rainfall variability and crop production in Northern Ghana: The case of Lawra District. *International Journal of Environmental Science* 6:75-89.

Ndobo, F., and Sekhampu, T. J. (2013). Determinants of vulnerability to food insecurity in a South African township: A gender analysis. *Mediterranean Journal of Social Sciences*, *4*(14), 311.

NEMA, (2007). State of Environment Report 2006/7, Kenya.

Ng'ang'a, T. K. (2015). Women's Experiences on Food Security in Kenya: Major Challenges That They Face. *Pathways to African Feminism and Development, Journal of African Women's Studies Centre*, *1*(2).

Niang, I., Ruppel, O. C., Abdrabo, M. A., Essel, A., Lennard, C.,and Padgham, J. (2014). Africa. Pp. 1199–1265. In:Barros, V. R., Field, C. B., Dokken, D. J., Mastrandrea, M. D., Mach, K. J., Bilir, T. E., Chatterjee, M., Ebi, K. L., Estrada, Y. O., Genova, R. C., Girma, B., Kissel, E. S., Levy, A. N., MacCracken, S., Mastrandrea, P. R.,and White, L. L. (Eds.), *Climate change 2014: impacts, adaptation, and vulnerability. Part B: regional Aspects*. Cambridge Univ. Press, United Kingdom.

Nkuna, T. R., and Odiyo, J. O. (2016). The relationship between temperature and rainfall variability in the Levubu sub-catchment, South Africa. *International Journal of Environmental Science* 1:66-75.

Oloo, G. I. (2013). *Evaluation of climate change adaptation strategies and their effect on food production among smallholder farmers in Bungoma County, Kenya* (Doctoral dissertation, Egerton University).

Ombogo, M. O. (2013). *The impact of climate variability on pastoralism: forage dynamics and trends in Cattle population in Kajiado County, Kenya* (Doctoral dissertation, University of Nairobi).

Omoyo, N. N., Wakhungu, J., and Oteng'i, S. (2015). Effects of climate variability on maize yield in the arid and semi-arid lands of lower eastern Kenya. *Agriculture & Food Security*, 4:8 Doi 10.1186/s40066-015-0028-2.

Opiyo, F. E., Wasonga, O. V., and Nyangito, M. M. (2014). Measuring household vulnerability to climate-induced stresses in pastoral rangelands of Kenya: Implications for resilience programming. *Pastoralism*, *4*(1), 1-15.

Orodho, A.J., and Kombo, D.K. (2002).*Research methods*. Nairobi: Kenyatta University

Osano, P. M., Said, M. Y., de Leeuw, J., Moiko, S. S., Ole Kaelo, D., Schomers, S., ... & Ogutu, J. O. (2013). Pastoralism and ecosystem-based adaptation in Kenyan Masailand. *International Journal of Climate Change Strategies and Management*, *5*(2), 198-214.

Owino, A., Wesonga, R., and Nabugoomu, F. (2014). Determining Food Insecurity: An Application of the Rasch Model with Household Survey Data in Uganda. *International Journal of Food Science*, 14 (1), 394-403.

Oxfam (2013): Growing Disruption. Climate change, food, and the fight against hunger. https://www.oxfam.org/sites/www.oxfam.org/files/ib-growing-disruption-climate-change.

Oyiga, B., Mekibib, H., and Christine, W. (2011). Implications of climate change on crop yield and food accessibility in Sub Saharan Africa. *Bonn University, Germany*.

Oyinbo, O., Adegboye, G. A., and Sulaiman, R. (2012). Retrospective Study of Causal Relationship between Climate Variability and Crop Production in Nigeria. *Journal of occupational Safety and Environmental Health*, 1 (1) 79-83.

Phiiri, G. K., Egeru, A., and Ekwamu, A. (2016). Climate Change and Agriculture Nexus in Sub-Saharan Africa: The Agonizing Reality for Smallholder Farmers. *International Journal of Current Research and Review*, 8(2), 57.

Poppy, G. M., Jepson, P. C., Pickett, J. A., and Birkett, M. A. (2014). Achieving food and environmental security: new approaches to close the gap. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, 369(1639), 20120272.

Porter,J.R.,Xie,L.,Challinor,A.J.,Cochrane,K.,Howden,S.M.,Iqbal,M.M.,Lobell,D.B.,and Travasso, M.I.(2014). Food security and food production systems. In: Field, C.B. (Eds.), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*. Cambridge University Press, UK, 485–533.

Ray, D. K., Gerber, J. S., MacDonald, G. K., and West, P. C. (2015). Climate variation explains a third of global crop yield variability. *Nature communications*, 6:76-86

Recha, C. W., Mukopi, M. N., and Otieno, J. O. (2015). Socio‐economic determinants of adoption of rainwater harvesting and conservation techniques in semi‐arid Tharaka sub‐county, Kenya. *Land Degradation & Development*, *26*(7), 765-773.

Reynolds, M.P., Hays, D., and Chapman, S. (2010). Breeding for adaptation to heat and drought stress. 447-454. In: Reynolds, M.P. (Ed.), *Climate Change and Crop Production*. CABI, London (UK).

Rosegrant, M.R., Ringler, C., Sulser, T.B., Ewing, M., Palazzo, A., Zhu, T., Nelson, G.C., Koo, J., Robertson, R., Msangi, S., and Batka, M. (2009). Agriculture and Food Security under Global Change: Prospects for 2025/2050. Background note for supporting the development of CGIAR Strategy and Results Framework. International Food Policy Res. Institute: Washington, D.C.

Sakyi, P. (2012). Determinants of food accessibility of rural households in the Limpopo province: South Africa. Unpublished MSc dissertation, Gent University.

Scribd. (2011). *Integrated Smart Survey Report - Kenya, Makueni - April 2011*. Retrieved April 2, 2016, from http://www.scribd.com/doc/59063564/Integrated- Smart-Survey-Report-Kenya-Makueni-April-2011.

Serdeczny, O., Adams, S., Baarsch, F., Coumou, D., Robinson, A., Hare, W., & Reinhardt, J. (2016) Climate change impacts in Sub-Saharan Africa: from physical changes to their social repercussions. *Regional Environmental Change*, 1-16.

Sianungu, P. (2015). The implications of climate variability and change on rural household food security in Zambia: experiences from Choma district, southern province. Unpublished PhD Thesis, University of Nairobi.

Singh, A. K. (2018). Influence of Climate and Non-Climatic Factors on Global Food Security Index: A Cross-Sectional Country-Wise Analysis. *SocialscI JournaL*, *1*(1), 22-35.

Shisanya, C. A., Recha, C. and Anyamba, A. (2011). Rainfall variability and its impact on Normalized Difference Vegetation Index in Arid and Semi-Arid Lands of Kenya. *International Journal of Geosciences,* 2: 36-47. Accessed Jan, 2016 at http://www.SciRP.org/journal/ijg.

Smale, M., Byerlee, D., and Jayne, T. (2011). Maize revolutions in sub-Saharan Africa. World Bank Policy Research Paper 5659. The World Bank, Washington, DC.

Susilo, G. E., Yamamoto, K., Imai, T., Ishii, Y., Fukami, H., & Sekine, M. (2013). The effect of ENSO on rainfall characteristics in the tropical peatland areas of Central Kalimantan, Indonesia. *Hydrological sciences journal*, *58*(3), 539-548.

Stocker, T. F., Qin, D., Plattner, G.-K., Tignor, M. M. B., Allen, S. K., Boschung, J., Nauels, A., Xia, Y., and Bex, V.: Climate Change 2013: The Physical Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change-Abstract for decision-makers, C/O World Meteorological Organization, Geneva, Switzerland, 2013

Teixeira, E. I., Fischer, G., Van Velthuizen, H., Walter, C., and Ewert, F. (2013). Global hot- spots of heat stress on agricultural crops due to climate change*. Agric. For. Meteorol*. 170: 206 – 215.

Thomas, D.S.G., Twyman, C., Osbahr, H., and Hewitson, B. (2007). Adaptation to climate change and variability: farmer responses to intraseasonal precipitation trends in South Africa. *Clim Chang* 83(3):301–322. Doi: 10.1007/s10584-006-9205-4

Thornton, P.K., Jones, P., Alagarswamy, G., and Andresen, J. (2009). Spatial variation of crop yield response to climate change in East Africa*. Glob. Environ. Chang.* 19:54-65.

Thornton, P.K., Jones, P.G., Ericksen, P.J. and Challinor, A.J. (2012) Agriculture and food systems in sub-Saharan Africa in a 4° C+ world. *Philosophical Transactions of the Royal Society,* 369:117-136.

UNDP, (2013). Adaptation to climate change in Arid and Semi-Arid Lands. Available at<http://www.ke.undp.org/content/kenya/en/home/operations/projects/environment_and_energy/Adaptation_to_Climate_Change.html>, accessed on Nov 20th 2015.

UNEP, (2002). Freshwater stress and scarcity in Africa by 2025. HTLM document. http://www.unep.org/dewa/assessments/ecosystems/water/vitalwater/21.htm. Accessed 5 April 2016.

UNEP,(2014).ClimateChange.Availableat<http://www.undp.org/content/undp/en/home/ourwork/environmentandenergy/strategic_themes/climate _change.html>, Accessed on September 26th, 2015.

UNEP/GoK, (2005). Climate change vulnerability in Kenya: Response and strategies.

UNEP/GoK, (2008). Kenya Atlas of our changing environment.

UNFCCC, (2007). IPCC Third Assessment report*.* Cambridge University Press.

USAID (2013). Food Security in Kenya: Situation report. Nairobi, Kenya. United States Agency International Development

Wakibi, S., Gichuhi, W., and Kabira, W. M. (2015). Food Security Score for Kenya. *Pathways to African Feminism and Development, Journal of African Women's Studies Centre*, *1*(2).1-12.

Wambua, B. N., Omoke, K. J., and Mutua, T. M. (2014). Effects of Socio-Economic Factors on Food Security Situation in Kenyan Dry lands Ecosystem. *Asian Journal of Agriculture and Food Science (ISSN: 2321–1571)*, *2*(01).

Weldearegay, S. K., & Tedla, D. G. (2018). Impact of climate variability on household food availability in Tigray, Ethiopia. *Agriculture & Food Security*, *7*(1), 6.

WFP, (2009) World Food Program: Division of Communication, Public Policy and Private Partnerships via cesareGivlio viola, 68/70-00148, Rome, Italy, Available at, www.wfp.org [accessed o 11/11/2015].

Wheeler, T., and von Braun, J. (2013). Climate change impacts on global food security. *Science*, *341*(6145), 508-513.

World Bank, (2012). Turn Down the Heat. Why a 4°C must be avoided? A Report for the World Bank by the Potsdam Institute for Climate Impact Research and Climate Analytics: 1–106.

Wortmann, C. S., Kirkby, R. A., Eledu, C. A., and Allen, D. J., (1998). *Atlas of common bean (Phaseolus vulgalis L.) production in Africa*. CIAT-Pan-African Bean Research Alliance, Kampala, Uganda.

Yadav, S.S., Redden, R.J., Hatfield, L., Lotze-Campen. H., and Hall, A. (2011). *Crop adaptation to climate change.* Wiley-Blackwell, Oxford, UK.

Yamane, T. (1967). *Statistics: An Introductory Analysis*, 2nd Ed., New York: Harper and Row.

Yusuf, S. A., Balogun, O. L., and Falegbe, O. E. (2015). Effect of urban household farming on food security status in Ibadan metropolis, Oyo State, Nigeria. *Journal of Agricultural Sciences*, *60*(1), 61-75.

Zewdie, A. (2014). Impacts of Climate Change on Food Security: A Literature Review in Sub Saharan Africa. *Journal of Earth Science & Climatic Change,* 5(8): 225. doi:10.4172/2157-7617.1000225

Zhao, C., Liu, B., Piao, S., Wang, X., Lobell, D. B., Huang, Y., ... & Durand, J. L. (2017). Temperature increase reduces global yields of major crops in four independent estimates. *Proceedings of the National Academy of Sciences*, *114*(35), 9326-9331.

Ziervogel, G., Nyong, A., Osman, B., Conde, C., Cortés, S., and Downing, T. (2006). Climate variability and change: Implications for household food security. Washington: AIACC Working Paper No. 20.

Ziska, L.H., Blumenthal, D.M., Runion, G.B., Hunt, E.R.,and Diaz-Soltero, H. (2011*)*. Invasive species and climate change: an agronomic perspective. *Clim Change* 105: 13–42.

APPENDICES

Appendix I: Field photos

Plate 4.1: Greenhouse farming in Oloolua area 5/4/2016 (source: Author)

Plate 4.2: Rooftop rainwater harvesting in Oloolua area 29/3/2016 (source: Author)

Appendix II: University Research Authorization

KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 8710901 Ext. 57530

Our Ref: N50/25545/13

DATE: 28th January 2016

The Director General,
National Commission for Science, Technology
& Innovation
P.O. Box 30623-00100,
NAIROBI

Dear Sir/Madam,

RE: RESEARCH AUTHORIZATION FOR MAYAKA KWAMBOKA ELVINE– REG. NO. N50/25545/13

I write to introduce Ms. Mayaka Kwamboka Elvine who is a Postgraduate Student of this University. She is registered for M.Env degree programme in the **Department of Environmental Education.**

Ms. Mayaka intends to conduct research for an M.Env. Proposal entitled, **"Effects of Climate Variability on Food Security in Oloolua Area of Kajiado County, Kenya".**

Any assistance given will be highly appreciated.

Yours faithfully,

MRS. LUCY N. MBAABU
FOR: DEAN, GRADUATE SCHOOL

AM/nn

Appendix III: NACOSTI Research Authorization

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471, 2241349, 310571, 2219420
Fax: +254-20-318245, 318249
Email: secretary@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

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

Ref. No. **NACOSTI/P/16/98982/9675**

Date: **4th April, 2016**

Elvine Kwamboka Mayaka
Kenyatta University
P.O. Box 43844-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Effects of climate variability on food security in Oloolua Area, Kajiado County,"*** I am pleased to inform you that you have been authorized to undertake research in **Kajiado County** for a period ending **1st April, 2017.**

You are advised to report to **the County Commissioner and the County Director of Education, Kajiado 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.

BONIFACE WANYAMA
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Kajiado County.

The County Director of Education
Kajiado County.

Appendix IV: Kenya Meteorological Department official receipt

FORM NO. 768 (7/97)

REPUBLIC OF KENYA
MINISTRY OF ENVIRONMENT & MINERAL RESOURCES
KENYA METEOROLOGICAL DEPARTMENT
Dagoretti Corner, Ngong Road, P. O. Box 30259-00100 GPO, Nairobi, Kenya,
Telephone: 254-20-3867880-5, Fax: 254-20-3876955/3877373,
Mobile: 0724-255153/4
E-mail: director@meteo.go.ke, directormet@yahoo.com,
Website: www.meteo.go.ke

HARAMBEE

INFORMATION/DATA/SERVICES REGISTRATION FORM NO. 821582
Please fill this form in triplicate

Date: 13/04/2016 **STATION NAME:** KMD
PART I *(To be filled by the Applicant)*

Applicant's Name: Elvine Kwamboka Moraka

Address: 62860 - 00100

Name of Institution: KENYATTA University

Type of Date required and period: Temperature & Rainfall (1980 - 2015) 35 years

Purpose for which data is required: Research

Station/s or area: Oloolua WARD

Declaration:
I hereby undertake that I shall use the data for the declared purpose(s) only and that I shall not by way of trade or otherwise, lend, resell, hire out or otherwise circulate it in any form without the Department's prior authority, and shall deposit with the Department one copy of the publication arising from the use of the data.

Sign: [signature] Date: 13/04/2016

Part II: ***(Reserved for Official use only)***
Name of Receiving Officer: C. O. MAHONGA

Designation & Signature: HOCM

Comments

Part III: ***(Reserved for Official use only)***
Proforma Invoice No. Amount: KShs. 6,000/=
Receipt No. C 8075325 Amount: KShs. 6,000/=

Part IV: ***(Reserved for Official use only)***
Data Collected by .... Date: .... Issued by ....
Comments of issuing Officer: ....

Appendix V: Questionnaire

1. Questionnaire for household head/ principle care giver.

My name is Mayaka Kwamboka Elvine. I am a post graduate student at Kenyatta University conducting a research on the Effects of Climate Variability on Food Security in Oloolua area of Kajiado County, Kenya. I humbly request your assistance by responding to my questions so that I conclude this study successfully. I further wish to clarify that the information you give for this interview will be confidential and anonymous and will only be used for academic purposes.

Profile of the household head

Location …………… Sub-location …………Household code…………Date…………

Code	Variable labels **House hold data and socio-economic characteristics**	***Variable values (Tick where applicable)***
1	Gender of household head	1.Male [ ] 2. Female [ ]
2	Age in years………………………..	
3	Marital Status of household head	1.Married [ ] 2.Single [ ] 3.Widowed [ ] 4. Divorced [ ]
4	Level of education	1.No formal education [ ] 2.Primary education [ ] 3.Secondary education [ ] 4.Tertiary education [ ]
5	Type of house wall	1.Mud 2. Iron sheets 3.Concrete 4.Bricks 5 Timber
6	Type of roofing	1.Grass thatches 2.Ironsheets 3.Concrete 4.Tiles
7	Main source of livelihood	1.Formal employment 2.Casual labour 3.Agriculture 4.Trading 5. Others (specify)………

1. Have you ever heard of climate change [ ] Yes [ ] No
2. Here are some of the possible causes of climate variability? Please tell me if you **1). Strongly agree 2). Agree 3). Undecided 4). Disagree or 5). Strongly disagree. (*Tick*)**
   i. Human activities 1 2 3 4 5

ii. Natural forces 1 2 3 4 5
iii. God's Annoyance 1 2 3 4 5

3. What significant changes in Rainfall and temperature have you observed in your community over the last years? (*Tick where applicable*). Please tell me whether **1. High 2. Moderate or 3.low**

Rainfall	**Temperature**
1.Unpredictable rains 1 2 3	1.prolonged droughts 1 2 3
2.floods 1 2 3	2.very hot seasons 1 2 3
3.very wet seasons 1 2 3	3.Verycold seasons 1 2 3
4.Low rainfall 1 2 3	4.Water stress 1 2 3
Others…specify………..	Others…specify……………

4. What is the main impact of these changes on local community? Please tell me whether **3. Major 2. moderate or 1.minor**

i. Crop failure 1 2 3
ii. Flooding 1 2 3
iii. Famine 1 2 3
iv. increased pests 1 2 3
v. disease outbreak 1 2 3

Others (specify)…………………………………………………

5. How do you describe these rainfall and temperature changes? (please tick appropriate responses)
   i. Rainfall amounts: Increased [ ] Decreased [ ] same [ ] Fluctuated [ ]
   ii. Rainfall spacing: Widened [ ] Narrow [ ] same [ ] Fluctuated [ ]
   iii. Rainfall season: Shortened [ ] Extended [ ] same [ ] Fluctuated [ ]
   iv. Rain onset: Delay onset & ends early [ ] early onset & ends late [ ] Frequent rain failure[ ]
   v. Temperature: Increased [ ] decreased [ ] same [ ] Fluctuated [ ]
6. What adjustments have you made in your farming practices to this shifts in temp and rainfall? Please tell me how often you use them. **1.Never 2.occasionally 3.always**
   i. change crop variety 1 2 3
   ii. build water harvesting schemes 1 2 3
   iii. implement soil conservation schemes 1 2 3
   iv. diversification of crop varieties 1 2 3
   v. changing planting dates 1 2 3
   vi. irrigation 1 2 3
   vii. diversify from farming to non-farming activities 1 2 3
7. What are the climate related disasters that have occurred in this area over the last few years?

Code	Variable	Frequency Most	moderate	least
		1	2	3
1	Droughts			
2	Floods			
3	Famine			
4	Pests and disease outbreak			

8. Which is the source of food in your household?

i. Local Market [ ]
ii. Government reserve stocks [ ]
iii. Village farmers retailers [ ]
iv. own production [ ]
v. neighbors' [ ]
vi. free relief food [ ]

9. Which of these statements best describe the food eaten in your household in the last 12 months?
   i. Enough
   ii. average
   iii. Low
   iv. Uncertain
10. What would you consider to be the main cause of food shortages? Please tell me whether **1.Often true 2.Sometimes true 3.Never true 4.Dont Know**

i. Changes in weather patterns	1	2	3	4
ii. Poor farming methods	1	2	3	4
iii. Land degradation and soil exhaustion	1	2	3	4
iv. Pests and diseases	1	2	3	4
v. Reliance on rain-fed agriculture	1	2	3	4
vi. High cost of inputs	1	2	3	4
vii. land not enough	1	2	3	4
viii. insufficient harvest from previous seasons	1	2	3	4

Others……………………

11. How do you cope with food shortages? 1, never true 2, sometimes true and 3, often true.

i. Reliance on less expensive/preferred foods	1	2	3
ii. Limit portion sizes	1	2	3
iii. Reduced no of meals in a day	1	2	3
iv. Restricted consumption by adults	1	2	3

Others……………..specify…………………………………

12. Generally, how can you describe the state of food security in your household?
    i. Food secure [ ]
    ii. Vulnerable to food insecure [ ]
    iii. Food insecure [ ]
13. In the past 2 months please tell me if the statements below were **1.false or 2.true**
    i. Did you worry that your households did not have enough food?1 2
    ii. Not able to eat the kinds of food you preferred? 1 2
    iii. Have to eat a limited variety of foods? 1 2
    iv. Have to eat some foods that you really did not want to eat? 1 2
    v. Have to eat a smaller meal than you felt you needed? 1 2
    vi. Have to eat fewer meals in a day? 1 2
    vii. Was there ever no food to eat of any kind in your household 1 2
    viii. Go to sleep at night hungry because there was not enough food? 1 2
    ix. Go whole day and night without eating anything? 1 2
14. What are the critical months in which you often encounter serious food shortages? ....
15. We could not afford to eat balanced meals, how true is this statement in your household?
    i. Never true

ii. Sometimes true
iii. Often true

19 How easily available were the food items in the past month. Please indicate level of availability for each of the commodities using the available codes below.

Food commodity (preferably stables &substitutes)	**Availability codes** *(0=not available, 1=available, 2=available but with difficulty)*		
	0	**1**	**2**
Maize			
Sorghum			
Rice			
Millet			
Wheat			
Beans			

20 Have the quantities on the markets increased, decreased or remained unchanged in the past 3 months? Please indicate changes in availability for each of the commodities

Food commodity (preferably stables & substitutes)	**Availability codes** *(0=no change, 1=decreased, 2= increased)*		
	0	**1**	**2**
Maize			
Sorghum			
Rice			
Millet			
Wheat			
Beans			

21 Which practices listed below are used in you locality in response to climate variability? Please tell me whether **1. Never 2. Hardly 3. Sometimes 4.often 5. Always.**

i. Agroforestry 1 2 3 4 5
ii. Drought tolerant crops 1 2 3 4 5
iii. Rain water harvesting 1 2 3 4 5
iv. Irrigation 1 2 3 4 5
v. Soil and water conservation 1 2 3 4 5
vi. Introduction of new seed variety1 2 3 4 5
vii. Change of planting seasons 1 2 3 4 5
viii. Application of fertilizer 1 2 3 4 5
ix. use of technology i.e. greenhouses 1 2 3 4 5

22 In the following statements, please tell me whether the statement was **1).often true, 2).sometimes true, or 3). Never true.** Which of the following would you consider to be the limiting factors to devising adaptation strategies? (*Tick where applicable).*

i. Financial constraints 1 2 3
ii. Poor infrastructure 1 2 3
iii. Lack of information 1 2 3
iv. Lack of relevant skills 1 2 3
v. Reliance on relief food 1 2 3
vi. Lack of scientific and technical knowledge 1 2 3

Thank you

2 Interview Schedule for Metrological Department

My name is Mayaka Kwamboka Elvine. I am a post graduate student at Kenyatta University conducting a research on the Effects of Climate Variability on Food Security in Oloolua area of Kajiado County, Kenya. I humbly request your assistance by responding to my questions so that I conclude this study successfully. I further wish to clarify that the information you give for this interview will be confidential and anonymous and will only be used for academic purposes.

Name (optional)………………. Position…………………… Station…………………

1. How has rainfall trends in Oloolua area changed over time?
2. How has temperature trends in Oloolua area changed over time?
3. Based on your observations, how are the impacts of this trend on house food security in the area?
4. Which are likely predicted future trends? i. positive ii. Negative
5. Which adaptation and mitigation strategies have you witnessed being employed by households to counter effects of climate variability?
6. What assistance does your department offer to households to counter the effects of climate variability?

Thanks for your time

3. Interview guide for Department of Agriculture

My name is Mayaka Kwamboka Elvine. I am a post graduate student at Kenyatta University conducting a research on the Effects of Climate Variability on Food Security in Oloolua area of Kajiado County, Kenya. I humbly request your assistance by responding to my questions so that I conclude this study successfully. I further wish to clarify that the information you give for this interview will be confidential and anonymous and will only be used for academic purposes.

Name (optional)………………. Position………………………

Department…………………………..

1 In your opinion, has climate variability affected food security in Oloolua area?
2. What would you consider to be the main cause of food shortages in the area?
3. What assistance does your Ministry offer to households to counter the effects of climate variability on household food security?
4. Is there a future for agriculture in this area?
5. What would you recommend as a suitable solution to counter food insecurity in the area? ....

Thanks for your time