ADAPTIVE STRATEGIES TO AGRICULTURAL DROUGHT EFFECTS ON SMALL SCALE CROP PRODUCTION IN KAKAMEGA SOUTH SUB-COUNTY, KAKAMEGA COUNTY

BY

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DECLARATION

This thesis is my original work and has never been presented for a degree in any institution of higher learning or a university.

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GEO/G/01-52811/2018

CERTIFICATION

The undersigned certify that they have read and hereby recommend for oral defense in Masinde Muliro University of Science and Technology a thesis entitled, "Adaptive Strategies to Agricultural Drought Effects on Small Scale Crop Production in Kakamega South Sub-county, Kakamega County."

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DEDICATION

I wish to dedicate this thesis to my family, my loving husband Mr. Marongo Macdonald, late son Merlin Baraka Kesire and my daughter Joy Jasmine Kagonya for their love and support. God bless you all abundantly.

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ABSTRACT

This study was undertaken in Kakamega South Sub-County in Kakamega County where small-scale farmers depend on rain fed agriculture and over the years have had frequent crop failure due to seasonal drought. This study's main objective was to establish adaptive strategies to agricultural drought effects on small scale crop production in Kakamega South Sub-county. The study established the evidence of climate change and agricultural drought on small scale crop production, determined the effects of agricultural drought on crop production and examined the adaptation strategies applied by small scale farmers to seasonal agricultural drought effects and challenges faced in Kakamega South Sub-county. Discrete Choice Model and Capability Theory was used in this study. Both qualitative and quantitative research design was used in the study as this catered for both qualitative and quantitative data. The study made use of primary data sources which included questionnaires, interview schedules, Focused Discussions Group (FDGs) and field observation to gather study information. Secondary data sources were publications from meteorological stations which were mainly rainfall and temperature trends for a period of at least 35 years (1985-2020). The sampling procedure was simple random sampling and a sample population of 377 households was sampled from a target population of 26,940 households using Krejcie and Morgan table. Purposive sampling was used to sample information from agricultural offices and meteorological stations to obtain detailed information on the study problem. The results of this study established that there was evidence of climate change and agricultural drought in Kakamega South sub-county as rainfall is positively correlated with humidity ($r=0.834$, $p < 0.05$). Humidity is negatively correlated with annual maize production ($r= -0.869$, $p < 0.05$) and annual average temperature ($r= -0.813$, $p < 0.05$). The study further showed that most of the respondents 96.1% agreed that there are effects of agricultural drought on agricultural produce and few respondents 3.9% disagreed with the statement. Most of the respondents 74.2% were affected by economic challenges, 15.5% faced social challenges while 8.7% geographical challenges and lastly1.6% by political challenges. Major adaptation methods used by small scale farmers were change of planting dates 61.3%, planting of drought tolerant crops 59.2%, protection of water catchment areas 54.0%, mulching for conserving soil moisture 56.4% and planting trees to reduce soil erosion 51.3%.The study established that small-scale farmers in the Kakamega South sub-county have implemented a variety of adaption tactics that are hampered by a number of obstacles. The study concluded that in order to improve the sustainability of crop production in the Kakamega South sub-county, rain-fed farming should be supplemented with drip irrigation, rain water gathering, and greenhouse techniques. In conclusion, the Kenya Meteorological Department and the Ministry of Agriculture should work together to provide farmers in Kakamega South sub-county with up-to-date, accurate weather reports and personalized weather forecasts and warnings. This will enable farmers on the smaller scale to acquire tools they will need to adopt sustainable methods to the effects of agricultural drought. This will make them to be more resilient and less vulnerable to the effects of agricultural drought.

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LIST OF ABBREVIATIONS AND ACRONYMS

ASALs: Arid and Semi-Arid Lands

ECHO: European Commission for Humanitarian Organization

EEN: Enterprise Europe Network

EEPH: Eradicate extreme poverty and Hunger

EU: European Union

FAO: Food and Agriculture Organization

FDGs: Focus Discussion Groups

GDP: Gross Domestic Product

GOK: Government of Kenya

ICDA: Inter-Ministerial Committee on Drought Assessment

ICID: International Commission on Irrigation and Drainage

IISD: International Institute for Sustainable Development

IPCC: Inter-governmental Panel on Climate Change

IWMI: International Water Management Institute

MDGs: Millennium Development Goals

NACOSTI: National Commission for Science, Technology and Innovation

NCCRS: National Climate Change Response Strategy

NDCM: National Committee for Disaster

NGOs: Non-governmental organizations

OAU: Organization of African Unity

OCHA: Organization for the Coordination of Humanitarian Affairs

RUM: Random Utility Model

SD: Sustainable Development

SDG: Sustainable Development Goals

SGR:	Strategic Grain Reserves
SSA:	Sub-Saharan Africa
SST:	Seas Surface Temperature
UN:	United Nations
UNEP:	United Nations Environment Program

OPERATIONAL DEFINITION OF TERMS

Atmosphere is the mixture of gases, which encircles the planet, moves in all directions, both horizontally and vertically, and is responsible for the weather and climate changes that occur on earth.

Weather the average atmospheric conditions of a place during a short time period; say an hour or a day. Atmospheric conditions including weather, wind, and humidity are included in this category.

Climate is the average weather condition of a specific location or region over a considerable time frame (at least 30 to 35 years).

Drought is a sort of environmental stress caused by a prolonged lack of precipitation that leads to water shortage, biodiversity loss, agricultural failure, human and animal mortality, and other problems.

Climate Change refers to the deviation from naturally occurring climatic variability over a same time span and can be traced back to human activity through the modification of the global atmosphere.

Climate variability refers to changes in the average state of the climate and other statistics (such as the frequency with which extremes occur) across all time and space, not only those associated with specific weather events.

Adaptation methods are actions taken by an individual or group to counteract effects of climate change in their immediate environment.

CHAPTER ONE: INTRODUCTION

1.1 Types of Drought

There is need for us to explore the four types of drought so that the context of seasonal drought can be understood in depth.

Meteorological drought typically begins as a result of a lack of precipitation brought on by climatic variables, and it typically results in economic losses (Smakhtin and Hughes, 2007). Droughts can be caused by anomalous weather patterns like low precipitation or high temperatures, or they can be caused by a lack of water (Qin et.al.2014). Even though it's challenging to stop this kind of drought, forecasting and monitoring it can help. Drought is caused by inadequate precipitation and, depending on its effects, might be related to other types of drought (Ibid, 2014).Meteorological droughts are a consequence of both human activities and climate change (Wanders and Wada, 2014). Drought in agriculture is caused by a lack of precipitation, which in turn leads to a lack of water in the drainage systems.

Hydrological drought is characterized by an inadequate supply of precipitation on land. In a normal dry season, both underground and above ground water sources would run dry (Van Loon and Laaha, 2014). As a result, water supplies are often inadequate to meet the needs of people and the environment. Water quality is highly dependent on stream-flow (Wander and van Lanen, 2013). With water sources like streams and lakes needing time to refill after a dry spell, much more so in areas where snowpack is the primary source of recharge, the recovery from hydrological drought can be an arduous process. Increased water usage has resulted in a 10-500 percent increase in the severity of hydrological drought and a 30 percent rise in the frequency of drought worldwide (Wanders and Wada, 2014).As a direct result of climate change, hydrological drought, which includes both ground water and stream flow, will display new features in the second decade of the 21st century (Wander and van Lanen,2013).Hydrological droughts will last longer and be more severe, and more extreme events will have a noticeable effect on water supplies including groundwater and stream flow. As a result, water resource managers must quickly develop preventative methods to address these problems.

A socioeconomic drought occurs when there is not enough precipitation to meet human and environmental needs; this drought is caused by human activity and shares characteristics with hydrological, meteorological, and agricultural droughts. Extensive droughts in arid and semi-arid regions are detrimental to the environment, the economy, and society (Wilhite, 2005)

Lack of rain or other precipitation can stunt plant growth and lead to a drought in the agricultural sector. Conversely, agricultural droughts that occur at specific times of the year are associated with periods of low soil moisture. Agricultural drought is defined as a drop in crop yield due to soil moisture content below the annual average (Qin et.al. 2014). Therefore, seasonal agricultural drought has direct negative consequences on crop output and is influenced by a variety of factors, including crop, soil type, soil moisture, and irrigation.

In times of agricultural drought, water supply is of paramount importance (Qin et al., 2014). After rain stops falling, plant life is sustained by the soil moisture (thanks to soil moisture capacity) (rainy seasons). Nonetheless, soils range in their ability to retain water. Carbon allocation, nitrogen cycling, microbial activity, and photosynthesis are all influenced by soil water connections, making them an essential part of the environment in which plants can flourish. Water-poor soil is more likely to experience drought (Piedallu et.al. 2011).

1.2 Background to the study

The term "climate change" refers to a shift in weather patterns outside the normal range of variation over a given time period that can be attributed to either human action or natural causes (Dixon et.al. 2001). In contrast, "climate variability" changes in the general state of climatic statistics and irregularities (For instance, extremes in temperature and rainfall), over all time and spatial scales beyond those of individual weather occurrences. (Ziervogel, et.al. 2006).

Countries that rely heavily on agriculture for food and livelihoods, like those in Sub-Saharan Africa, have been hit hard by climate change (Dixon et.al. 2001). This is because climate change is linked to both a decrease in available water and an increase in the occurrence of extreme weather events.

Both fluctuations in rainfall and temperature can have a significant impact on crop production. Thus, even little shifts in these factors can have a significant impact on agricultural output. These components are crucial for the majority of the physiological reactions that occur in a plant's life cycle, from germination through harvest (Mulinya et.al. 2016).

Frequent droughts are evidently a result of modern climate change. Drought is a type of environmental stress caused by a prolonged lack of precipitation that leads to low moisture levels, the death of plants and animals, failed harvests, human and animal deaths, and other difficulties (Ngaira, 2004). Roughly 630 million people, or about 60% of the global population, live in the world's arid and semi-arid regions (ASALs), which are severely impacted, by drought (Ngaira, 2005).

Climate change, rapid population increase, pollution, and the degradation of water catchment regions all pose serious threats to water's ability to maintain a healthy soil moisture balance. According to the Intergovernmental Panel on Climate Change, the frequency with which droughts and floods occur is expected to rise due to climate change, further limiting already limited resources (IPCC, 2001). This indicates that small-scale farmers will experience lower agricultural productivity as a result of rising drought brought on by climate change's negative effects on water levels and availability.

Since agriculture provides the majority of people's food and income needs and is a very vulnerable sector to climate change, it stands to reason that the industry will suffer a number of negative consequences as a result of global warming (IPCC, 2007).

As a result of climate change, precipitation levels may decline, which could reduce the amount of water available for farming. According to the International Water Management Institute, there will be a need for an additional 12–27% more water to produce food for the world's rising population by the year 2025 (IWMI, 2000). In order to guarantee food security through consistent agricultural production, it is important to educate farmers on adaptive measures to reduce the effects of seasonal drought, with a particular emphasis on finding and protecting alternate sources of water on the farm.

Due in large part to its unusual eco-climatic characteristics, Kenya is prone to drought. While the equator cuts through the southern half of Kenya, there are only a few places that receive high and consistent precipitation (>2000 mm) year. 80 % of the land area is classified as ASALs by Kandji (2006). Periodic droughts are a natural element of the climatic system in these regions, where annual rainfall ranges from 200 to 500 mm (Ibid, 2006). Given the climate, it's important to examine how drought affects agricultural output in the country and offer solutions to the ongoing problem. In most cases, the absence of seasonal precipitation is to blame for a drought's occurrence.

Kenya experiences two different rainy seasons, with the long rains occurring between March and May and the short rains occurring between October and December.

The sub-county of Kakamega South is one of the most food-efficient and food-secure sub-counties in Kenya. However, the growing aridity of the county is often regarded as a consequence and indication of climate change. Given these climatic conditions, it is necessary to investigate the consequences of seasonal agricultural drought in Kakamega South sub-county. Therefore, it was simple to identify adaption techniques that may be implemented to assist the small-scale farmers in Kakamega South to deal with the issue.

1.3 Statement of the Problem

The sub-county of Kakamega South has been facing significant climate change consequences, which endanger agricultural activities and water resources. January, February, and March have high temperatures, a period which experiences agricultural drought. The economy of Kakamega South Sub-County is dominated primarily by rain fed agriculture; as a result, it is badly impacted during the months that experience seasonal agricultural drought.

Climate change has an impact on food production in Kakamega South Sub-County, hence affecting people's means of subsistence. This in turn affects the economy of the small scale farmers as low crop production reduces their main source of income. This consequently will result to low living standard, food shortage, unemployment, fragile economy, high crime rates, high school dropout among students whose fees payment is from crop production, malnutrition and poverty among the small scale farmers and their households. Some of the small scale farmers will even opt to engage in other economic activities such as mining which is not affected by agricultural drought despite all the dangers associated with it so as to earn a living.

Since most of the small farmers rely on agriculture, effects of agricultural drought affects their social and economic life negatively. As much as they would like to adapt to these effects most of them are not in a position as they face many challenges such as financial challenges and social challenges. Thus, the study sort to establish various adaptation strategies that can be used by the small scale farmers to adapt to the effects of agricultural drought. This will help them to be less vulnerable and more resilient to the effects of agricultural drought and increase their crop production. To establish this, a precise drought assessment is essential for environmental planning, water resource management, and ecosystem management in Kakamega South Sub-county

1.4 Research objectives

The overall objective of this study was to establish adaptive strategies to agricultural drought effects on small scale crop production in Kakamega South Sub-county.

The specific objectives were to:

i. Establish the evidence of climate change and agricultural drought on small scale crop production in Kakamega South Sub-county.

ii. Determine the effects of agricultural drought on crop production in Kakamega South Sub-county.

iii. Examine the adaptation strategies applied by small scale farmers to seasonal agricultural drought effects and challenges faced in Kakamega South Sub-county.

1.5 Research Hypotheses

The following hypotheses were tested in the study:

1. **H_0:** There is no evidence of climate change and agricultural drought on small scale crop production in Kakamega South Sub-county.

H_1: There is evidence of climate change andagricultural drought on small scale crop production in Kakamega South Sub-county.

2. **H_0:** There are no effects of agricultural drought on crop production in Kakamega South Sub-county.

   H_1: There are effects of agricultural drought on crop production in Kakamega South Sub-county.

3. **H_0:** There are no adaptation strategies applied by small scale farmers to seasonal agricultural drought effects and challenges faced in Kakamega South Sub-county.

   H_1: There are adaptation strategies applied by small scale farmers to seasonal agricultural drought effects and challenges faced in Kakamega South Sub-county.

1.6 Justification of the study

Climate change has affected the small scale farmers' calendar in Kakamega South sub -county especially on the seasons that receives little or no rainfall. This is from January, February, and March which have high temperatures, a period which experiences agricultural drought. This interferes with the normal planting periods which are supposed to start from February if the farmer is to achieve two complete planting seasons of maize and beans annually.

Many studies on climate change in Kenya have concentrated on the country's ASALs, or arid and semi-arid areas, where precipitation is "always" a limiting factor in agricultural production (Jones et.al. 2009). However, small scale farmers in Kakamega South sub-county are affected by effects of seasonal drought since they have low level of technology to adapt to these effects. This is contributed mainly by the low level of income among the small scale crop farmers who depend majorly on the rain-fed agriculture as their main source of income. This hinders their ability to afford irrigation tools such as pumping machines and generators which would them during the periods that they experience agricultural drought.

Additionally, most farmers in Kakamega South sub-county have low level of education. This has great impact on how they respond to the effects of agricultural drought as most of them probably have no other formal or professional employment which could supplement their source of income apart from income from crop production. Most of the small scale farmers are self-employed in the agriculture sector, thus agricultural drought renders them vulnerable to its effects as they have low or no other source of income to enable them adapt to effects of agricultural drought due to the low income level.

The high poverty level among the small crop farmers also influence their level of adaptation to the effects of agricultural drought.

This research aimed to examine how farmers in the Kakamega South sub-county react to the challenges of seasonal agricultural drought. The main obstacles to integrating mitigation and adaptation in underdeveloped countries, especially in Africa, are poverty and a lack of technical capacity (Michaelowa 2001; Yohe 2001; Wilbanks et.al. 2003). Financial capital is generally seen as the most important measure of adaptation ability because of the widespread belief that the poor are the most at risk from the effects of climate change.

Evidence suggests that Sahelians have attained sustainable livelihoods through a combination of agricultural innovation, animal husbandry, and other sources of income (Mortimore 2000). Since the magnitude of past impacts in the Kakamega South region far exceeded that predicted by future climate change models, any serious attempt to implement or integrate adaptation strategies to reduce people's vulnerability to those impacts needs to begin with an analysis of how communities in the region had successfully reduced their vulnerabilities and coped with them.

1.7 Scope of the study

The study was conducted in Kakamega Sub-county in Kenya. Kakamega South was studied and not any other sub-county because it is one of the food efficient sub-counties and yet it was still affected by seasonal agricultural drought. The study mainly focused on the seasonal agricultural drought experienced in months of short rains mainly December, January and February. Study was limited to small scale farmers leaving out the large scale farmers. The fact that the study was carried out in Kakamega South Sub-County in Kenya made the findings applicable to some other sub-counties that receive reliable rainfall with some seasonal drought annually in the Kenya. The study did not involve all small scale farmers due to limited time and limited funds. Therefore, the target population of small scale farmers was sampled them to represent the others.

1.8 Assumptions of the study

In undertaking this study, it was assumed that:

i. Respondents were willing to answer the questions in the questionnaire.
ii. Seasonal agricultural drought was experienced in Kakamega South sub-county.
iii. Seasonal agricultural drought had affected the social, economic and political activities of the small scale farmers in Kakamega South sub-county.
iv. All small scale farmers were available for interview.
v. The remedies and strategies that have been put in place to reduce the effects of agricultural drought in Kakamega South sub-county had not been effective.

1.9 Limitations of the study

Limitations are conditions beyond jurisdiction of the researcher that may place boundaries to the conclusion of the study carried out and other application to other situation (Kombo & Tromp, 2008). The limitations of this study were:

i. Agricultural officers and agricultural ministers were difficult to access due to their busy schedules.

ii. Some small scale farmers were not available since they had attended to other activities.

iii. The study was also limited to Kakamega South sub-county only and not any other sub-counties in Kakamega County.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The chapter reviews literature on the effects of agricultural drought on agricultural production and adaptation strategies by small scale farmers. An overview of the connection between climate change and agricultural productivity was given, as well as an examination of the difficulties small-scale crop producers face in adapting to the seasonal agricultural drought that has become common in some parts of the world. Drought has devastated ecosystems, reduced food production, led to hunger, and exacerbated social inequality across Africa, with devastating effects felt most acutely in Kenya.

2.2 Climate Change and Agricultural Drought

While Ngaira (2007) defines climate change as long-term shifts in weather patterns, the Intergovernmental Panel on Climate Change (IPCC) defines it as a change in the condition of the climate that can be determined (through statistical tests) by shifts in the average and standard deviation and that lasts for an extended period of time (usually more than a decade) (IPCC, 2007). In this way, it influences a wide range of human activities on Earth's surface, including agriculture, through its impacts on precipitation and temperature. Agricultural and societal progress are thus in jeopardy from climate change (Niang et.al. 2014).

According to the Intergovernmental Panel on Climate Change (2014), climate change is one of the most pressing problems facing humanity in this century. A combination of factors, including rising water consumption and climate change, has led to predictions of worsening drought in the years to come. Food production is impacted by climate change, which has knock-on effects for people's lives. This suggests that the availability of water for agricultural output is diminishing as a result of climate change, making it increasingly difficult for governments around the world to achieve their goal of assuring sustainable development through food security (IPCC, 2014).

Over the course of 157 years of observation, it was determined that the average temperature of the Earth's surface has increased (Savo et.al. 2016). From the 1910s to the 1940s, the atmosphere warmed by 0.350 °C; from the 1970s to the present day, it warmed by 0.550 °C. However, a study that relied on forecasts of future dryness based on present precipitation levels found that dry spells would be repeated (Burke et.al. 2006). As a result, we can clearly see that climate change is causing agricultural drought by looking at the rise and fall of atmospheric temperature. Other climatic variables (wind speed, humidity, moisture, and temperature) were utilized by Sheffield et.al. (2012) to demonstrate similar trends of likely recurrent drought.

A trend in the rise and fall of land and ocean temperatures as a result of global warming is depicted in Figure 2.1 below. It demonstrates the deviation from the average land and ocean temperatures from 1850 to 1900. More rapid growth is seen in land averages compared to ocean averages. Numerous indicators point to long-term climate change, such as the accelerated disintegration of snow and ice caps, an increase in global average temperature, higher ocean temperatures and acidity, and a rise in sea level. The scientific community agrees that human activities are a major contributor to climate change (IPCC, 2013).

However, the effects of climate change are highly variable over space and time. More frequent and severe climate-related disasters will have devastating effects on human health, ecosystems, and the economy. Drought in agriculture has far-reaching consequences for both the natural world and human civilization, including human casualties, crop failures, the extinction of species, and water shortages (Kusangaya et.al.

2014). Droughts in crop production due to weather patterns are a major contributor to the economic downturn that has hit several nations in recent years.

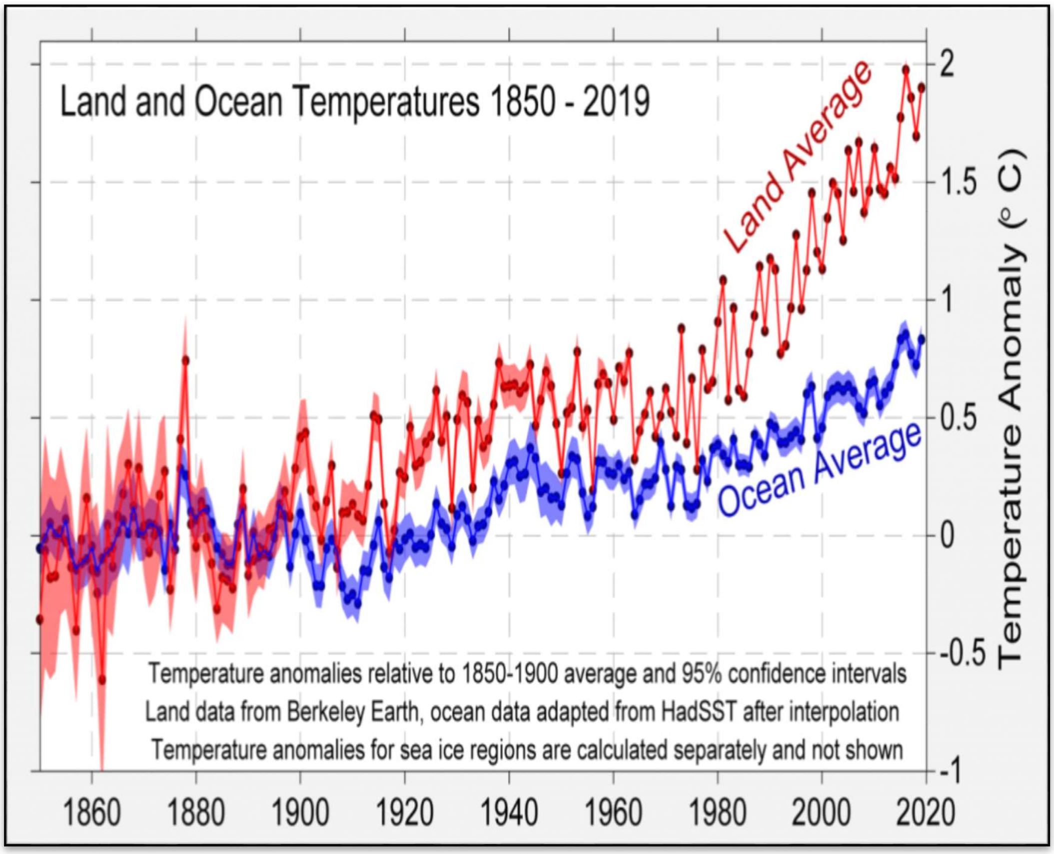

Figure 2.1: Trend of the change in land and ocean temperatures due to climate change from 1850-2019

Source: *Land and Ocean data from Berkeley adapted from HadSST (Hadley Centre Sea Ice and Sea Surface)*

2.2.1 Climate Change and Agricultural Drought Globally

About 70% of all freshwater consumption goes toward agriculture (Ngigi, 2009). Furthermore, about 13.5% of yearly greenhouse gas emissions come from agriculture, making it a major contributor to the global warming crisis. (Nelson et.al. 2009). However, agriculture is also part of the solution, as it helps reduce greenhouse gas emissions in several ways (the production of biomass, the capture of carbon dioxide, and the improvement of land use management).

The global trend in land and ocean temperatures over the past few years is shown in Figure 2.2 below, confirming the presence of climate change. This point to the fact that climate change is causing temperature shifts in the land and ocean, which in turn leads to seasonal agricultural drought, which in turn affects the rate at which food is produced around the world. While all farming is susceptible to weather extremes, the agricultural sector in developing countries is especially so because subsistence farming is often practiced with only rudimentary knowledge and technologies (whether traditional or modern) on small plots of land (Regassa et.al., 2010).

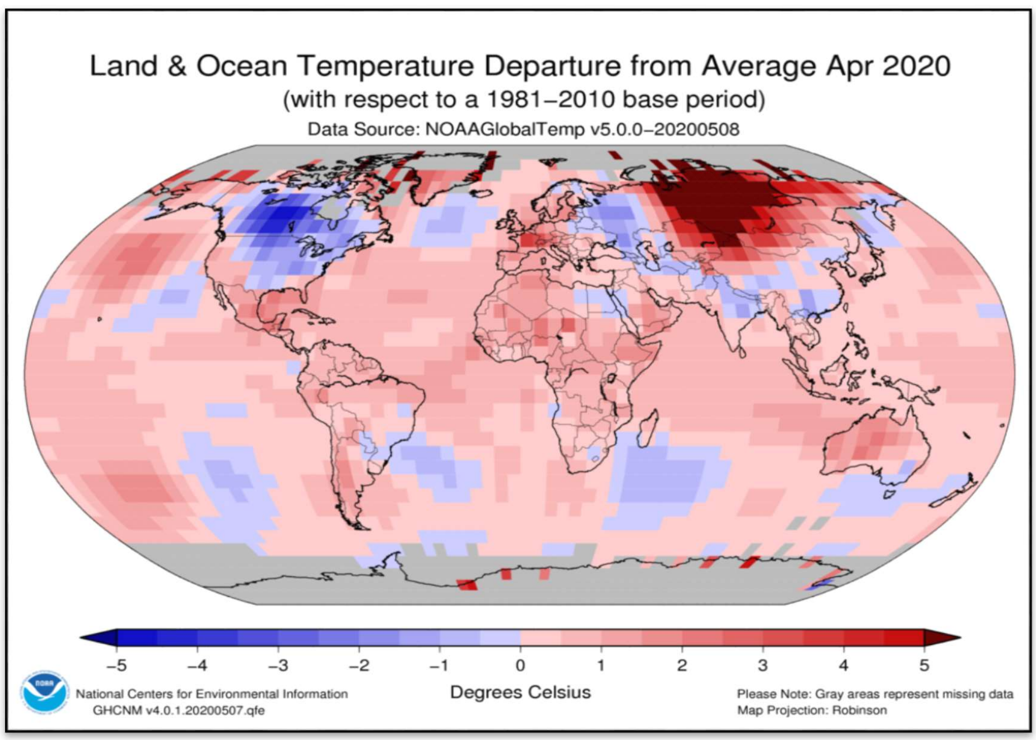

Figure 2.2: Trend of land and ocean temperature indicating climate change for the past years globally from 1981-2010.

Source: *NOAAGlobalTemp V5.00-20200508*

2.2.2 Climate Change and Agricultural Drought in Africa

Temperatures in Africa are on the rise compared to a century ago, and the predictions of climate models indicate that this trend will likely continue and even speed up in the future (Hulme et.al. 2001). Evidently, the average temperature in Africa rose by roughly 0.05°C during the last decade of the twentieth century (IPCC, 2001). Therefore, the frequency and severity of severe occurrences such as floods, droughts, and heavy rains have changed as a result of the rise in global temperatures (Christensen et.al. 2007).

It is expected that climate change and unpredictability will have varying impacts on various parts of the planet (Rosegrant et.al. 2008). Overreliance on natural climatic conditions for agricultural output, a lack of resources to adapt efficiently, inadequate infrastructure, and inadequate planning and policies are all factors that make Sub-Saharan Africa particularly vulnerable to the effects of climate change and unpredictability (Kabubo-Mariara & Kabara, 2015;Ngaira, 2007).

The low productivity of rain-fed farming systems in Sub-Saharan Africa is a major contributor to the region's food insecurity and rising poverty rates, as detailed in the International Water Management Institute's strategic plan for 2009 to 2013. Insufficient or nonexistent water management practices are to blame in part for this problem. Investment in small irrigation technology and supplementary irrigation, as part of an adaptive water management strategy, has been shown to increase agricultural output and decrease poverty.

2.2.3 Climate Change and Agricultural Drought in Kenya

Climate change is associated with decreased agricultural output. Each of Kenya's six agro-climatic zones (zones I, II, III, IV, V, and VI) is assigned a specific moisture index (Sombroek et.al., 1982). These zones span the full spectrum from those with abundant agricultural potential to those with no such prospects at all. This includes both places with predictable precipitation and those that are prone to drought. Over the past half-century, The average temperature in Kenya has risen by close up to 1 °C, and scientists forecast that this rise will quicken to close to 3 ° C. by the year 2050 (GoK,2010 a; IPCC, 2007). In addition, it appears that the drought cycle is decreasing in most sections of the country (GoK, 2010 a).

In most of Kenya, regular flooding and catastrophic, diminished or delayed rainfall are becoming increasingly evident (GoK, 2010 a). Changes in the availability of suitable growing conditions for crops and the spread of certain pests and diseases are further indicators of global warming. Key industries and Kenya's land use structures are already experiencing the consequences of climate change, as presented by many stakeholders at the National Climate Change Response Strategy (NCCRS) seminars (GoK, 2012 b). Agriculture; cattle, and notably in the rangelands of Kenya; tourism and wildlife; the conservation of forests, lakes, rivers, and oceans, health and physical infrastructure; and so on.

Droughts in recent years (particularly in 2000) have shown the economic vulnerability of the country, which resulted in severe power rationing. Kenya Power Company suffered a $20 million loss, economic activity ground to a halt, and the country's GDP fell by 0.3%. (Kandji, 2006). Kenya has suffered from severe droughts in recent years, leading to widespread food insecurity (Ngaira, 2004).

Two successive rainy seasons have failed to materialize in the impacted areas. For the most affected areas of Kenya, the current March-May rainy season brought about 42% of predicted rainfall (64mm), based on the 30-year average. Previous rainy season (October–December 2010) was a bust, with only 59% (46mm) of expected rainfall in such areas, much below the 30-year average, has exacerbated the current rainfall deficit and its consequences. The current La Nia is responsible for the dry conditions, as La Nia's are known to reduce precipitation in the equatorial regions and enhance it in the regions immediately to the north and south (PREM, 2011).

Drought has far-reaching effects that affect many parts of the economy and aren't limited to the place where it's physically happening. Having access to clean water is crucial to our economy and society. Whereas rural lifestyles in Kenya have adapted to water availability, rainfall patterns, particularly rain failure or unpredictable rainfall, are frequently the source of natural disasters in the country (NDMC, 2006).

2.3 Effects of Seasonal Drought on Small Scale Crop Production

2.3.1 Effects of Seasonal Drought on Crop Production Globally

Future conditions are predicted to be warmer and drier as a result of global warming (Solh and Maarten, 2014 and Olmstead, 2014). Most climatic factors like temperature, precipitation, humidity, water outflow, and availability are expected to be impacted by future climate change (Arnell et.al., 2011). Developments in the economy, the number of people living there, and environmental pollution are to blame (Koutroulis et.al. 2013).Tourism, agricultural output, and biodiversity are only some of the environmental and social factors that could be negatively affected by climate change and pollution's effect on water availability and quality (Olmstead, 2014).

Drought in agriculture correlates weather conditions with harvest failure, with an emphasis on less precipitation. Definitions of agricultural drought are an attempt to clarify why certain developmental phases of plants are more vulnerable to drought than others (Anthony M., 2007). As indicated in Table 1, below, researchers have summarized the various factors that contribute to and result from agricultural drought.

Table 1: Causes and Effects of Agricultural Drought

Causes of Agricultural Drought	Effect 1	Effect 2	Effect 3	Finally
Climate change 1.Less rainfall 2.Global warming	1. Rivers and water holes dry up. 2.Less rainfall due to climate change	Vegetation cover dies.	Decrease in vegetation cover	**AGRICUTURAL DROUGHT**
Population growth 1.High birth rates 2.Immigrants	Farmers change traditional method of land use as more land is needed for food crops leading to land size reduction.	Over-cultivation reduces soil fertility due to vegetation being removed	Deforestation causing increase evaporation from soil and risk of soil erosion	

Source: *Based on David Waugh 1998*

From table 1 above, based on Waugh (1998), it is clear that, droughts exacerbate environmental degradation caused by things like reduced wetland areas, poor land use practices like cutting down trees for firewood or making money off of charcoal, bush and range fires, and overgrazing, and so on. Population growth and the subsequent relocation of impoverished people to more remote areas sometimes worsen environmental degradation. Because of human activity, environmental deterioration prevents restoration even after a drought has ended. Droughts accelerate desertification and result in the depletion of natural resources in some parts of the district (EEN, 2004).

Drought causes a number of problems, including decreased agriculture and livestock output and increased pest infestations, plant diseases, and wind erosion. Droughts not only stunt forest expansion but also increase the prevalence of pests and diseases that threaten forest cover. Drought conditions enhance the likelihood of forest and range fires, which poses a threat to human and animal populations. Due to poor animal productivity and agricultural failure, people in the area must pay a premium price for their food. Extra costs are added to the national budget because the government and NGOs are providing relief food to the locals.

As a result, food insecurity will increase as a result of reduced agricultural productivity as a result of climate change's impact on water availability and accessibility in the context of achieving sustainable development. Because of this, it's crucial that both government officials and small-scale crop growers be taught adaptive measures before things get out of hand. This section will describe the drought condition in a few nations throughout the world to help shed light on the worldwide drought crisis.

Increasing water stress and temperature have contributed to a reduction in crop production across most of Asia during the past few decades. About 60 million people were affected by several droughts in Central and Southwest Asia in 1999-2000 in Afghanistan, Uzbekistan, Pakistan, Iran, and Turkmenistan (Mishra and Singh, 2010). This is largely attributable to anthropogenic climate change, which includes things like water, soil, and air pollution, as well as the cutting down of trees and other vegetation.

India is one of the countries that mostly depend on agriculture that is supported by rain. (Arlappa et.al.2011). Repeated drought is a common occurrence, with a 35% chance of occurrence and a 30% risk of vulnerability. While agricultural output has been falling in India, it still accounts for 15% of the country's GDP as of 2013-2014. There have been 13 major droughts in India over the past 50 years, the most recent occurring from 2001-2012. (Kumar et.al. 2005; Birthala et.al. 2015). Climate change is causing droughts to occur more frequently, and unless the government takes adaptation measures, the economy would be negatively impacted anytime a drought occurs.

Farming in Iran was notoriously difficult due to frequent drought. As a result, in areas where supplying water was difficult, farmers were forced to cut back on their operations, leading to increased human misery and lower food yields. However, the government's inability to effectively mitigate drought damage means that few effective drought mitigation or coping techniques exist (Dariush et.al. 2010).

Vietnam is one of many countries with long histories of climate problems including drought and flooding. In terms of its exposure to the effects of climate change, the country ranks thirteenth (Lohmann and Lechtenfeld, 2015). Vietnam's received precipitation has fluctuated greatly during the previous few decades. Rain-fed agriculture is a major economic driver in rural areas (Nguyen, 2011). Despite improvements in the economy, many individuals still struggle to make ends meet on less than $1.25 per day (World Bank, 2012). People in Vietnam tend to buy lower-quality food at higher prices when a drought hits (UNISDR, 2011). Economic harm from drought, for instance, was estimated at $110 million, or 0.2 percent of GDP (UNISDR, 2011).

The average economic losses in China caused by drought between 1950 and 2002 were predicted to decrease in the latter part of the 21st century (Jenkins, 2012). Financial losses due to drought were $883 million between 1950 and 2002 and were anticipated to total $540 million between 2003 and 2050. In 1997 and 1999-2002, China was hit by devastating droughts that impacted over 40 million acres (Zhang, 2003). Drought was particularly severe in southwest China, reducing crop yields. Reduced wet season precipitation reduces food yield, making this region the most drought-prone in China (Lu et.al. 2017).

It is possible that agricultural drought might not strike the same parts of a country at the same time in similar portions. Agricultural regions are particularly vulnerable because they feed the majority of the population and contribute significantly to national GDP.

In the 2000s, Australia was hit by a drought known as the "Millennium Drought" (Bond et.al. 2008). Low river flows were recorded, with many rivers recording less than 40 percent of their normal discharge throughout the occurrence. Many fresh water habitats were impacted by its extent and intensity, with losses estimated in the billions of Australian dollars. This is significant because agriculture accounts for 5 percent of Australia's GDP. As a result, estimates suggest that droughts will become more common in the future, particularly in the south and west (Jenkins, 2012). This suggests that when climate change impacts water sources, agricultural production will also be affected.

There have been droughts in the United States of America, which has led to lower water levels in the country's rivers and reservoirs. Nevada, New Mexico, Utah, and Wyoming are the affected states. Drought in 2004 caused water levels in Lake Powell, Colorado, to drop (Cook et.al. 2007). Drought has been a major cause of economic loss and property destruction in the U. S. (Sahr, 2005). Therefore, even in countries with robust economies, agricultural drought presents many difficulties due to the location of specific locations.

Drought has also been a major contributor to economic loss in the United States. Over $66 billion in 2002 dollars was spent cleaning up from the 'Dust Bowl' drought of 1934-1935. (Sahr, 2005). In the 1930s, efforts to alleviate the effects of the drought cost more than one billion dollars, which was the equivalent of thirteen billion dollars in 2002. Droughts occurred in 1980, 1988, and 2002, with 2002's costs exceeding $10 billion. The episodes in 1980 and 1988 cost $48.8 and $61.6 billion, respectively (Ross and

Lott, 2003). There were two major droughts in Canada in 2001 and 2002, causing a total loss of crop production of $3 billion. This was one of the worst droughts Canada has faced in recent history (Wheaton et.al. 2008).

Many sections of Europe have experienced repeated droughts over the past few decades. Most of the continent faced a serious threat from drought throughout the past seven or eight decades. Drought has become common and extensive across Europe, especially in the Mediterranean region, as a result of potential future climate change (EC, 2007; Cammalleri and Vogt, 2015).

Droughts have been a problem across Europe in the last three to four decades, particularly in Northern and Western Europe in 1976. The years 1989, 1991, and 2003 also saw notable occurrences (Hisdal et.al. 2001). In 2005, the Iberian Peninsula had the worst drought in the region in more than 60 years, resulting in a 10% drop in EU cereal production (UNEP, 2006). Drought has cost Europe $100 billion over the previous three decades. When looking at the frequency and intensity of droughts, we see that both Denmark and the United Kingdom suffered very dry conditions in 1976 and 1996.

The drought that transpired in 1975/1976 was the worst in decades (Fleig et.al. 2011). The UK had little rainfall and a severe drought in the summers of 1975 and 1976, the worst such conditions have seen since records began keeping such tabs in 1766. The 1975–1976 droughts caused a loss of crops worth £500 million (Marsh et.al., 2007). The President of the Romanian Agricultural Producers Association reported that agricultural production in Romania was reduced due to drought in 2015, with maize being particularly hard hit. There would be a two billion euro loss, according to estimates (BR, 2015).

2.3.2 Effects of Agricultural Drought on Crop Production in Africa

One of the most vulnerable economic sectors in Africa is agriculture, which provides the majority of the continent's food and income (IPCC, 2007). Farmers in Africa play a crucial role in ensuring that the region always has access to a sufficient food supply. Because of the importance of agriculture to the economies of most African countries, the detrimental effects of climate change on agriculture -the continent's principal economic and livelihood- are felt throughout the continent. According to Quan, they are thus extremely important to both domestic food production and the provision of food for the export market (2011).

More than 40 million people in Sub-Saharan Africa were impacted by drought in the 1980s. Climate scientists have been baffled by the severity of droughts in the Sahel because of its notoriously difficult to anticipate weather. While Africa is frequently struck by natural disasters, drought is the most devastating in terms of human casualties. From 1974-2007, 450,000 people perished in Africa as a direct result of drought, which also contributed to epidemics and land degradation across the continent (Vicente-Serrano et.al. 2012).

Reduced arable land, rising populations, and shifting climates all pose serious threats to global food security (Kang et.al. 2009). Desertification, global warming, unpredictable precipitation, and degraded soil all contribute to lower food yields in rural areas, especially in sub-Saharan Africa (Ngaira, 2007).

The economic well-being of millions of Nigerians, particularly farmers, has been negatively impacted by climate change (Olaniyi et.al., 2014). Climate change poses a new and unprecedented danger to food security, especially in the arid zones, where droughts are worsening and climate unpredictability is increasing. Global warming will cause many dry areas to become dryer and many wet areas to become wetter, including the desert and semi-arid regions of northern Nigeria and the wetter regions of the south of the country (Atilola, 2010).

More than 10 million people in Somalia were impacted by the catastrophic drought that began in 2011; 2 million of these were malnourished children, and 380,000 of their families were forced to seek safety in neighboring Kenya (Vicente-Serrano et.al. 2012). One-third of Africa is desertified, and 73% of the continent's farmland is unusable (UNEP, 1992). Extreme environmental stress will result from two or three consecutive seasons of drought in those areas (Lean, 1995).

While Africa is frequently struck by natural disasters, drought is the most devastating in terms of human casualties. In addition to causing epidemics and soil degradation across Africa, drought is one of the natural disasters responsible for the highest mortality in Africa between 1974 and 2007 (450,000 deaths) (Vicente-Serrano et.al. 2012).

The Greater Horn of Africa is characterized by a semi-arid climate and is hence particularly vulnerable to drought. The effects of rain-fed agriculture on crops and human populations can be particularly severe because nearly 75% of the region's workforce is engaged in smallholder agriculture (Salami et.al. 2010). More than 250 000 people in Somalia died as a direct result of the catastrophic drought that hit Kenya, Somalia, and South Eastern Ethiopia in 2010/2011. (UN OCHA 2011; Checchi and Robinson 2013).

Long-term drought predictions are getting mixed messages, especially in eastern Ethiopia, Kenya, Somalia, and north-central Tanzania. Significant decreases in the March-May (MAM) "long rains" have been observed since 1999, prompting questions about the likely involvement of human-caused climate change (Lyon and De Witt, 2012). There has been an observed increase in sea surface temperatures (SSTs) in the central Indian Ocean over the past few decades, and some research has linked this to the decline of the long rains over a longer time span (Funk et.al. 2008). In the meantime, climate model forecasts indicate that, in response to human-caused greenhouse gas forcing, the protracted rains will grow during the current century (Christensen et.al. 2007; Shongwe et.al. 2011).

According to the Intergovernmental Panel on Climate Change (IPCC), all parts of food security could be affected by climate change if local temperatures rise by 2°C or more above what they were in the late 20th century. This includes food production, access to food, food use, and price stability. As a result, the need for adaptation strategies and policies, as well as the incorporation of the climate change agenda in regards to agricultural drought into broader development plans, has become urgent.

Most of the food grown in Sub-Saharan Africa (SSA) is grown on fields that rely heavily on rain. However, because to climate change, the region has been suffering irregular rainfall patterns and Agricultural drought, leading to decreasing and unequal yield trends, which has had serious consequences for small-scale farmers and the food security of their households (URT, 2008).

In recent decades, Africa has experienced a rise in its prevalence of drought difficulties, which have contributed to decreasing crop yields, poverty, unemployment, and migration (Bhavnani et.al. 2008). Most economic damage occurs during the disasters gradual spread since it is difficult to anticipate which areas will be hit (Desanker et.al. 2001).

Drought prevention in Africa is a top priority for several international groups and initiatives, including the Sustainable Development Goals, the European Commission's

Humanitarian Aid Program (ECHO), and the Food and Agriculture Organization of the United Nations (FAO). With the 2007 drought affecting Somalia, Uganda, and Kenya, the European Union donated €53 million to help alleviate the situation (Bhavnani et.al. 2008). Sub-Saharan African farmers are more vulnerable to the devastating effects of crop failure caused by drought (Wossen et.al. 2017). Farmers in the area are resorting to the sale of their land, possessions, and cattle as a means of weathering the drought.

Drought forces many people to leave rural areas and move to cities. Stress on water and other natural resources are exacerbated by the movement of people from rural to urban regions. Population growth in relation to available natural resources is a direct result of this migration. Therefore, due to the enormous population, there is fierce rivalry for limited supplies. Drought and desertification in Africa have been challenges for the past three decades, however there have been governmental and non-governmental attempts to combat these problems (Msangi, 2004). Droughts in the Eastern Sahel and Southern Africa prompted the initiative's implementation in the 1970s. For the first time on the continent, governments were paying close attention to ecological degradation.

Drought conditions in 2009 caused widespread damage to livestock and agricultural production in Yobe State and other regions. The incident caused farm animal deaths and considerable crop damage, which in turn reduced food production (ICDA, 2010). During the incident, water levels dropped to record lows, wreaking havoc on the State's economy. Markets had an impact on the cost of animals and produce as a result. The livestock market in Yobe State is the biggest in all of Nigeria. Beans, maize, guinea corn, and pea nuts are just a few of the commonly grown crops in the State. Sheep, goats, and cattle are some of the livestock raised in Yobe State, and they, too, have suffered from the drought (ICDA, 2010).

Ethiopia's agricultural productivity has taken a hit because of the country's ongoing drought. In 1888 and 1889, for instance, famine was brought on by drought, and 90 percent of Ethiopia's livestock perished. Livestock and crop losses were incurred as a result of the severe drought that occurred in 1984. Some regions, like Wollo Province, saw losses as high as 94% (Little et.al., 2006). More than 325,000 people, predominantly in Ethiopia, lost their lives to drought in the Sahel between 1974 and 1984 (UN, 2008).

2.3.3 Effects of Agricultural Drought on Crop Production in Kenya

Kenya has a total area of 583,684 square kilometers, with just around 5% of that covered in forest. More than 75% of Kenyans depend on agriculture for their livelihood. Because of its reliance on rain rather than irrigation, food production drops when drought strikes, threatening the country's food security (GOK, 2007).

Most Kenyans rely on agricultural exports to support their families. Therefore, even seasonal climate fluctuations can have a significant impact on income and food security. This is due of the interconnected nature of food security and climate for subsistence farmers and smallholders (IPCC, 2014). Climate change and climate variability may impact food systems by increasing the likelihood of agricultural drought. This occurs in a number of ways, the most obvious being direct effects on agricultural output due to things like shifts in precipitation patterns that cause drought or flooding, or shifts in average temperature that affect the length of the growing season. Food supply and food security in a country are both affected by indirect factors such shifts in markets, food costs, and the architecture of the supply chain (Ibid, 2014.).

There is a wealth of data on the subject of climate change and fluctuation in Kenya (Obando et.al. 2007). According to the available research, agricultural drought is a significant barrier to achieving sustainable development through food security. The weather, the amount of carbon dioxide in the air, and the amount of ozone in the earth have all been altered by human activities (Thornton et.al. 2006). Warmer climates may be beneficial to food production in temperate regions (IPCC, 2007), but they will create difficulties for farmers in tropical regions due to the increased likelihood of droughts, floods, and heat waves.

More than 3.7 million people in Kenya are in need of aid due to the drought. Most affected are the counties of Turkana, Mandera, Marsabit, Garissa, Wajir, Isiolo, and Tana River. Areas hit hard by the drought have also been hit hard by the inflow of Somalian refugees from the neighboring country. Case in point: the Dadaab refugee camp, where a large number of people have recently arrived, is adding to the region's already heavy load (PREM, 2011).

Some Kenyans feel that more has to be done to ready the country for the effects of climate change. Water-scarcity issues have been exacerbated by the deterioration of watershed regions and lakes, as well as by the reported 0.7-2.0°C temperature increase in Kenya during the last 40 years (Mutimba et.al. 2010). The rate of rise in crop yields has slowed significantly, and climate change-induced agricultural drought is anticipated to further lower crop yields in many regions of the world, posing a danger to national food security (Braun, 2007; Pingali, 2012).

Recent years in Kenya have seen an increase in the frequency and severity of droughts caused by climate change and variability, which has had a negative impact on the country's agricultural output (UNEP, 2007). The recent decade has seen three of Kenya's 28 major droughts in the last century. Droughts are becoming more severe and occurring more frequently across the country (Murungaru, 2003). In the latter half of the 20th century, Kenya experienced droughts in 1951, 1952-1955, 1957-1958, 1974-

1976, 1980-1981, 1983-1985, 1987, 1992-1993, 1995-1996, 1999-2000, and 2004-2006. (Downing et.al., 1985; Ngaira, 2004).

Increases in food costs have been felt all around the country, not only in the places hardest hit by the drought. Drought and a general spike in commodity costs are both contributing to food price inflation. The price of a 90-kilogram bag of maize has increased by 160 percent since June 2010, when it was sold for $16. This is 70 percent more than the price at which the commodity could be purchased on the global market. Strategic Grain Reserves (SGR) is nearly empty, with over 80% having been used for emergency food distribution (PREM, 2011).

The per capita availability of renewable freshwater in Kenya has been decreasing and is expected to reach only 235 million by 2020. (GoK, 2010a). Climate change, growing human strain on water supplies, overexploitation of wetlands, and deterioration of water catchment areas have all contributed to the severity of these water shortages over time. Unusual heavy downpours and floods are another consequence of climate change. The agriculture industry is vulnerable to both drought and excessive rainfall. Adaptation can greatly lessen susceptibility, according to research of the effects of climate change on African agriculture (Kurukulasuriya & Mendelsohn, 2006a; Seo & Mendelsohn, 2006; Mano & Nhemachena, 2006).

Degradation of the land, high rates of soil erosion, contamination of water sources caused by sedimentation, eutrophication, and discharges from industries, deforestation, illegal logging, and charcoal burning, water catchment devastation, particularly in riparian areas, and landslides are just some of the environmental problems that have arisen as a result of human activity. Loss of biodiversity and the consequences of climate change are just a few of the environmental sensitivities that threaten Kakamega south sub county's water supply and contribute to climate change (Kakamega County Integrated Development Plan, 2018).

2.4 Adaptation Strategies Used and Challenges Faced by Small Scale Farmers

2.4.1 Adaptation Strategies to Agricultural Drought

Adaptation techniques are those that help an individual or a group deal with or adjust to the effects of climate change in their immediate surroundings. Planting early mature crops, adopting resistant types of crops, and selectively keeping cattle in places where rainfall fell are all examples of measures that will be used to manage environmental resources more effectively. In addition, they involve the utilization of technical items that allow the human to function in the "new" situation. Clearly, a wide variety of adaptation techniques are to be anticipated, and it is likely that diverse combinations of these strategies would be necessary in any particular area (Research gate, 2019).

Developing resistance to high-intensity rainfall and protracted dry spells requires farmers to adapt to the effects of climate change on agricultural systems. Existing agriculture and water systems have been disrupted by climate change, with significant repercussions for livelihoods, as evidenced by studies like De Wit & Stankiewicz, (2006); IISD, (2007). In order to attain food security and raise the level of living in rural regions, better management of land and water resources is essential (ICID, 2001).

The first step in adapting to climate change is being aware of the shift, followed by the second step of determining whether or not to make any changes (Maddison, 2006). So, it may be said that perception is essential for adaptation. Micro-level options Market reactions (such as crop diversification and adjusting the schedule of activities) (such as income diversification and credit schemes), Agricultural adaptations include the creation and dissemination of new crop types, technology developments (such as the improvement of agricultural markets and information availability), and adaptable capability and institutional strengthening (Smit & Olga, 2001; SEI, 2009). Farmers will be better prepared to face the problem of seasonal agricultural drought brought on by climate change if they follow the procedures outlined in the study.

2.4.1.1 Adopting Agricultural Drought Strategy

Developing plans that appropriately address the following questions is recommended by the International Strategy for Disaster Reduction (ISDR) (2005) to better deal with drought hazards. Is this type of drought typical for this area, and how bad is it typically? What dangers and costs may come from such a drought? How much would it cost to put into action the possible strategies and approaches to dealing with this sort of drought?

Through changes to or reinforcement of land use and farming methods, as well as the implementation of programs that increase water and food security, which in turn boost poverty reduction, these initiatives attempt to lessen the vulnerability of communities prone to seasonal agricultural drought. The gradual onset of drought, in conjunction with the ability to foresee drought, allows for the development and implementation of mitigation and preparedness measures prior to the commencement of the drought disaster. Improved seasonal and long-term climate forecasts, such as those recently provided by a number of national and regional institutions and centers, are aiding in the development and implementation of efficient drought-contingency plans.

2.4.1.2 Drought Prediction

Climate scientists, hydrologists, policymakers, and decision-makers have all struggled to accurately predict drought because of the complexity of its causes and the range of scales over which it occurs. Drought forecasting techniques fall into one of three categories: Hybrid, stochastic, or statistical models (Mariotti et.al. 2013; Mishra & Singh, 2011; Pozzi et.al. 2013). The statistical technique of forecasting makes use of empirical relationships gleaned from past data, with a variety of elements acting as predictors. Predicting drought conditions by considering atmospheric, oceanic, and land-based physical processes is now possible with the use of state-of-the-art General Circulation Models (GCMs), which have been developed as computing power and climate knowledge have grown. Hybrid prediction methods, which integrate forecasts from statistical and dynamical approaches, have also emerged in the previous decade.

A general definition of drought prediction is the ability to foretell how severe a drought will be (e.g., values of a specific drought indicator). There are a number of different characteristics and stages that can be predicted in relation to droughts (Sharma & Panu, 2012; Wetterhall et.al. 2015). The seasonal time scale forecast of drought severity is at the heart of this study, since it is directly related to operational early warning for the purpose of reducing the negative effects of drought.

The purpose of drought prediction studies is to increase knowledge of the drought's physical process and the accuracy of forecasts by drawing on all available data (Huang et al., 2016). Precipitation-generating processes (or their ultimate cause, in the case of meteorological drought) are often influenced by a number of processes that act across relatively broad spatial distances via large-scale atmospheric movements (e.g., Hadley circulation and Walker circulations, Rossby wave), which are often influenced by sea-surface temperature (SST) anomaly, land-surface interactions/feedbacks, and both natural and human fluctuations in radiative forcing (or external influences superimposed on natural climatic variability) (Schubert et al., 2016). When used together, these driving factors improve drought prediction (Heim & Brewer, 2012; Kingston et al., 2015; Mueller & Seneviratne, 2012; Rodrguez-Fonseca et.al. 2015; Wood et.al. 2015).

Slowly changing boundary factors, such as sea surface temperature and land surface features (e.g., soil moisture, high-latitude snow cover, and sea ice) are the factor that most significantly contributes to the seasonal predictability of the atmosphere or climate, It might result in more accurate seasonal forecasting to the degree that these boundary conditions and the corresponding climatic consequences can be predicted (Goddard et al., 2001; Roundy & Wood, 2015). Most seasonal predictability comes from the ocean-atmosphere El Nio–Southern Oscillation (ENSO) phenomenon (with periods of 2–7 years), and the identification of tele-connections between hydro-climatic anomalies and SST events has been a major development in drought (or climate) prediction. (Schubert et.al.2004b). ENSO affects the seasonal weather patterns in North America, South America, East and South Africa, India, Indonesia, Southwest Asia, and Australia. In a nutshell: (Schubert et.al. 2016; Smith et.al. 2012).

2.4.1.3 Change in Farming Techniques

Land use management is a crucial part of the response to climate change in both Malaysia and South Africa. Positive results can be seen in drought and climate change adaptation programs when better-adapted crop varieties are used, planting dates are moved, and farming methods are switched up (Bryan et.al. 2009). However, these regional initiatives can have unintended consequences, such as disrupting local economies and making life difficult for farmers. To mitigate drought's negative consequences, it's crucial to investigate eco-friendly adaption strategies (Lei et.al. 2016).

2.4.1.4 Practice of Conservation Agriculture

Kenyan farmers have been taught the techniques of conservation agriculture, including crop rotation and reduced postharvest clearing (FAO, 2018). Farmers were instructed to tolerate weeds as a means of lowering soil erosion. In 2018, 1,200 farmers were directly dependent on their crops as a source of income thanks to the FAO program that began in 2014. Farmers were given instruction on how to best sell their wares in order to increase their income. Irrigation, crop rotation, and agro forestry are three methods effective in mitigating land degradation in Nigeria Macaulay (2014).

2.4.1.5 Use of Policy and Strategies on Drought Management

Since the government has been around for a while, the region has been prepared for droughts. The Office of the President's Ministry of State for Special Programs has played a crucial role in coordinating federal efforts to reduce vulnerability to natural disasters. The elimination of food insecurity and the promotion of environmental protection through afforestation are both acknowledged in Kenya's growth story, which is why they are essential goals in the country's Vision 2030 and development plans. The government has enacted several drought relief initiatives and developed a disaster management strategy (PREM, 2011).

2.4.1.6 Agricultural Soil and Water Management

Ngigi (2009) argues that agricultural water management is one strategy for helping farms weather the effects of climate change. The water industry employs a number of different adaption tactics. Both supply- and demand-side factors play a role (Boko et.al. 2007; Bates et.al. 2008). Options on the supply side include things like building more reservoirs or expanding access to water sources, while options on the demand side include things like changing how water is irrigated, using more water-efficient technology, collecting rainwater, and improving soil moisture retention. Water management to reduce flooding, erosion, and leaching following heavy rains are another demand-side approach (Adejuwon, 2008).

Adaptation to climate change is a top objective for the Kenyan government, as outlined in its Agricultural Sector Development Strategy. Information on agriculture's top priorities as it relates to climate change was expanded upon in the National Climate Change Response Strategy (NCCRS). The NCCRS has placed a high priority on funding in drought-resistant agriculture research, weather information systems, and water and soil conservation (GoK, 2010 a).

Deressa et.al. (2009) hypothesized that farmers will utilize soil and water conservation (SWC) to retain moisture in response to rising temperatures, particularly in arid regions. An essential part of adaptive water management is the implementation of soil and water conservation practices. Cover cropping, minimal tilling, mulching, terracing, soil bunds ridges, bench terraces, and grass strips are all examples of soil and water conservation measures. Nyangena (2007) claimed that accelerating development in Kenya would require researchers to examine the societal influences on farmers' adoption of soil and water conservation technologies.

The 2006 Climate Change Convention in Nairobi, Kenya, acknowledged rain water harvesting as a viable strategy for meeting present water demand and safeguarding against future droughts, particularly in African nations (Mashood et.al. 2011). Bouwer (2000) argues that storing water is essential for safeguarding supplies against climate change. This involves putting water to use during drought by storing it during times of plenty. It is also vital to promote methods of water conservation in agriculture, such as Irrigation via a drip system, water recycling and reuse, mulching, and land usage that is appropriate, in order to guarantee a sufficient supply of water for farming. Thus, evaluating the factors that affect adaptation to climate might serve as a helpful guide for farmers seeking to successfully adapt to changing climatic conditions.

Some researchers have examined what elements farmers consider when making decisions about how to respond to climate change. For instance, Maddison (2006) found that a variety of socioeconomic factors influenced farmers' decisions on adaptation tactics. The level of education of the family's primary breadwinner, the availability of relevant markets, the level of farming expertise among local residents, and the availability of relevant information via extension services all play a role. Similar findings were reported by Hassan & Nhemachena, (2008). However, this research zeroes on adaptive water management on farms as a means of combating the effects of climate change on agricultural water resources.

2.4.2 Challenges Facing Small Scale Farmers

A society's vulnerability to drought can be increased by a number of factors, There are several factors that contribute to insecure water supplies, such as poverty and low income levels, violence and war, pandemics, a reliance on rain-fed systems, and a lack of regulations, The insufficient design and management of agricultural irrigation and water supply systems, as well as significant water usage like irrigation and hydropower generation, all pose potential risks to human health. Factors like high population density make it difficult for people to move around and use tried-and-true methods of coping with drought. People also lack the necessary knowledge and experience to deal with droughts, and they may be unwilling to accept certain risks in exchange for the services or goods they need (EEN, 2004).Societal and physical factors of vulnerability reinforce one another differently and to varying degrees in various regions of the globe. This means that places like Kenya are hit more by drought than others.

2.4.2.1 Age and Farming Experience of Farmers

There are both beneficial and detrimental effects of age and farming experience on adaptability (Ochenje, 2016). According to the findings of a few researches, both age and agricultural experience significantly and favorably affect adaptation (Nhemachena & Hassan, 2007).

A farmer's propensity to embrace technological advancements may be influenced by his or her age (Gbegeh & Akubuilo, 2012).Farmers with more experience may be better able to implement adaptive water management solutions due to their familiarity with production equipment and their ability to save money. By being more malleable, they are able to readily adopt a wide range of adaptive water management practices, making them more resistant to the adverse impacts of drought.

Nevertheless, it's reasonable to assume that elderly farmers will be less eager to take chances on cutting-edge tools and methods, and less physically capable of implementing these innovations. However, because of their lack of expertise, younger farmers may have reduced switching costs when embracing new farming practices and technologies (Marenya & Barrett, 2007).

2.4.2.2 Household Characteristics

It's unclear how much a family's size factors into their decision to adopt a given strategy. Given that the availability of labor is positively impacted by household size, this may be a factor in the adoption of innovative tactics (Marenya & Barrett, 2007; Teklewold et.al. 2006). Whereas most agricultural labor is done by family members rather than paid workers, adoption practices may be hampered in Sub-Saharan Africa due to a lack of enough family labor and an inability to pay labor (Nkonya et.al. 2008).

However, in order to optimize revenue and relieve the consumption pressure brought on by a high family size, some large-family households may be forced to transfer a portion of their labor force to non-agricultural activities (Tizale, 2007; Gbetibouo, 2009). Researchers have found that larger families benefit more from more progressive adoption policies (Anley et.al. 2007; Nyangena, 2007). Some adaptive water management systems demand a lot of manual labor, which may be provided by families with more members. Most farmers in the countryside can't afford to pay for outside help, so they rely on family members instead. That's why we're conducting this research to discover if there's a correlation between family size and the success of adaptive water management.

Different societies have different effects on adoption decisions based on the gender of the head of the household (Gbetibouo, 2009). For various cultural and historical reasons, women in many parts of Africa do not have equal access to property ownership. As a result, women are less powerful and have fewer resources than men (Gbegeh & Akubuilo, 2012). Because of this, they are often unable to adopt agricultural technologies that require a lot of manual labour.

To counteract the effects of climate change, however, female-headed households are more likely to adopt these strategies (Gbetibouo, 2009). A probable explanation for this trend is that more women than men make up rural smallholder farming communities in Africa. When it comes to farming, women tend to have more expertise and knowledge about different management strategies and how to adapt them in response to varying climatic circumstances, market demands, and dietary needs within their households (Nhemachena & Hassan, 2007).

The study found that while men and women have different roles in society, there are also variations in their access to resources and information, which may have a substantial impact on how they perceive and adapt to change. Women have far less access to land, money, and prosperity than males do, particularly in rural regions. Women also have a more difficult time gaining access to information and education (Kaliba et.al. 2000).

2.4.2.3 Education and Awareness Information to Small Scale Crop Farmers

Evidence from the past suggests that farmer's attitudes about and use of technology may be influenced by their level of education (Tologbonse, et.al. 2010). Farmers with higher levels of education are better prepared to adjust to the effects of climate change and to use any new technologies that may facilitate this shift. Therefore, educated farmers are better prepared for the impacts of climate change and may more readily adopt adaptive water management practices. This research hypothesizes that educating people about the effects of climate change on water resources and the necessity of adopting adaptive water management practices will have a positive and substantial impact on the whole.

Higher earnings, greater access to information and a higher standard of living are all benefits of education that help protect individuals from environmental hazards. Many other studies have documented the detrimental effects of climate change on Africa's agricultural output and food security (Ngaira, 2007). Awojobi and Jonathan (2017) argue that climate change is not a hoax, and they show how the destruction caused by weather events is having real consequences for Africa's ecosystems and people's ability to make a living there.

Similarly, education helps families gain entry to and make sense of knowledge that is critical to making creative choices (Ochieng', Owuor, & Bebe, 2012). However, increased literacy levels can serve as a deterrent to adoption because they introduce new ways of making a living that could threaten traditional agricultural methods.

It is more likely that adaption strategies will be used if people have better access to formal and informal institutions and weather forecasting tools. Households are more likely to adapt their farming methods to climate change if they have access to institutional agricultural extension, farmer-to-farmer extension, and information about future climate change (Smit et.al. 2001; Mariara & Karanja 2007). A greater possibility of perceiving and adjusting to climate change is connected with access to knowledge through extension (Deressa et.al. 2009; Nhemachena & Hassan, 2007). Farmers' opinions of climate change might improve if they had easier access to relevant information (Bradshaw et.al. 2004).

However, certain information sources are better suited to impact change than others, and different types of information can affect the likelihood of adoption in unique ways (McBride & Daberkow, 2003). In a similar vein, the adoption process progresses through many phases, each of which is influenced by distinct sets of information sources. For example, while the media plays a key role in raising general awareness, interpersonal information sources like extension staff and fellow farmers are essential for disseminating the more technical and adoption-supportive data (Ibid, 2003).

However, in some parts of Sub-Saharan Africa, extension-farmer links are quite weak, and most agricultural knowledge is gained through farmer-farmer contacts (Adesina & Forson, 1995). This point to farmers' significance as both knowledge providers and intermediaries in the spread of new technologies. The purpose of this research is to determine if farmers who have easier access to climate information through means such as radio or extension services are more likely to recognize the negative impacts of climate change on their water supplies (Bryan et.al. 2009).

2.4.2.4 Market Accessibility

Access to markets is a key aspect in how people understand and respond to climate change. As an indicator of transaction costs and a source of essential services like farm inputs and credit institutions, markets play a crucial role. (Lapar & Pandely, 1999; Mano et.al., 2003). Previous research has found that factors like proximity to markets for both inputs and finished goods, as well as to a highway or asphalt, play a significant role in determining whether or not farmers choose to implement soil and water conservation measures (Nyangena, 2007; Madison, 2006).

It was hypothesized that households located closer to the market and the tarmac road would have greater access to the market and would be better able to recognize and adapt to the consequences of climate change based on on-farm water supplies. This was based on the assumption that households would be more likely to have access to the market if it were located closer to them.

2.4.2.5 Financial Resources

The ability of small-scale farmers to adopt particular technical methods is significantly impacted by their asset endowments and level of affluence (Reardon & Vosti, 1995; Nkonya et.al., 2008; Gbetibouo, 2009).Those with more disposable income and assets are more likely to try out innovative farming techniques than those with a lower standard of living (Shiferaw & Holden, 1998).

Access to economic resources will be indicated by variables such as the wealth index, the annual income of Farm-sized households, and the availability of credit. More readily available capital allows farmers to purchase the inputs essential for implementing adaptive water management strategies. Thus, there is an a priori good indication that financially secure farmers are more likely to produce healthy crops.

Knowler and Bradshaw (2007) discovered that higher levels of family prosperity are associated with greater utilization of agricultural technology. Asfaw et.al. (2014) also confirmed that a farmer's ability to invest in sustainable land management methods corresponded with their level of wealth. Since affluence correlates with farm size, it stands to reason that more expansive farms would benefit from adaptive water management.

Researchers have found that even when access to credit is limited, smallholder farmers and other resource users still choose specific conservation measures to take (Gbetibouo, 2009).This is due to the fact that investing in cutting-edge tech usually necessitates using money that is either borrowed or already owned. Therefore, efforts to adopt adaptation methods, financial constraints may prevent farmers from implementing important practices including irrigation, terracing, tree planting, and fertilizer use. Moreover, research shows that the spread of an adoption technology occurs mostly through people's social networks and not always due to physical proximity (Maddison, 2006).

2.4.2.6 Institutional Factors

In order to effectively evaluate and demonstrate different practices, future extension agents should collaborate with farmer cooperatives on research and field testing. Since it is difficult for the government to offer extension services due to the inevitable diversity of agricultural situations, the trained farmers can help spread the acceptance of new technology (Pannell, 1999). According to this research, social capital consists of intangible assets that might strengthen groups' ability to take collective action. Participation in a farmers' cooperative will stand in for social networks.

The purpose of the study was to examine if farmer membership in a group may improve their perspectives of climate change and favorably affect their water management strategies. Adger (2003), for instance, found that social capital helped communities face climate change challenges as a unit.

Other studies have demonstrated that involvement in a farmer organization can raise awareness of climate change and adaptability to it (Deressa et.al. 2009; Nyangena, 2007). In addition to facilitating the exchange of information and technologies, farmer groups can provide alternative funding to farmers through informal savings and credit services.

2.4.2.7 Farm Characteristics

Farm size and soil fertility are examples of farm variables that could impact adoption decisions. The size of the farm affects both accesses to information and adoption decisions. As these site-specific crop management technologies are more likely to be sold to larger farms, a higher amount of crop land should increase the amount of exposure that farmers have to them (Marenya & Barrett, 2007; Daberkow & McBride, 2003). Due to the general unknowns and the constant transaction and information costs of innovation, there may be a minimum viable farm size below which it is not feasible for smaller farms to adapt (Daberkow & McBride, 2003). Consequently, it is likely that huge automated farms will be the first to adapt to climate change.

2.5 Gaps in Literature Review

Possible effects of climate change on farming were discussed in the literature. These findings generally supported the idea that farmers can mitigate the negative effects of climate change through the use of adaptation strategies (Yesuf et.al, 2008; Matui, 2009). Despite the fact that these studies placed a premium on adjusting farming techniques to an arid climate, they rarely discovered farm-level adaptation strategies that were unique to individual sites and production systems.For instance, in regions where rainfall is consistent throughout the year, seasonal agricultural drought has not been studied extensively.

The majority of the literature assessment on agricultural drought adaptation to climate change focused on a variety of factors that influence the rate of adoption among small-scale families. Numerous studies have identified family and farm traits and institutional factors as the most important predictors of adoption (Nkonya et.al. 2008; Shiferaw et.al.

2009). However, information regarding the decision-making process for adaptation among farmers remained scarce.

In addition, it remained unclear how and when agriculture in semi-arid regions should adapt to climate change. In particular, the research studies the elements that influence adaptive water management techniques in high potential agricultural regions (Tizale, 2007; Marenya & Barrett, 2007; Adolwa et.al. 2012). However, data on the ways in which Kenyan farmers have adapted to climate change by seeking out non-agricultural sources of income are scant. However, data on the ways in which Kenyan farmers are adjusting their lives to account for the impacts of climate change is limited.Therefore, the purpose of the study was to contribute to bridging the gap. Indigenous wisdom could potentially be used to adjust agriculture to climate change. Since no previous research had been conducted in this area, this study aimed to fill the void.

2.6 Theoretical Framework

This research was guided by Capability theory (Sen, 2000; Nussbaum, 2011) and Discrete Choice Model (McFadden, 1978).

2.6.1 Capability Theory

The theory by Sen and Nussbaum analyzed the abilities required for people to live fulfilling lives. A person's functioning represents the collection of "beings" and "doings" and can be understood as the diverse results a person may attain (Goeme, 2010). The key tenet of this philosophy was the necessity of evaluating equitable arrangements in terms of their impact on the well-being and functionality of people's lives.

The issue of basic fairness is not products or the total/average GDP, but rather the extent to which they make it possible for us to function (Nussbaum, 2011).Under the premise of the capability approach, attention is directed toward whether or not a person possesses the set of skills essential to establishing a satisfying and successful life. Natural systems, such as the weather, are directly responsible for maintaining such capabilities.

The capabilities approach provides ideas that can be incorporated into the current climate justice paradigm, but in a way that is more applicable to the formulation of adaptation policy (Schlosberg, 2011). In order to protect human populations and the ecosystem, it is crucial to combine adaptation policies with climate justice, given that this approach addresses the necessities for human existence to operate and flourish.

Instances of seasonal agricultural drought limited people's ability to make use of available resources. If a seasonal agricultural drought hinders agricultural activities and/or erodes local infrastructure, then functionality will be restricted. In this scenario, seasonal agricultural drought is a hindrance to human existence (Schlosberg, 2009). Similarly, potential mental health effects, such as the heightened stress of seasonal agricultural drought refugees and the general worry of quick seasonal agricultural drought, could be viewed as an impediment to emotional health capabilities (Nussbaum, 2011).

Most importantly, a capabilities-based strategy for adaptability does not rely on a command-and-control model led by experts. Instead, locals should be heavily involved in determining their own susceptibilities and crafting equitable adaptation plans meant to protect them against seasonal agricultural drought (Schlosberg, 2009; Ribot, 2010).

As a result, the method provided a framework for assessing local conditions, pinpointing the obstacles that prevent people from adapting to seasonal agricultural drought, focusing adaptation policy on protecting and restoring the abilities most at risk from such drought, and gauging the effectiveness of those efforts.

2.6.2 The Discrete Choice Model

Discrete Choice Model by McFadden serves as the framework for deciding which adaptation alternative to select. This theoretical framework holds that individuals freely decide which options to pursue while leaving the remaining options to chance (McFadden, 1973).

There are both random and deterministic aspects to the value of a decision. The random portion follows a fixed distribution and is thus distinct from the deterministic portion. This demonstrates that determining which option a decision-maker will choose is typically a crapshoot. However, the likelihood that a given option is preferred due to its higher perceived utility can be quantified (Luce, 1959; Cascetta, 2009).

Basing on (McFadden, 1978), factors influencing adaptive water management options adopted by a farmer will be examined using the discrete choice model. The following techniques are predicated to be used:

Let $\mathbf{T_1}$= Cropping strategy

$\mathbf{T_2}$= Irrigation and water harvesting

With $\mathbf{U_1}$ = Utility a farmer gains by adopting cropping approach

$\mathbf{U_2}$= Utility a farmer gains from employing irrigation and water harvesting methods

Based on RUM, the farmer will adopt $\mathbf{T_2}$ instead of $\mathbf{T_1}$ if $\mathbf{T_2}$will lead to a higher utility than $\mathbf{T_1}$ (Greene, 2003).

For instance, the decision-maker in this study was a small-scale crop farmer who was presented with choices of adaptive water management options from which to select one in order to maximize his or her utility. It is assumed in the discrete choice model that the farmer selected the most beneficial options. The estimated parameters of the observable explanatory factors, such as farm and farmer characteristics, and the linear combination of these two sets of variables constituted the deterministic portion of the analysis.

2.7 Conceptual Framework

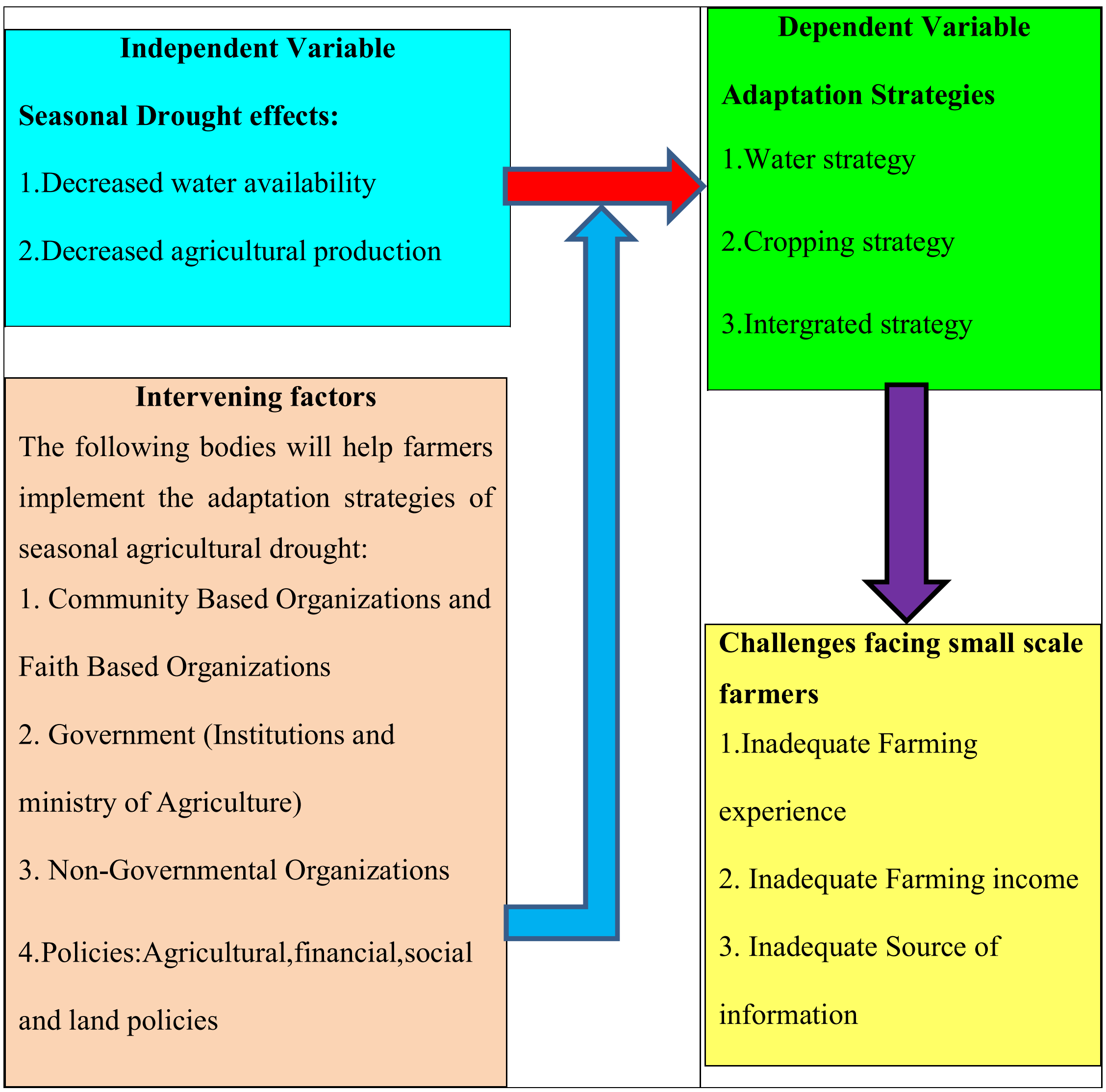

Figure 2.3: Relationship between independent and dependent variable

Source: Based on Capability and Discrete Choice Model theory

The conceptual framework above provides clear link between dependent and independent variables in the study. The researcher developed it from the knowledge and ideas adopted from documented literature review and the theories used: Capability theory and Random Utility Maximization theory.

The independent variable is agricultural drought effects on small scale crop production that is decreased agricultural production and decreased water availability in Kakamega South Sub-county. The various data collection methods to gather data that portrayed these effects that affects small scale farmers' agricultural production due to agricultural drought.

The dependent variable is adaptive strategies used by small scale crop farmers in Kakamega South Sub-county. These strategies include water, cropping and integrated strategy which enable the small scale crop farmers to adapt to the effects of agricultural drought.

The data collected from the effects and adaptation strategies on small scale farmers' agricultural production will help them to become more resilient and less vulnerable to seasonal agricultural drought effects.

The intervening factors are the bodies implementing the seasonal agricultural drought adaptation strategies and they include: Community Based Organizations and Faith Based Organizations, Government (Institutions and ministry of Agriculture),policies and Non-Governmental Organization which have impacts on small scale farmers' adjustment to seasonal agricultural drought in Kakamega South Sub-County.

The recommendations and suggestions that are given by the researcher from research findings will guide these organizations on the strategies to implement so as to help the small scale farmers to adapt to seasonal agricultural drought in Kakamega south sub-county and others regions experiencing the same problem.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter covers the methodology that is research design, study area, research instruments, validity, reliability of the instruments, data collection procedure, data source, data analysis techniques and ethical consideration.

3.2 Research Design

The researchers of this study employed a mixed-methods strategy, integrating quantitative and qualitative techniques to discover more about the subject at hand. This method guarantees that no relevant details are overlooked (Denscombe, 2007; Creswell, 2009).

A quantitative research design is an investigation used to examine variable-based hypotheses. Evidence is counted and examined statistically to decide if a theory or hypothesis should be accepted or rejected (Amaratunga et.al. 2002). Probability sampling is the standard method for quantitative approaches since it allows for statistical inferences to be drawn (Patton, 1990). This study strategy allowed for more efficient and rapid data gathering than alternative approaches, as well as the provision of numerical and exact data and the elimination of any potential bias introduced by the researcher.

According to Kothari (2013), the goal of a descriptive survey is to provide a snapshot of the current condition of affairs. Thus, descriptive survey design was appropriate for this study in describing the current state of small scale farmers in relation to adaptation strategies that need to be implemented to manage agricultural drought in Kakamega South Sub-County. In addition, the research design guided the study in conducting research and as well structuring and designing methodology, methods of data collection, analysis and interpretation.

3.3 Study Area

The study was conducted in Kakamega South sub-county as shown by Figure 3.0 below which is situated in Kakamega County in Kenya.

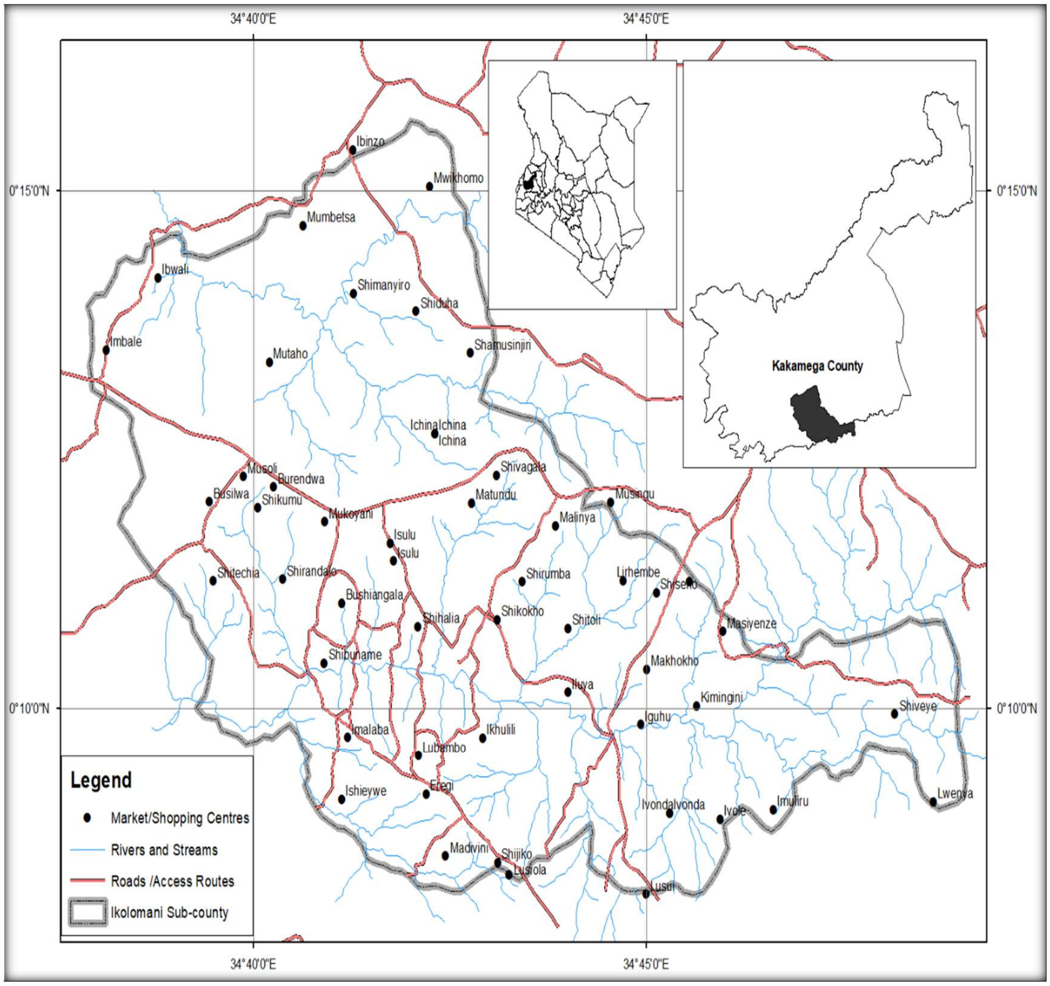

Figure 3.1: Map of Kakamega South/Ikolomani Sub-county

Source: *Based on ESriGIS*

Previously, it was referred to as Ikolomani sub-county. It is bordered by Lurambi sub-county to the North, Sabatia and Emuhaya to the South, Shinyalu to the East and Khwisero to the West. Kakamega South sub county is divided into four sub county wards; Idakho East, Idakho South, Idakho Central and Idakho North. The wards are further divided into six locations Iguhu, Eregi, Shikumu, Shirumba, Isulu and Shisele with a total of twenty-two (22) sub locations).

According to Kenya National Bureau of statistics, 2019 the study area had a population of about 111,743 people, with ratios of 53,219 (47.63%) male and 58,524 (52.37%). The population density is 764 per square kilometer with approximately 26,940 households and average household size of 4.1 (KNBS, 2019).

The Sub-county covers an area of 146.2 Km^2 of which 118.9Km^2consists primarily of subsistence farms, with only a minuscule proportion dedicated to income commodities like tea and sugar cane. Kakamega South, in contrast to Lugari and Likuyani, where large-scale farming is common, is known for its intensive small-scale production of maize, tea, beans, and horticulture. There are four separate administrative districts in this area, each with its own unique agro-ecological zone, soil conditions, rainfall, and agricultural production. Across all agro ecological zones, a representative sample of study households was drawn for the purpose of this research (Mulinya et.al. 2016).

Kakamega sub-county receives an average annual rainfall of between 1280.1 mm and 2214.1 mm, depending on the surrounding county. Rainfall is bimodal, with the heaviest months being March and July and the driest being December and February. The weather is mild, with highs of 29^0C and lows of 18^0C. Hotter than average temperatures are experienced in January, February, and March, with the rest of the year experiencing temperatures that are just slightly lower than average. The average humidity across the county is 67%. Minimum (night) and maximum (day) temperatures have been on a warming trend across Kenya since the early 1960s. The current forecasts suggest that climate change may cause temperature increases (KCIDP, 2018).

There is a wide variance in elevation from 1,240 metres to 2,000 metres above sea level in this area. Kakamega South, located in the region's south, is steep and consists of rough granite rocks that reach elevations of around 1,950 metres above sea level. In addition, the county contains a number of hills, some of which include the Eregi and Lihanda hills, among others. Because of these hills, the weather in Kakamega South is significantly altered.

Heavy rains in the area have resulted in a variety of permanent drainage features, such as rivers. The sub-county is home to a number of rivers and streams, including the Shianambunga stream and the River Yala, as well as a number of springs, boreholes, shallow wells, and trough catchment. Vegetation in the watershed region is mostly determined by its geomorphologic characteristics (KCIDP, 2018).

3.4 Target Population

The study population of 26,940 households was drawn from the four sub county wards; Idakho East, Idakho South, Idakho Central and Idakho North. The study area was selected for study on adaptation to effects of seasonal agricultural drought as the researcher saw the need of providing solution to the problem among small scale farmers in Kakamega South sub-county. The target population for this study was 26,940 households from the four wards (KNBS, 2019).Additionally,4 agricultural officers, 12 maize sellers and 3 meteorologists was added to the target population so as to provide additional information on seasonal agricultural drought.

3.5 Sample Size and Sampling Procedures

A sample size of 377 households was picked from the target population of 26,940 households using statistical sampling tables and specific sampling procedures in the study. The study used Morgan table (Krejcie & Morgan, 1970) in (Appendix VI) which is statistically verified for sampling to select sample population of 377 out of a target population of 26,940 households.

This study used random sampling technique to group Kakamega South Sub County to the four wards. Simple random sampling was used to apportion 377 households to the six locations in the sub county at a confidence level of 95% and a margin error of 5.0% (Researchers Advisors, 2006). Random sampling was suitable in this study as it minimized biasness in data selection.Since 377 households represent only a very tiny subset of the total population, a sampling range of 10–30% was used (Mugenda & Mugenda 2003) as shown in Table 2 below.

Table 2: Summary of Study Sample Size for the Small Scale Farmers

No.	Ward	Location	Number of households targeted	Sample size of households	Percentage (%)
1.	Idakho North	Shisele	6,623	93	25
2.	Idakho Central	Isulu	4,827	68	18
		Shirumba	4,520	63	17
3.	Idakho East	Iguhu	5,658	79	21
4.	Idakho South	Eregi	2,021	28	7
		Shikumu	3,291	46	12
Total	**4**	**6**	**26,940**	**377**	**100**

Source: *Based on Kenya National Bureau of Statistics 2019 for household per sub-county and Krejcie and Morgan Table*

However, an additional 5% that is 19 respondents as shown in Table 3 was included using purposive sampling. These additional respondents had targeted information related to agricultural drought effects and adaptations. Sample of agricultural officers, crop sellers and meteorologists was done because they had specific and detailed information on adaptation strategies of small scale farmers to agricultural drought in Kakamega South Sub County.

Table 3: Sampling Frame for Other Respondents

No.	Category	Target population	Sample size
1.	Agricultural officers	4	4
2.	Maize sellers	12	12
3.	Meteorologists	3	3
Total		**19**	**19**

Source: *Based on Krejcei and Morgan, 1970 Table*

From the sample size categories the total sample population that was used to collect data on the adaptation strategies to seasonal agricultural drought due to climate change in Kakamega South sub-county was 377 small scale farmers, 4 agricultural officers, 12 maize sellers and 3 meteorologists. This enhanced the reliability and validity of the data that was collect during the study since different data were gathered from different respondents.

3.6 Data Sources and Collection Methods

Primary and secondary data was both obtained. This provided real time and non-biased data on agricultural drought effects and adaptation. The collected primary data includes agricultural drought adaptation tactics, crops farmed, family size, education levels, gender, land tenure, farming experiences, and farmer perspectives on agricultural drought concerns.

Secondary data was collect from publications of the Kakamega Meteorological center on rainfall and temperature for the past 35 years. The data that already exist helped in providing information needed for the study (Mertler, 2019). For instance, this ensured that the climatic data on rainfall and temperature trends over the 35 years was genuine and thus enhancing reliability and validity of the meteorological data.

3.6.1 Observation

Field observation was used to collect data that expounded more on the effects of seasonal agricultural drought on small scale farmers' agricultural drought. Field observation involves carefully watching and systematically recording what you see and hear in a particular setting (Mertler, 2019).

Field observation method was important since subjective bias is eliminated as the researcher observes for themselves hence obtaining a true picture at hand. In addition to that, the information obtained is most certainly correct (up to date) since it concerns what is currently happening in the setting.

After data was gathered in the field, it was recorded in the form of field notes, which are documented accounts of what the observer saw (Mertler, 2019).This helped the researcher to record all events in the chronology that they happened.

Unstructured field observation (participatory observation), which implies being directly involved in the activity that you are observing was also used. The main aim of participatory observation is to gain firsthand knowledge by being as close as possible and do observation from the 'inside' (Kavulya, 2014).

3.6.2 Questionnaires

Data were collected from household heads using questionnaires. They are utilized for administration and are able to capture a significant amount of data in a short period of time. It made it possible for the researcher to gather information of varying quantitative and qualitative levels on seasonal agricultural drought effects on small scale farmers' agricultural production within a short time.

Both open-ended and close-ended questions in the questionnaire were used to collect large data from small scale farmers. Structured (closed-ended) questions were used because they are easy to analyze when using statistical analysis and they are also easy to administer because it had already given alternative answers. On the other hand, unstructured (open-ended) questions were used since they gave more varied and deeper ideas about seasonal agricultural drought depending on the background, interest and opinions of the small scale farmers (Kavulya, 2014).

The questionnaires were administered using hand-delivery method to the small scale crop farmers by the researchers and the research assistants. For the small scale farmers who were likely illiterate were interviewed using the questionnaires and fill it out by the researcher or the research assistants on their behalf (Ibid, 2014).

3.6.3 Interview Schedules

Face to face interviews were used to collect data among the small scale farmers. It enabled the researcher to have one-on-one relationship with the small scale farmers and additional information was obtained through maintaining eye contact by interpreting both facial expression and body language (Kavulya, 2014).

Interviewing technique helped the researcher to obtain in-depth information on the effects of seasonal agricultural drought on small scale farmer's agricultural production compared to questionnaires. In addition to that, it enabled the researcher to clarify issues that are not clear immediately and therefore, the likelihood of collecting information that was relevant to the study was high (Ibid, 2014).

Interview schedules were used to validate data from agricultural officers and crop sellers in the sub-county. The information was on the effects, challenges and adaptation strategies used by small scale farmers in Kakamega South Sub-county for the last thirty five years in Kakamega County.

3.6.4 Focused Group Discussion

Focused Group Discussion Schedules are normally used for validating data therefore the study used this method to collect extra data as well as validate the data that was collected from the other sources. Focus Group Discussion is a discussion of a group of people; consisting of a small number of persons, typically less than a dozen and the discussion last between 1 and 2 hours.

This data collection method is important since the views of the small scale farmers was used to justify or reinforce the views collected from other small scale farmers through the questionnaires. Small-scale farmers preferred group discussions to individual interviews. Furthermore, people have a tendency to feed off the opinions of those around them, thus interactions inside the focus group conversation could yield a wealth of useful information (Mertler, (2019).

3.7 Data Collection Procedures

The researcher made a pre-visit (earlier visit) to the sub locations for introduction, seeking permission from the chiefs, and making appointments for data collection. On second visit, the researcher together with the two research assistants administered questionnaires to small scale farmers. The interview schedule was used for Agricultural officers and crop sellers given that they are too preoccupied to reply in a timely manner to the questionnaires and was 19 in total. The interview schedules focused on the effects; climate change, water and agricultural production linkages; challenges and adaptation strategies used by small scale farmers in Kakamega South sub-county for the last five years. In addition to that, Focus Group Discussions (FGDs) were held with small scale farmers.

Two research assistants who understand the local language (*idakho*) were used especially in collecting data among the small scale farmers who might not be able to fill the questionnaire by themselves. These research assistants also played a great role as interpreters to the local respondents and the researcher during the data collection. They interpreted the respondents answer in local language to English and filled the responses in the questionnaires.

3.8 Reliability and Validity of Data Collection Instruments

3.8.1 Reliability of Instruments of the Research

Kothari (2004) defines reliability as the extent to which an instrument reliably measures the characteristics for which it was designed. An instrument is reliable if it produces the same results whenever it is repeatedly used. Reliability helps the researcher to establish whether or not the test or instrument measures the purpose of that particular study if he or she obtains similar results each time the test is administered.

The study tested reliability using test-retest reliability. As pointed out by Mertler (2019), to determine test-retest reliability, researchers' first offer a test to a sample of people and then give the same test to the same people again, on average, a week later. The dependability of a test can be measured by correlating its results from two separate administrations and calculating the coefficient of correlation between them (that is as it approaches 1.00), the more reliable the test.

Reliability coefficients can range from a minimum of 0.00 to a maximum of +1.00 and the closer a reliability coefficient is to +1.00, the closer we are having a perfect reliability. No test or instrument guarantees perfect reliability Mertler, (2019). Thus, the researcher ensured that the research instruments such as questionnaires and interview schedules were well structured and free from bias.

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In addition, seminars, journal publications, conferences, and workshops were utilized to ensure academic reliability and consistency. Reliability was ensured by comparing other research done on agricultural drought effects and adaptation study findings in literature review. Evaluative testing was used to confirm the results (In other words, this can be done by comparing the results to those of other research during the analysis and discussion of the findings). Validity of an instrument can be determined by other factors besides its reliability alone. This is due to the fact that while it's true that a valid test will always yield accurate results, this cannot be said of every reliable test (Mertler, (2019). Thus, this study further tested for the Validity of instruments that were used in the study.

3.8.2 Validity of the Instruments

Validity refers to the extent to which evidence supports the inferences a researcher draws from the data obtained using a particular instrument; the inferences, not the instrument, are verified (Fraenkel et.al.,2012).Thus, validity determines whether we actually measured what we intended to measure, and whether the inferences follow logically from our interpretations (Mertler,2019).The validity of this study therefore, helped answer the research questions as well as measure what the study intend to measure.

To enhance validity pilot study was carried out in Lurambi constituency in Kakamega County to help the researcher to identify items in research instrument that may be ambiguous. The pilot study from Lurambi constituency in Kakamega County responses was compared with the expected responses from Kakamega South sub-county. Discrepancies were addressed by making adjustment and corrections to improve the quality of the instrument.

Moreover, triangulation (the practice of employing a wide variety of approaches, methodologies, sources, and researchers) was used in validating qualitative data as pointed out by Glesne (2006). As adapted from Fraenkel et.al. (2012), one strategy that can be used to validate data is multiple methods where a wide range of tools, methods, and sources for information gathering are employed.

The validity of the research tools was established using a pilot survey. Testing questionnaires in a pilot study is crucial in research, particularly during the questionnaire-design stage (Munn and Drever, 1990). It was helpful in determining whether or not research surveys were feasible, if their questions were easily understood, and if their coverage was all-encompassing.

Using this method the data findings were supported by showing that the data collected through questionnaires do agree with data collected through field observations, Focus Discussion Group and interview schedules. This helped in validating the qualitative data with confidence since the data was concluded to be true and accurate in testing the variables under study as explained by Mertler (2019).

3.9 Data Analysis Techniques

Data analysis involves editing, organizing, sorting and summarizing data extracted from research instruments. The study is expected to generate both quantitative and qualitative data. Quantitative data were analyzed through descriptive statistics in the form of frequency distribution counts and percentages for instance in demographic information.

Furthermore, inferential statistics were used in testing relationship between seasonal agricultural drought and adaptation strategies used by small scale crop farmers using Pearson product-moment correlation coefficient (r_{xy}).A correlation coefficient of -1.00 and +1.00 will be used Metrler, (2019).This helped in testing the research questions and research hypothesis to see if there is relationship between the variables under study. Positive correlation indicated that there was relationship between variables while negative correlation indicated no relationship between variables under study.

Linear regression analysis was used to find out if the independent variable can be used for predicting the dependent variables under study (Ibid, 2019). A good example is analyzing the temperature and rainfall trends that were used to explain Climate Change. All acquired data were encoded and imported into Statistical Package for the Social Sciences (SPSS) version 23 for analysis. Wherever possible, Microsoft Excel was utilized to create graphs in place of SPSS.

Frequency of responses to each question was analyzed using descriptive statistics (Fisher and Marshall, 2009). The four wards of the Kakamega South sub-county were surveyed, and their responses were cross-tabulated to determine how they deal with agricultural drought. Cross-tabulation, as reported by Fisher and Marshall (2009), can be used to spot trends in data. This data was useful in making sure that consideration was given to the right local factors during the planning process. If this isn't established, efforts to mitigate and intervene in lower-priority regions may take precedence. To avoid this priority bias, questionnaires distribution was according to the wards and villages.

Inductive analysis was used to process the gathered qualitative data. By "systematically structuring and presenting the findings in a way that facilitates the understanding of these data," qualitative analysis, as defined by Parsons and Brown (2002), allows for a more thorough comprehension of the data collected. Additionally, they detail the three stages of qualitative analysis as being: organization, description, and interpretation (Optic, 2019). Therefore, inductive analysis was used to compile an outline of the study's qualitative findings.

3.10 Interpreting Tests of Statistics and Significance

The research suggested that the p-value was statistically significant. In this analysis, the null hypothesis was rejected anytime the p-value was less than 0.05. The analysis, which included descriptive and inferential statistics, yielded data that were already presented in accordance with the aims of the study. Statistical testing of hypotheses was conducted with a 0.05 threshold of significance. The estimated test statistics and the significance level (p-value) were used to decide whether or not to reject the null hypothesis. The null hypothesis was accepted if $p \geq 0.05$ as this indicated that there was no relationship between variables as the data was beyond 0.05 threshold of significance level. Null hypothesis was rejected if $p < 0.05$ on the other indicated that there was relationship between variables under study as the data was below 0.05 which is the threshold of significance level.

3.11 Ethical Consideration

The issue of ethics is very significant in the field of research, particularly in cases when the research incorporates people as participants. Therefore, prior to the collecting of data, ethical approval was sought from the Department of Geography at Masinde Muliro University in order to guarantee that any and all ethical concerns raised by this research was appropriately addressed and resolved. The researcher obtained a research permit from NACOSTI, after getting clearance letter from the Department of Geography, Masinde Muliro University of Science and Technology. This granted permission of data collection from the 377 households in the sub locations of Kakamega South sub-county, permission was also sought from the sub-county director of agriculture.

Everyone who took part in the research project was asked for their informed consent at any point during the process. Those who were not interested in taking part in the study were not required to do so under any circumstances. For reasons of confidentiality, the names of respondents were not included anywhere in the instruments used to collect data. The information that was collected was only utilized in the study. Additionally, approval was sought from the appropriate authorities in the area under study.

CHAPTER FOUR: DISCUSSION OF RESULTS

4.1. Introduction

This chapter gives results and discussions that were based on the four study objectives: Which are to establish the evidence of climate change and seasonal drought among small scale farmers; to determine the effects of seasonal drought and challenges facing small scale farmers' agricultural production; and adaptation strategies of agricultural drought in Kakamega South Sub-county.

4.2 Questionnaire Return Rate

A response rate of 50% is considered sufficient for analysis and reporting, while a rate of 60% is considered good and a response rate of 70% or higher is considered exceptional, as stated by Mugenda & Mugenda (2003). According to the argument, the response rate of 96% was regarded as outstanding. This was a good return rate since it was over 50% of the expected questionnaires as shown in Table 4 below;

The percentage of respondents who completed the questionnaire in its entirety represents the proportion of the sample that provided data as anticipated across all analyses. This was done to make certain that there would be a sizable enough response to draw conclusions about the study's aims. This study involved 396 small scale farmer's households, 4 agricultural officers, 12 maize sellers and 3 meteorologists. Out of the expected 396 questionnaires from the small scale farmers a total of 96.0% was returned. All the other respondents that is, 4 agricultural officers, 12 maize sellers and 3 meteorologists were interviewed, which was 100 percent of the return rate.

Table 4: Questionnaire Return Rate of Small Scale Farmers and other Respondents

Small-scale farmers	Percentage (%)	Other respondents	Percentage (%)
Response	96.0	Agricultural officers	21.0
None Response	4.0	Maize sellers	63.0
		Meteorologists	16.0
Total	**100**		**100**

4.3 Demographic Data

This section summarizes the distribution of respondents by age, gender, academic qualification and professional experience among others. It also shows the distribution of respondents by the category of their agricultural roles. The background data enabled the researcher to make correct inferences from the responses in relation to adaptation strategies of seasonal agricultural drought among the small scale farmers.

4.3.1 Gender of the Respondents

The gender of the respondents was sought and Table 5 summarizes the findings:

Table 5: Gender of the Respondents

Gender	Percent (%)
Male	54.6
Female	45.3
Total	**100.0**

A total of 380 respondents from Shisele, Isulu, Shirumba, Iguhu, Eregi, and Shikumu locations were interviewed. Table 6 shows that the majority of the respondents were male 54.6% whereas 45.3% were female. This is an indication that both genders were involved in assessing adaptation strategies of seasonal agricultural drought among small scale crop farmers in Kakamega South Sub-county. This is confirmed by Okello (2010) who said that it was important to involve both genders while conducting a study in order to be representative.

4.3.2 Age of the Respondents

The age of the participants was sought and the findings were given in Table 6.

Table 6: Distribution of the Respondents by Age

Age	Percentage (%)
15-25 years	22.9
26-36 years	29.7
37-47 years	11.8
48-58 years	15.3
59 years and above	20.3
Total	**100.0**

Majority of the household heads were between 26-36 years 29.7%. This is a very significant age of crop productivity for they are middle aged with a great potential to produce food for the rising population. This was followed by those between 15-25 years at 22.9%, and 59 years and above was 20.3%. 15.3% were aged 48 to 58 years, and a small percentage was between 37 to 47 years 11.8%.

This indicated that most household heads respondents will be able to easily accept various water and technological measures that would help them to adapt well to adaptation strategies of seasonal agricultural drought in Kakamega South Sub-county. Younger generations have been exposed to a lot of technologies and information on agricultural adjustment strategies thus they are more willing to adapt new adaptation strategies unlike the elderly people who are unwilling to adapt change that would help them adapt to seasonal agricultural drought. This is similar to what Samel, (2015) showed that households headed by people younger than 50 were more likely to seek out information about adaptation measures for seasonal agricultural drought as compared to their elderly counterparts.

4.3.3 Level Education of the Respondents

The research wanted to know the highest education level of the respondents.

Table 7: Highest Education Level of the Respondents

Education Level	Percent (%)
No schooling	11.8
Primary Level	12.9
Secondary Level	43.2
Tertiary Level	32.1
Total	**100.0**

Table 7 shows that among the respondents, 43.2% had completed some form of secondary education, and those who had tertiary school education 32.1%. About 12.9% of the respondents had primary level education, while 11.8% had not attended school. In this study most farmers had access to secondary education.

This implies that most farmers were in a position to read, understand and write. This was very crucial in helping them access helpful information, technology and input on how to adapt to seasonal agricultural drought by adapting various adaptation strategies that were recommended or researched on by various researches. This is similar to what FAO, (2010) argues that good access to education makes one able to access critical services such as credit, technology and input supply which will enable them make good decisions on adaptation strategies for seasonal agricultural drought.

4.3.4 Family Sizes

The summary and findings of family sizes are shown in Table 8.Itindicates that most households had 1 to 5 people that are 83.9%, while 6 to 10 people were 15.0% and those with no people were 1.1%. This indicates that most farmers had a source of farm labor in their households. This is very crucial in determining the level at which farmers could adapt the strategies used to adapt to seasonal agricultural drought. This shows that the households have enough labor to support their farming activities especially in adapting the strategies that will aid local farmers in weathering the seasonal drought.

Table 8: Number of Persons per Households

Number of persons per households	Percent
None	1.1
1-5 people	83.9
6-10 people	15.0
Total	**100.0**

This provides further evidence that household size is a good predictor of new strategy adoption among small-scale farmers during times of seasonal agricultural drought because its availability lessens manpower restrictions (Marenya & Barrett, 2007; Teklewold et.al., 2006).

4.3.5 Farming Status of the Respondents

The study sought to find out the farming status of the small scale famers and the findings were as shown in Table 9 below:

Table 9: Farming Status of Respondents

Farming status	Percent
None farmer	23.4
Full-time farmer	45.5
Part-time farmer	31.1
Total	**100.0**

As shown by Table 9 majority of the respondents 45.5% were full-time farmers, 31.1% were part-time farmers. Agriculture forms the backbone of this country and most parts of Kakamega south sub-county. This coupled with factors such as high rate of unemployment makes most people in the country to turn to agriculture in order to earn their daily living. Those who did not participate in farming could be doing other off-farm job so as to compensate their source of income since farming has been affected by climate change.

Additionally, IPCC (2014) confirms that agriculture is the primary source of income for the vast majority of Kenyans. Therefore, even seasonal climate fluctuations can have a significant impact on income and food security. This is due to the fact that smallholder and subsistence farmers' livelihoods are intrinsically related to the weather.

4.3.6 Type of Farming Done by the Respondents

Table 10: Type of Farming Done by the Respondents

Type of Farming	Percent
Irrigated farming	32.6
Rain-fed farming	67.4
Total	**100.0**

The study sought to find out the type of farming practiced by the respondents and the findings were as illustrated in Table 10 above. It indicates that majority of the farmers 67.4% practiced rain-fed farming, while a small percentage 32.6% practiced irrigated farming. This is likely to indicate that the farmers on a smaller scale are more susceptible to climate change's negative consequences such as seasonal agricultural drought and thus it is difficult to adapt to the seasonal agricultural drought in Kakamega South sub-county.

Sub-Saharan Africa's (SSA) agricultural output relies heavily on rainfall. However, because to climate change, the region has been suffering irregular rainfall patterns and Agricultural drought, leading to decreasing and unequal yield a trend, which has had serious consequences for small-scale farmers and the food security of their households (URT, 2008).

4.4 Climate Change and Agricultural Drought Evidence

4.4.1 Indicators of Climate Change and Agricultural Drought

The study sought to find out whether there were some indicators that enabled the farmers to establish the evidence of climate change and agricultural drought. The findings indicate the response of the small scale farmers in the table below.

Table 11 indicates that majority of the farmers 43.2% agreed that the greatest indicator was high solar radiation, both rainfall and temperature change 32.1%, temperature change 12.9%, and rainfall change 11.8 % were indicators of climate change. On the other hand indicating the evidence of seasonal agricultural drought majority agreed that crop wilting 49.7%, reduced crop production 20.3%, drying up of grass and vegetation 16.2%, death of crops 11.8% were the indicators of seasonal agricultural drought .Climate change indicates that the hydrological cycle has been disrupted directly and indirectly. This results in insufficient water for crops to thrive well especially during the dry seasons.

Table 11: Indicators of Climate Change and Agricultural Drought

Indicators of climate change and agricultural drought			
Indicators of climate change		**Indicators of agricultural drought**	
Statement	**Percentage (%)**	**Statement**	**Percentage (%)**
Rainfall change	11.8	Crop wilting	49.7
Temperature Change	12.9	Death of crops	11.8
High solar radiation	43.2	Grass drying	16.2
Both rainfall and temperature change	32.1	Reduced crop production	20.3
Total	**100**		**100**

Direct interference with hydrological cycle occurs when there is destructive human activities such as deforestation, it reduces the rate of evaporation and evapo-transpiration. Consequently the amount of water vapor in the atmosphere which in turn leads to shortage of rainfall. Indirect interference with hydrological cycle occurs when destructive human activities like deforestation results to global warming which causes change in normal climatic patterns such as high temperatures and irregular rainfall patterns. This results to prolonged droughts in some seasons thus increasing the effects of agricultural drought on crop production. Shortage of rainfall makes the vegetation such as the agricultural crops to be stressed due to inadequate water content in the soil.

This study concurs with Fischer et.al. (2002), Climate change impacts local water systems by altering the frequency and intensity of rainfall. As a result, these factors could shift the timing of the years most suited for various forms of agricultural output due to changes in average temperatures and precipitation. The International Water Management Institute (IWMI) found that rain-fed farming systems in Sub-Saharan Africa had low productivity in its strategy plan for 2009-2013. In rural places, this exacerbates already high poverty rates and threatens people's ability to feed them. The findings from this study managed to show this relationship between climate change and agricultural drought among small scale farmers.

4.4.2 Rainfall and Temperature Analysis

Annual temperature and rainfall trends for the past 35 years was analyzed and used to explain the climate change and agricultural drought evidence in Kakamega South Sub-County.

4.4.2.1 Kakamega South Sub-county Annual Rainfall Trends from 1985 to 2020

Climate change is evident in figure 4.2 and 4.3 as there has been positive and negative change in the temperature and rainfall received in Kakamega South Sub-county for the past 35 years. This change in the two elements of weather temperature and rainfall has clearly indicated the evidence of climate change which when related to the months of February and January with low rainfall of below 90 mmm and high temperature of above 26ºC.

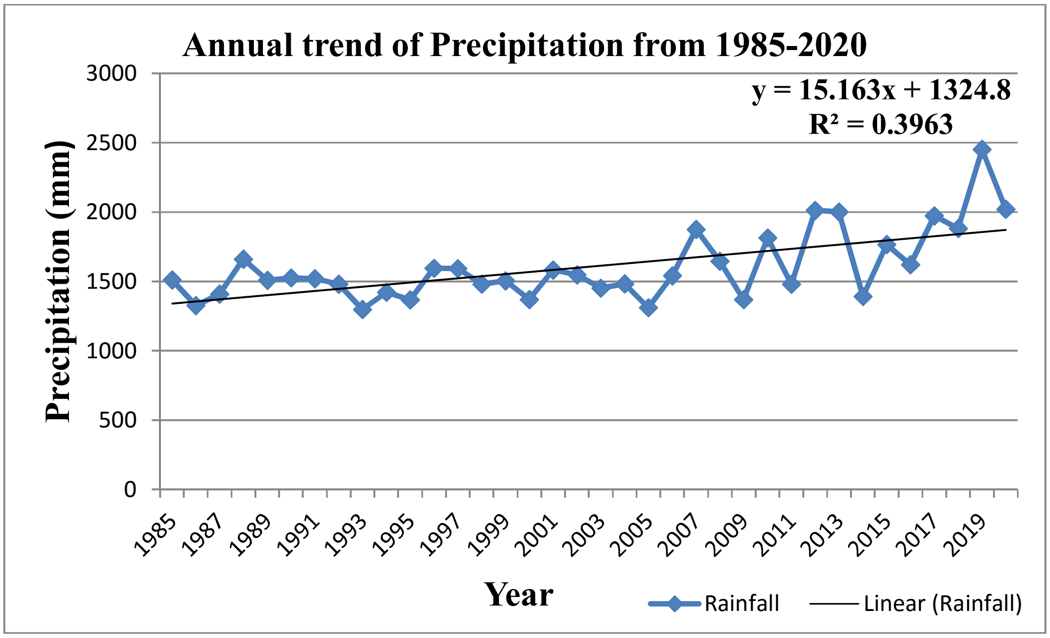


Figure 4.1: Annual Trend of rainfall as from 1985- 2020

Source: Researcher Own Construction

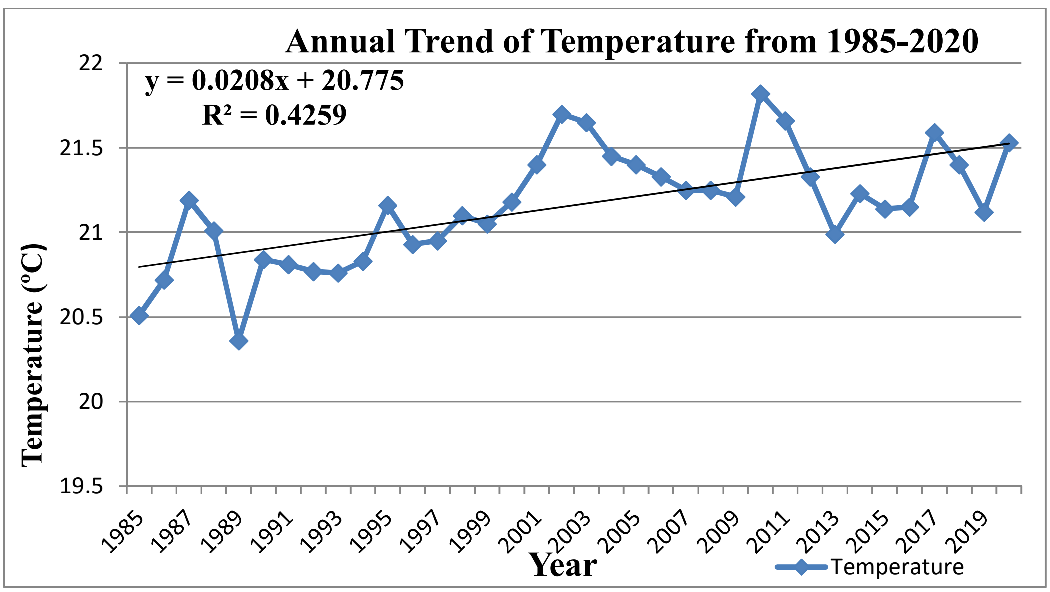


Figure 4.2: Kakamega South Sub-County annual temperature trends

Source: Researcher Own Construction

According to the findings presented in figure 4.2 below, there is a discernible upward linear trend in the annual mean precipitation from the years 1985 to 2020. This trend indicates presence of global warming over the years. Regression coefficient data show a value of 15.16. Coefficient of determination (R^2) for yearly precipitation is 0.3963, which equates to 40.0% of variability in precipitation levels over time (1985-2020). This means that average annual precipitation rose through time, with a 15.16 mm rise in precipitation for each subsequent year. This forecast indicates that the region will likely experience a rise in annual mean precipitation in the years to come.

The data shown in figure 4.3 below indicate the existence of a regression coefficient of 0.0208, which indicates that there is a positive linear trend in annual mean temperature as from 1985 to 2020. This tendency is demonstrated by the fact that there is a progression from lower to higher values. The yearly temperature coefficient of determination (R^2) is 0.4259, which indicates that 42.6% of the fluctuation in temperature levels may be attributed to random chance (1985-2020). This means that the average yearly temperature rose with time, with a 0.02°C increase in temperature for each consecutive year. An increase in the region's average yearly temperature is forecast.

This agrees with the findings of O'Brien et.al. (2008), who found that a considerable proportion of the African population relies on resources that are vulnerable to climatic changes but has limited ability to adjust to these changes. In Africa, water is an essential commodity for supporting human life. Especially vulnerable to climate change is the majority of the population's reliance on rain-fed agriculture, which supports the poor (Hassan & Nhemachena, 2008). Climate change impacts local water systems by altering the frequency and intensity of rainfall. As a result, these factors may shift the timing of when optimal temperatures and precipitation levels for agriculture occur (Fischer et.al. 2002).

4.4.2.2 Kakamega Sub-County Annual Temperature and Rainfall Trends

Annual temperature and rainfall averages for 10 years that is 2010 to 2020 was sought to be used with the maize production for the past 10 year.

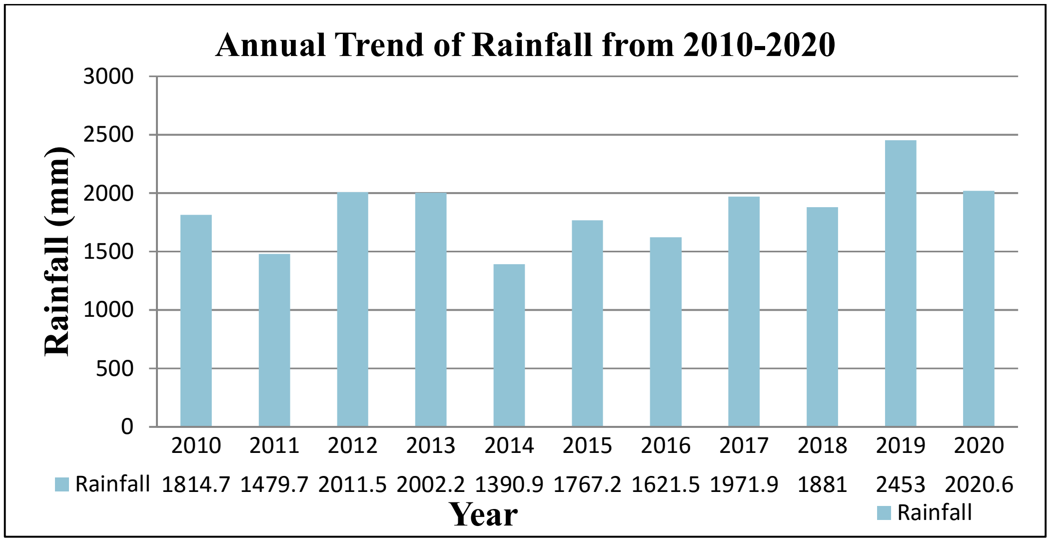


Figure 4.4: Kakamega South Sub-County annual rainfall trends from 2010-2020

Source: *Researcher Own Construction*

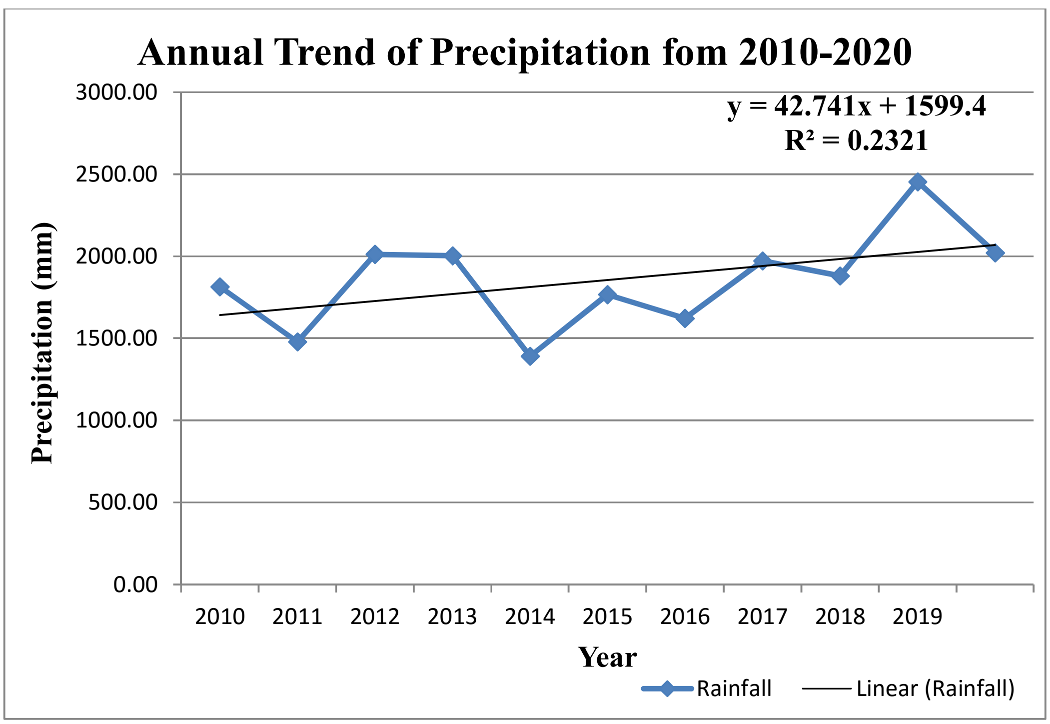


Figure 4.3: Kakamega South Sub-County annual rainfall trends from 2010-2020

Source: *Researcher Own Construction*

Figure 4.4 indicated variability of rainfall in Kakamega South from 2010 to 2020.Using regression analysis to establish the rainfall variability the data shown in Figure 4.5 suggests that there was a regression coefficient of 42.741, which points to the existence of a positive linear trend in annual mean rainfall as from 2010 to 2020. This trend can be seen in the graph labelled Figure 4.5. Annual rainfall has a coefficient of determination (R^2) of 0.232, indicating that 23.2% of rainfall variability can be attributed to time trends (2010-2020). This means that precipitation has been steadily increasing over time, by an average of 42.741mm per year. This forecast indicates that future years in the region will likely see an increase in annual mean rainfall. This shows that the change in climate is there and was used to determine if the Climate Change will influence the Seasonal Agricultural Drought will influence Maize production in the region.

Figure 4.6 reveals a negative linear trend in the annual mean temperature from 2010 to 2020, as demonstrated by the regression coefficient of -0.0207, which is depicted in the results of Figure 4.6. The annual temperature has a coefficient of determination (R^2) of 0.0685, which indicates that there is 6.85% of variance in the temperature quantities throughout the course of time (2010-2020). This means that the average temperature has been rising over time, with a yearly increase of 0.02^{o}c. This forecast indicates that there is a good chance that there will be a reduction in the annual mean temperature in the area in the years to come.

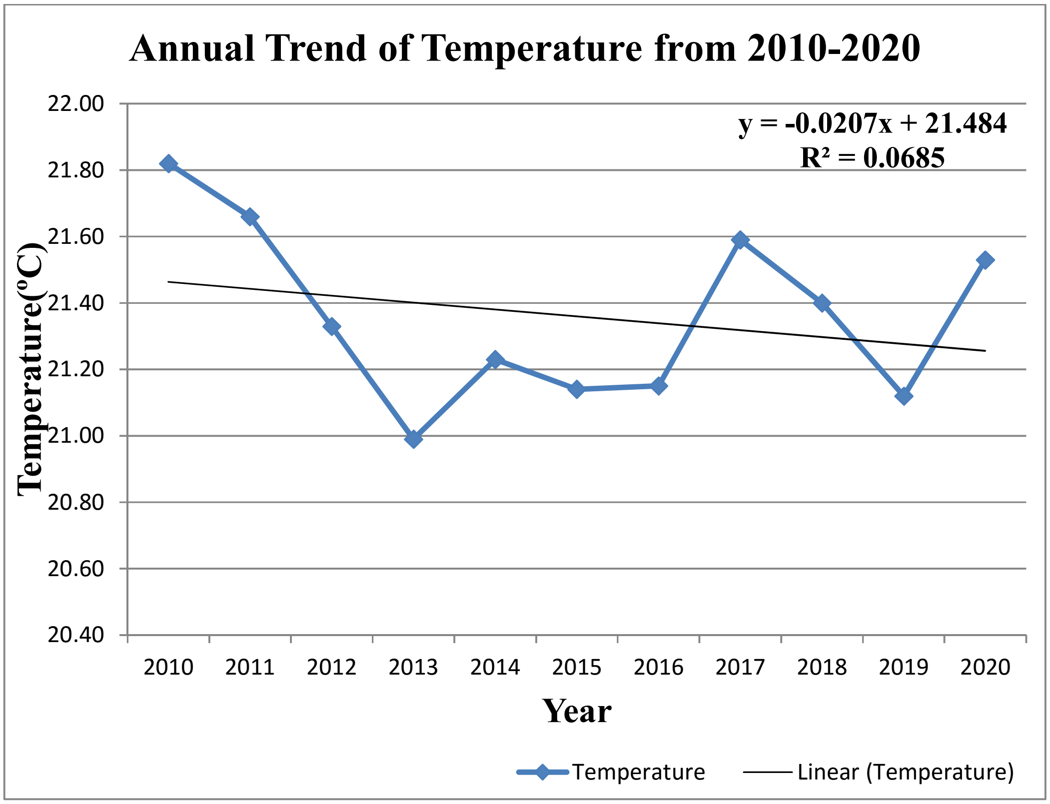


Figure 4.4: Kakamega South Sub-County annual temperature trends from 2010-2020

Source: *Researcher Own Construction*

This data was used to establish the evidence of temperature and seasonal agricultural drought in Kakamega South Sub-County. The average change in temperature for the past 10 years clearly brings out the Climate Change evidence that shows that as the climate change the seasonal agricultural drought also changes in relation to the change in temperature and rainfall trends.

4.4.3 Seasonal Agricultural Drought Evidence in Kakamega South Sub-County

The attributes that were used to asses Seasonal Agricultural drought in Kakamega South Sub-County were the trend of agricultural production of crops and water variability.

4.4.3.1 Evidence of Agricultural Drought from 2010 to 2020

This research aimed to identify the most important crops farmed by these farmers. As can be seen in Table 12 below, the most common crops over the past decade have been various types of maize, beans, sugarcane vegetables, and sweet potatoes.

Table 12: Crops Grown in Kakamega South Sub-county

Crop grown	Yes	Percentage (%)
Maize	263	68.2
Beans	254	66.0
Vegetables	185	48.1
Sorghum	169	43.9
Sweet potatoes	164	42.6
Cassava	150	39.5
Sugar cane	110	28.6
Yams	95	24.7
Fruits	74	19.2
Tea	66	17.2
Arrow roots	41	10.7

Source: *Researcher Own Construction*

4.4.3.2 Evidence of Agricultural Drought by Production of Maize and Beans

In Kakamega South Sub-county, The principal subsistence crops cultivated were primarily corn and beans; consequently, it was required to determine the production over time. In terms of the number of bags produced per acre, the County's agricultural output has been fluctuating. Other elements being held constant, this might be attributable to the changes in climate, which could have had an impact on the length of the growing season of these vital food crops grown in the sub-county. It is important to note that the average number of bags of corn per hectare is 20, but there have been years where this number has dropped as low as 10 bags, such as in 2015, and when this is associated with rainfall amounts, it is apparent that there was less rain than projected in that year. Although 8 bags of beans are typically harvested per hectare, this number dropped to 6 on several instances in 2018. Most farmers who responded to the survey on their crop yield over the past decade said that changing weather patterns were to blame.

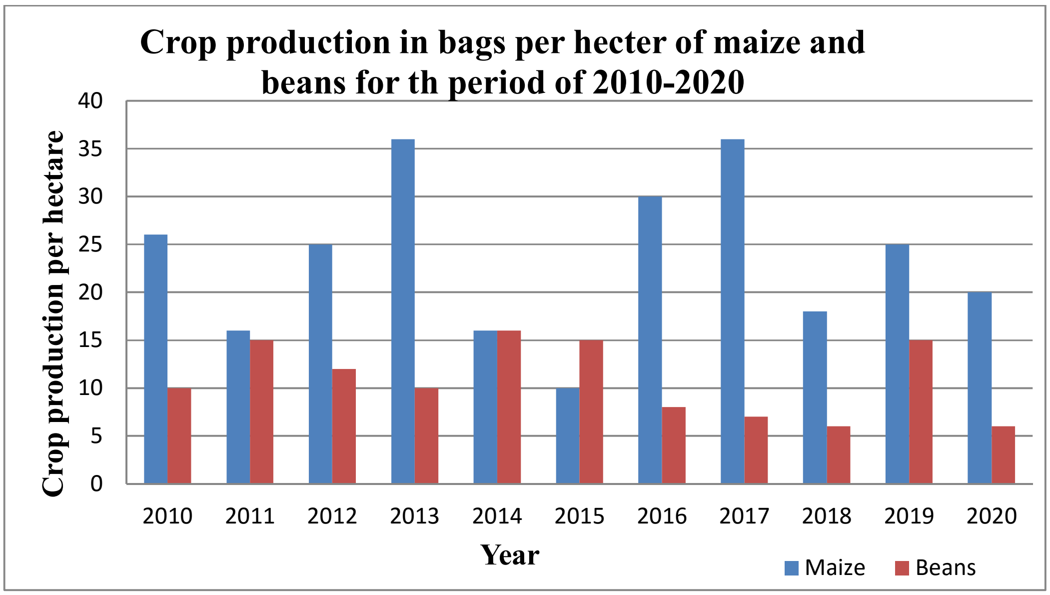


Figure 4.5: Crops Grown by the small scale farmers annually

Source: *Researcher Own Construction*

4.4.4 Evidence of Climate Change in the Sub-County from Respondents

Respondents view on evidence of Climate Change was crucial for this study to proof whether climate change was evident among the small scale farmers. Thus this study came up with the following findings in Table13 below.

Table 13 indicates that one of the climate change evidence by the respondents was the water sources at farm level had been affected by climate change. Majority of the respondents that is 69.7% strongly agreed that water sources at farm level has been affected by climate change, this was followed by 21.85% who agreed with the statement on the other hand 4.5% strongly disagreed and 2.9% disagreed. This is attributed to the reduction of the water level underground as a result of reduced transpiration. Since most trees have been cleared to create more room for settlement and agricultural activities it has resulted to reduced amount of water vapor that would have been released by tree roots from underground to the atmosphere through their leaves.

Table 13: Evidence of Climate Change in the Sub-County from Respondents

Climate change evidence	SD	D	UD	A	SA
There is decreased in crop yield	2.9%	4.5%	1.3%	14.5%	76.8%
Volume of water in streams/rivers reduces	1.3%	2.1%	1.6%	19.2%	75.8%
Affects Water sources at farm level	4.5%	2.9%	1.1%	21.8%	69.7%
There is an increased crop wilting	4.2%	5.5%	11.3%	56.1%	22.9%

Table 13 indicates that one of the climate change evidence by the respondents was the water sources at farm level had been affected by climate change. Majority of the respondents that is 69.7% strongly agreed that water sources at farm level has been affected by climate change, this was followed by 21.85% who agreed with the statement on the other hand 4.5% strongly disagreed and 2.9% disagreed. This is attributed to the reduction of the water level underground as a result of reduced transpiration. Since most trees have been cleared to create more room for settlement and agricultural activities it has resulted to reduced amount of water vapor that would have been released by tree roots from underground to the atmosphere through their leaves.

Majority of the respondents 56.1% agreed that there is an increased incidence for crop wilting, 22.9% strongly agreed, 5.5% disagreed and 4.2% strongly disagreed with the statement. This resulted from water stress among the crops cultivated as there was reduced moisture content in the atmosphere during dry seasons making the soil to also be moister deficient due to high rate of water loss to the atmosphere by the crops.

Most respondents 76.85% strongly agreed and 14.5% agreed that there were decreased crop yields due to reduced rainfall during seasonal drought. On the other hand only a small percentage 2.0% strongly disagreed and 4.6% disagreed that there was decreased crop yields due to seasonal drought. Clearly, when there is low moisture content in the soil and atmosphere the crops tend to be stressed and their photosynthesis process is disrupted. This makes the plants to produce low yields as there is no maximum crop production by the water and temperature stressed crops.

The study established that there was reduced volume of water in the streams and rivers during dry seasons. Most respondents 75.8% strongly agreed and 19.2% agreed that there was reduced water volume during dry season. Only a small portion of the respondents 1.3% strongly disagreed and 2.15% disagreed with the statement. The study established that most respondents observed that, during the dry season the level of water in the streams reduces following the reduction of water in the water table. This is a consequence of inadequate rainfall to replenish the lost water through the high rate of evaporation during the day when the temperatures are high.

4.4.5 Climate Change and Agricultural Drought Evidence Summary

The study further used the summary of the means and standard deviation to summarize the findings on the climate change and agricultural drought evidence as shown in Table 14 below shows the means of the statements in relation to a scale of one to five: 1 represented strongly disagrees, 2 represented agree, 3 represented undecided, 4 represented agree and 5 represented strongly agree. The statement volume of water in streams/rivers during dry seasons reduces had the highest mean of 4.66 and a standard deviation of 0.736 indicating that majority of the respondents strongly agreed with the statement. This was followed by the statement there is decreased in crop yield due to rainfall shortages with a mean of 4.58 and a standard deviation of 0.942.Water sources at farm level being affected by climate change had a mean of 4.49 and a standard deviation of 0.992.

Table 14: Climate change and agricultural drought evidence summary

Climate change evidence	**Mean**	**Std. deviation**
Volume of water in streams/rivers reduces	4.66	0.736
There is decreased in crop yield due to rainfall shortages	4.58	0.942
Water sources at farm level is affected by climate change.	4.49	0.992
There is an increased incidence for crop wilting	3.88	0.964

Source: *Researcher Own Construction*

4.4.6 Hypothesis Test of Evidence of Climate Change and Agricultural Drought

The study sought to find out whether there was evidence of climate change and agricultural drought. Several variables were used to collect data and the findings used to test the correlation as shown in Table 15. This was established by relating the amount of rainfall and temperature trends in relation to the number of bags of maize and beans produced in the respective years from 20120 to 2010. There was need to establish the pattern of rainfall and temperature changes in relation to crop production which was affect in the process of climate change.

Table 15: Production of Maize and Beans from 2010-2020 in Relation to Rainfall and Annual Temperature Trends

YEAR	VARIABLE			
	Rainfall (mm)	**Temperature (°C)**	**Maize Production (bags per acre)**	**Beans Production (bags per acre)**
2010	1814.7	21.82	26	10
2011	1479.65	21.66	16	15
2012	2011.47	21.33	25	12
2013	2002.22	20.99	36	10
2014	1390.90	21.23	16	16
2015	1767.17	21.14	10	15
2016	1621.5	21.15	20	5
2017	1971.91	21.59	36	7
2018	1881.02	21.4	18	6
2019	2452.96	21.12	25	15
2020	2020.63	21.53	20	6
Average	**1855.83**	**21.36**	**23.45**	**10.91**

It is important to note that the average number of bags of maize per hectare is 23, but there have been years where this number has dropped as low as 10 bags, such as in 2015, and when this is associated with rainfall and temperature amounts, it is apparent that there was less rain and temperature projected in that year. Although 10 bags of beans are typically harvested per hectare, this number dropped to 5 on several instances in 2016 and when this is associated with rainfall and temperature amounts, it is apparent that there was less rain and temperature projected in that year. Most farmers who responded to the survey on their crop yield over the past decade said that changing weather patterns were to blame.

Table 16: Evidence of Climate Change and Agricultural Drought

Variable		Rainfall	Humidity	Maize and beans bags produced
Rainfall	Pearson Correlation	1		
	Sig. (2-tailed)			
Humidity	Pearson Correlation	.834*	1	
	Sig. (2-tailed)	.001		
Maize an bean bags produced	Pearson Correlation	-.801	-.869*	1
	Sig. (2-tailed)	.055	.024	
Temperature	Pearson Correlation	-.549	-.813**	.643
	Sig. (2-tailed)	.064	.001	.168

****. Correlation is significant at the 0.01 level (2-tailed). (n=380)**

In table 16 above rainfall is positively correlated with humidity ($r=0.834$, $p < 0.05$). Humidity can be used to determine the amount of rainfall received in a place. When there is high humidity the rainfall received will also be high due to high moisture content in the atmosphere which in turn will influence the amount of cloud formation that will result rainfall formation. However, when we have seasonal agricultural drought due to high temperatures the amount of water lost to the atmosphere as humidity will result to crop wilting as a lot of soil moisture will be lost leading to crop stress which will affect the crop growth and crop production.

Humidity is positively correlated with annual maize and beans production (r= -0.869, p<0.05) and annual average temperature (r= -0.813, p<0.05). The higher the temperature the higher the rate of evaporation which will result to a lot of soil moisture being lost to the atmosphere. The higher the rate of soil moisture lost the higher the crop will be stressed due to crop wilting. Continued crop wilting will result to reduced crop growth and finally results to low maize production.

From the above summary, it is evidence that there is Climate Change and Seasonal Agricultural Drought among small scale farmers. Thus, since p values of th discused variables are < 0.05 we reject the Ho (Null hypothesis) that there is no evidence of Climate Change and agricultural drought among small scale farmers in Kakamega South Sub-county and accept the H_1 (Alternative hypothesis) that there is evidence of agricultural drought and climate change.

4.5 Effects of Seasonal Agricultural Drought on Crop Production

4.5.1 Effects of Seasonal Agricultural Drought on Crop Production

It was necessary to find out effects of agricultural drought on agricultural produce and the outcome is as shown in Table17 below:

Table 17: Effects of Agricultural Drought on Agricultural Produce

Effects of agricultural drought on agricultural produce	Percentage (%)
No	3.9
Yes	96.1
Total	**100.0**

Table 17 above indicates that majority 96.1% of the respondents agreed that there are effects of agricultural drought on agricultural produce and a few 3.9%of the respondents disagreed with the above statement. An increase in agricultural drought reduces the agricultural produce of the small scale farmers. When there is agricultural drought as we have seen in the evidence of climate change and agricultural drought in objective one in 4.4 above there is increase in atmospheric changes such as reduced rainfall, increased temperature, prolonged drought reduced soil moisture content among others.

As affirmed by Anthony M. (2007) Agricultural drought connects several aspects of a meteorological drought to the effects of drought on agriculture, with a particular emphasis on inadequate precipitation. It refers to the susceptibility of crops to a lack of water at various stages of crop development when the crop is being grown.

4.5.1.1 Social Economic Effects of Agricultural Drought

The study sought to find out the socio-economic effects of agricultural drought among small scale farmers in kakamega South sub-county. The findings were as shown by Tables 18 below indicated that agricultural drought results to depletion of economic resources in the sub-county as most 72.1%strongly agreed while 23.45 agreed with the statement. Only few respondents 2.1% strongly disagreed and 1.3% disagreed with the statement normally agricultural drought results in food shortage due to. Agricultural drought results in low crop yields. Since the crop yields produced will be less that the population required to feed, it will consequently lead to food shortage.

The study sought to find out whether agricultural drought resulted in decrease in crop production. Table 18 indictes that, majority 85.3% of the respondents strongly agreed while 11.8% agreed that agricultural drought results to decrease in crop production. On the other hand few repondents 1.1% strongly disagreed and 0.8% disagreed with the statement.Climate change causes seasonal agricultural drought since it results in reduced water level in the farms, rivers and the water table generally. Due to the high temperatures in the dry season, it makes the rate at which soil looses water to the atmosphere high by evaporation unlike the rate at which the water is being replenished by the rainfalll. This supports Dariush et al., (2010) who states that drought was a problem that consistently affected farming in Iran. As a result, in areas where restocking water was difficult, farmers were forced to cut back on their operations, leading to increased human suffering and lower crop yields.

Table 18: Social Economic Effects of Agricultural Drought

Socio-economic statement	**SD**	**D**	**UN**	**A**	**SA**
Agricultural drought depletes resources	2.11%	1.32%	1.05%	23.42%	72.11%
Agricultural drought decreases crop production	1.05%	0.79%	1.05%	11.84%	85.26%
Agricultural drought lowers GDP/income	1.05%	1.05%	2.63%	14.21%	81.05%
Agricultural drought increases in food prices	2.89%	2.11%	0.26%	9.21%	85.53%
Agricultural drought results to unemployment	1.05%	2.37%	7.63%	26.05%	62.89%
Agricultural drought results to natural disasters	1.32%	1.84%	2.63%	25.00%	69.21%
Agricultural drought decreases vegetation cover	3.42%	1.05%	1.32%	11.05%	83.16%
Agricultural drought reduces water availability	2.37%	1.58%	1.05%	26.32%	68.68%

Most respondents 81.1% strongly agreed and 14.2 % agreed that seasonal agricultural drought leadsto low GDP or income. However few individuals both 1.1% strongly disagreed and disagreed with the statement. As discussed in above, seasonal agricultural drought results in reduce crop production. This makes the farmers to have a deficit in their surplus crops that they would have sold so as to earn an extra income for other activities in the households.

Agricultural drought results in increased food prices as most of the farmers from the findings indicated that 85.5% strongly agreed and 9.2% agreed with the statement. On the other hand a few respondents 2.9% strongly disagreed and 2.1% disagreed with the statement. Once the crop producytion reduces as discussed above , the ration of food supply and consumption will be unbalanced. This will make the prices of food to fluctuate due to high demand and low supply of food crops.For instance, in Vietnam, food prices tend to rise during droughts, and people's dietary standards tend to deteriorate as a result (UNISDR, 2011).

Agricultural drought results to unemployment as most of the respondents 62.9% strongly agreed and 26.1% agreed with the statement.on the other hand oly a few 1.1% strongly dsagreed and 2.4% disagred with the staement.Most small scale farmers do create their own self employmet when they do their agricultural farming.Thus, a degree in crop production as an effect of seasonal agricultural drought makes them to be unemployd as they can't gain any earning from their agricultural produce.This overcomes the fact that many people live on less than $1.25 a day despite the fact that the economy is growing; as a result, the incomes of many households are below the poverty line (World Bank, 2012).

Agricultural drought results to natural disasters such as famine as majority 62.9% and 25.0% agreed with the staement. 1.3% strongly disagreed and 1.8% disagreed withg the statement.this is a consequence of sesonal agricultural drought o crop production. When there is reduces crop production in relaton to the human populatio being feed it causes famine doe to shortage of food.

The study examined wether agricultural drought led to decrease in vegetation cover and the findings are shown in Table 18. Majority of the respondents 83.2% strongly agreed and 11.1 % agreed that agricultural drought resuts ti decrease in vegetation cover. Agricultural drought causes crop wilting due to high rate of evaporation . this in the end may make the vegetative crop cover like maize crops, tress,grass and other vegetation to die if it looses excss water. Repeated evaporatian cause crop wilting makng the the vegetation to be water stressed ad finaly the roots become dry as the soil moisture content reduces.

Agricultural drought results to reduced water availability as majority of the respondents 68.68% stronglt agreed while 2.37% strongly disagreed. Seasonal agricultural drought affects the availability of water in form of rainfall, humidity and ground water which in turn affects the annual maize production produced. This is as a consequence of inaadequate moisture contet in thatmosphere to form rainfall which is supposed to replenish the water in the hyrological system.

4.5.1.2 Summary of Agricultural Drought Effects

Table 19 below, shows the means of the statements in relation to a scale of one to five: 1 represented strongly disagrees, 2 represented agree, 3 represented undecided, 4 represented agree and 5 represented strongly agree. The statement agricultural drought results to depletion of economic resources had a mean of 4.69 and a standard deviation of 0.599.This had the leading mean meaning that most respondents strongly agree with the statement. This was followed by the statement Agricultural drought results to decrease in crop production with a mean of 4.63 and standard deviation of 0.663.

An agricultural drought result to low GDP/income was the third statement with a mean of 4.62 and standard deviation of 0.825. Both statements that said Agricultural drought results to unemployment and Agricultural drought results to reduced water availability had a mean of 4.59.Agricultural drought results to decrease in vegetation cover with a mean of 4.57 was the second least and Agricultural drought results to natural disasters such as famine was the least statement with a mean of 4.36 answered by the respondents.

Table 19: Summary of the Means and Standard Deviation of Agricultural Drought Effects

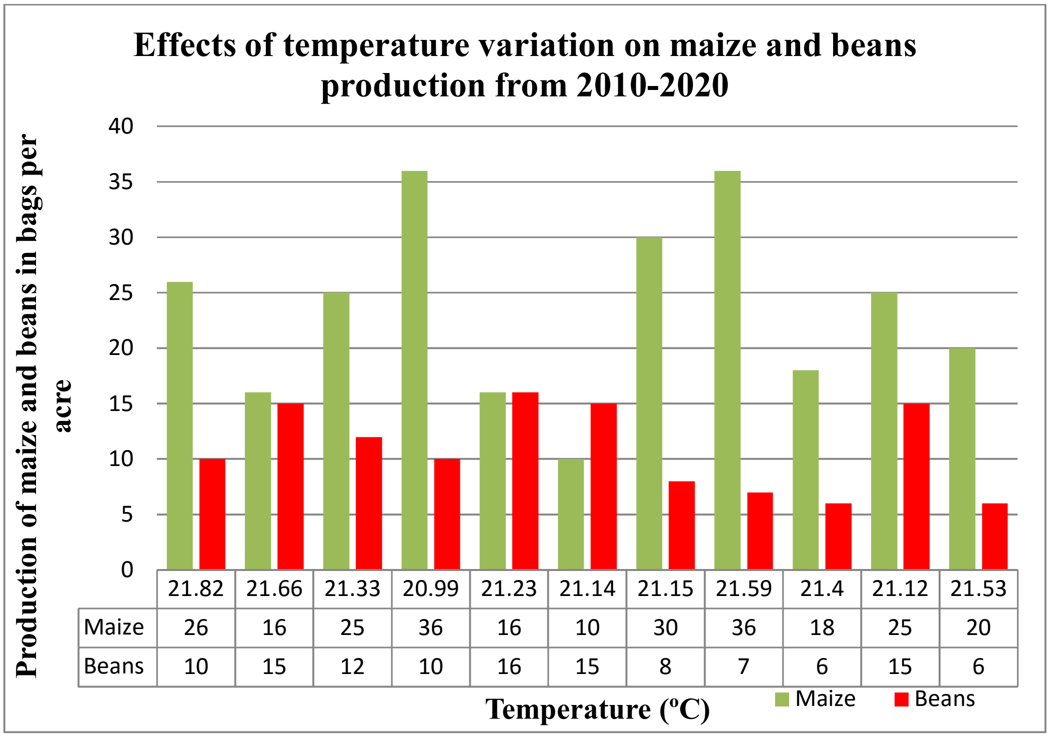
Socio-economic statement	Mean	Standard Deviation
Agricultural drought results to depletion of economic resources	4.69	0.599
Agricultural drought results to decrease in crop production	4.63	0.663
Agricultural drought results to low GDP/income	4.62	0.825
Agricultural drought results to increase in food prices	4.47	0.820
Agricultural drought results to unemployment	4.59	0.751
Agricultural drought results to natural disasters such as famine	4.36	1.039
Agricultural drought results to decrease in vegetation cover	4.57	0.804
Agricultural drought results to reduced water availability	4.59	0.795

These findings point to the fact that future climate change will have an effect on the vast majority of climatic variables (Arnell et.al. 2011). Developments in the economy, the number of people living there, and environmental pollution are to blame (Koutroulis et.al. 2013). Tourism, agricultural output, and biodiversity are only some of the environmental and social factors that could be negatively affected by climate change and pollution's effect on water availability and quality (Olmstead, 2014).The 2011 Somali drought, for example, resulted in a massive humanitarian disaster that more than 10 million people were affected, 2 million of whom were children, and 380,000 refugees ended up in Kenya. (Vicente-Serrano et.al. 2012). One-third of Africa is desertified, and 73% of the continent's farmland is unusable (UNEP, 1992). Extreme environmental stress will result from two or three consecutive seasons of drought in those areas (Lean, 1995).

4.5.3 Effects of Seasonal Agricultural Drought on Crop Production

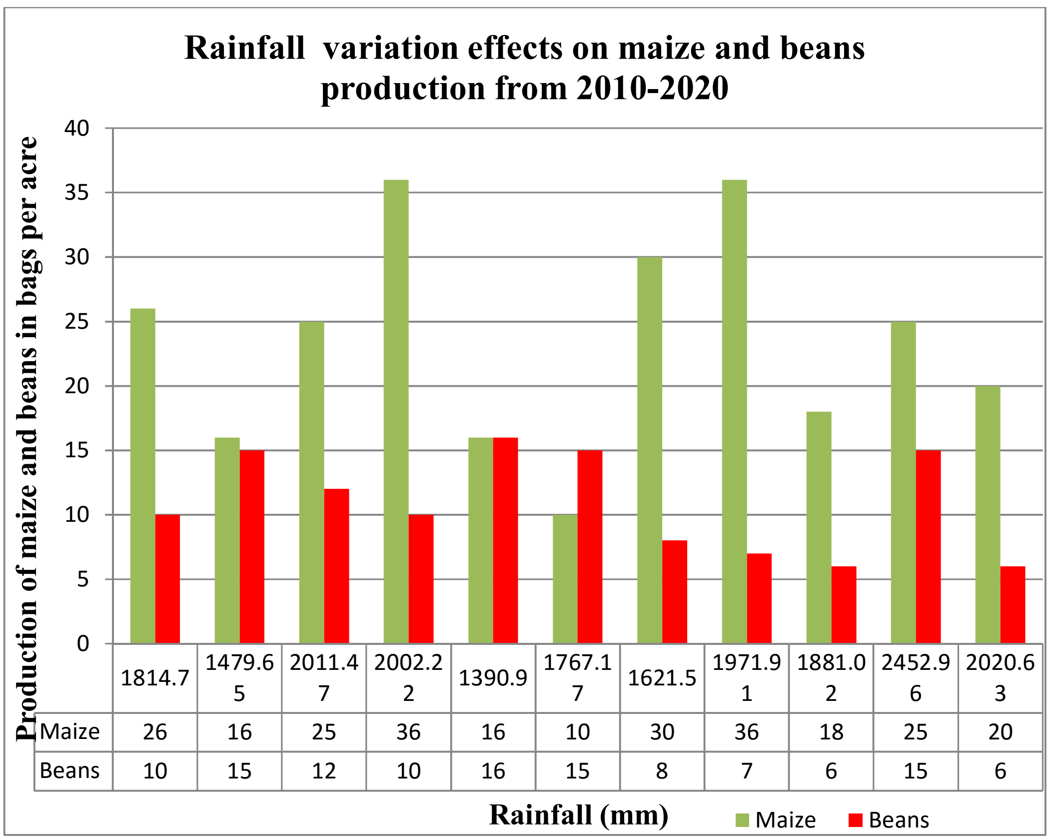
The study correlated the effects of seasonal agricultural drought on small scale farmers' agricultural production in Kakamega South Sub-county. The findings are as shown in figure 4.8, 4.9 and table 33 below.

There was positive correlation between the amount of temperature and the crop production. The higher the temperatures the higher the amount of bags produced in the year. For instance when the temperature was 21.88ºC the number of maize bags produced was 26 and beans 10 bags while when the temperatures were low such as 21.14ºC maize bags produced was 10 and beans 15 bags. This is evidence that the change in temperature from the year 2010 to 2020 indicated that there was change in crop production.



	21.82	21.66	21.33	20.99	21.23	21.14	21.15	21.59	21.4	21.12	21.53
Maize	26	16	25	36	16	10	30	36	18	25	20
Beans	10	15	12	10	16	15	8	7	6	15	6

Figure 4.6: Effects of temperature variation on maize and beans production



	1814.7	1479.65	2011.47	2002.22	1390.9	1767.17	1621.5	1971.91	1881.02	2452.96	2020.63
Maize	26	16	25	36	16	10	30	36	18	25	20
Beans	10	15	12	10	16	15	8	7	6	15	6

Figure 4.7: Effects of rainfall variation on maize and beans production

From the finding there was positive correlation between the amount of rainfall and the crop production. The higher the rainfall the higher the amount of bags produced in the year. For instance when the rainfall was 2020.63 mm the number of maize bags produced was 20 and beans 6 bags while when the rainfall was low such as 1390.9 mm maize bags produced was 16 and beans 16 bags. This is evidence that the change in rainfall from the year 2010 to 2020 indicated that there was change in crop production.

Table 20: Correlation of Effects of Agricultural Drought and Crop Production

Agricultural drought effects		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Decrease in crop production(1)	Pearson Correlation	1							
	Sig. (2-tailed)								
Low income (2)	Pearson Correlation	.539**	1						
	Sig. (2-tailed)	.000							
Increase in food prices (3)	Pearson Correlation	.371**	.467**	1					
	Sig. (2-tailed)	.000	.000						
Unemployment(4)	Pearson Correlation	.161**	.298**	.272**	1				
	Sig. (2-tailed)	.002	.000	.000					
Natural disasters (5)	Pearson Correlation	.193**	.334**	.195**	.291**	1			
	Sig. (2-tailed)	.000	.000	.000	.000				
Decreased vegetation cover(6)	Pearson Correlation	.335**	.244**	.238**	.274**	.355**	1		
	Sig. (2-tailed)	.000	.000	.000	.000	.000			
Reduced water availability(7)	Pearson Correlation	.207**	.285**	.092	.127*	.251**	.527**	1	
	Sig. (2-tailed)	.000	.000	.072	.013	.000	.000		
Economic decline(8)	Pearson Correlation	.245**	.312**	.342**	.346**	.324**	.619**	.499**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	

****. Correlation is significant at the 0.01 level (2-tailed). (n=380)**

Table 20 indicates that, low GDP/income is positively correlated with decrease in crop production ($r = 0.539$, $p < 0.05$). Increase in food prices is positively correlated with decrease in crop production ($r = 0.371, p < 0.05$) and low GDP/income ($r = 0.467, p < 0.05$) .Unemployment is positively correlated with decrease in crop production ($r = 0.161, p < 0.05$), low GDP/income ($r = 0.298, p < 0.05$) and increase in food prices ($r = 0.272, p < 0.05$). Natural disasters is positively correlated with decrease in crop production ($r = 0.193, p < 0.05$), low GDP/income ($r = 0.334, p < 0.05$), increase in food prices ($r = 0.195, p < 0.05$) and unemployment ($r = 0.291, p < 0.05$).

Decrease in vegetation cover is positively correlated with decrease in crop production ($r = 0.335, p < 0.05$), low GDP/income ($r = 0.244, p < 0.05$), increase in food prices ($r = 0.238, p < 0.05$), unemployment ($r = 0.274, p < 0.05$) and natural disaster ($r = 0.355, p < 0.05$). Reduced water availability is positively correlated with decrease in crop production ($r = 0.207, p < 0.05$), low GDP/income ($r = 0.285, p < 0.05$), increase in food prices ($r = 0.092, p < 0.05$), unemployment ($r = 0.127, p < 0.05$), natural disaster ($r = 0.251, p < 0.05$) and decrease in vegetation cover ($r = 0.527, p < 0.05$).

Economic decline is positively correlated with decrease in crop production ($r = 0.245, p < 0.05$) ,low GDP/income ($r = 0.312, p < 0.05$) increase in food prices ($r = 0.342, p < 0.05$), unemployment ($r = 0.346, p < 0.05$) , natural disaster ($r = 0.324, p < 0.05$) ,decrease in vegetation cover ($r = 0.619, p < 0.05$) and reduced water availability ($r = 0.499, p < 0.05$).

From the above summary on the effects of seasonal agricultural drought on small scale famers' agricultural production, it is true that there is correlation. Thus, since p values < 0.05 we reject the Ho that there are no effects of seasonal agricultural drought and challenges facing small scale farmers' agricultural production in Kakamega South Sub-county.

Thus it is evident that Kakamega South sub-county is affected by seasonal drought which is a result of climate change. As much as these effects are there the small scale crop farmers face a lot of challenges as they try to adapt various strategies which can help them adjust to seasonal drought effects. Thus supports the fact that, African countries are particularly vulnerable to climate change because of their dependence on rain fed agriculture, high levels of poverty, low levels of human and physical capital, and poor infrastructure. Moreover, the negative effects of climate change on crop production are especially pronounced in Sub-Saharan Africa, as the agriculture sector accounts for a large share of Gross Domestic Product (GDP) export earnings, and employment (IFPRI, 2009). Thus, without appropriate responses, climate change is likely to constrain economic development and poverty reduction efforts and escalate the already pressing difficulties.

4.6 Adaptation Strategies to Agricultural Drought Effects and Challenges

Developing resilience to high-intensity rainfall and protracted drought spells calls for adaptation to climate change impacts on farming systems. In order to attain food security and raise the level of living in rural regions, better management of land and water resources is essential (ICID, 2001).

4.6.1 Adaptive Water Strategies

Communities that are prone to seasonal agricultural droughts can be made more resilient through adaptive water strategies by adopting or improving land use and farming practises and participating in initiatives that increase water and food security, all of which contribute to the larger goal of reducing poverty.

Developing methods to deal with drought hazards is recommended by the International Strategy for Disaster Reduction (ISDR) (2005). Bouwer (2000) argues that storing water is essential for safeguarding supplies against climate change. This involves putting water to use during drought by storing it during times of plenty. Availability of water for agricultural output relies on a number of factors, including the widespread adoption of water-saving practises like drip irrigation, water recycling and reuse, mulching, and proper land use strategies like ploughing along the contours (across the hill). Thus, evaluating the factors that affect adaptation to climate might serve as a helpful guide for farmers seeking to successfully adapt to changing climatic conditions.

Table 21: Adaptive Water Strategies

	Adaptive Water Strategies	**Number of respondents**	**Rank**
1.	Do nothing	3	0.9
2.	Varying the timing of planting	59	15.4
3.	Applying mulch on cropland	28	7.4
4.	Sowing Drought-Resistant Crop Variety	57	14.9
5.	By implementing new methods of irrigation	25	6.7
6.	Harnessing water from rainfall	26	6.8
7.	Construction of reservoirs to collect rainwater runoff	37	9.6
8.	Erosion control by tree planting	49	12.9
9.	Prepare for the dry season by drilling boreholes or wells	44	11.6
10.	Conservation of water catchment zones	52	13.7
Total		**380**	**100**

Table 21 indicated that most respondents 15.4% saw Changing planting dates very important as a strategy that would help them adjust to seasonal agricultural drought.Planting of drought tolerant crop variety was considered second most imortant as it had 14.9%.Protection of water catchment areas was considered third most important strategy in adapting to seasonal agricultural drought as it had 13.7%.Planting trees to reduce soil erosion was considered the forth most important strategy a it had 12.9%.Dig bore holes/wells to supply water during dry season was considered the fifth most important 11.6% and this ws followed by Water dams/pans for runoff water harvesting as it 9.6%.

4.6.2 Simple adaptation strategies

The study assessed the adaptations that the small scale farmers used to cope with seasonal agricultural drought and the findings were as shown in Table 22 below.

Table 22: Other Adaptation Strategies other than Water Adaptive Strategies

Other adaptation strategies	Percent
Get off farm job	4.5
Growing drought resistant crops	6.6
Changing planting dates	75.0
Reduce the farm size	1.3
Seek agricultural drought information	8.7
Pray to God to intervene	3.9
Total	**100**

Table 22 indicates that majority 75.0% of the respondents agreed that changing planting dates will help them in adapting to seasonal agricultural drought. Others 8.7% agreed that seeking agricultural drought information, growing drought resistant crops 6.6%, getting off farm job 4.5%, pray to God to intervene 3.9%,reducing the farm size 1.3%.All these combined if implement and followed to the later will help the small scale farmers to be less vulnerable to seasonal agricultural drought.

4.6.2 Challenges Facing Small Scale Farmers' Adaptation to Agricultural Drought

According to EEN (2004), the societal characteristics maximize vulnerability to drought. Societal characteristics contribute to the challenges that the small scale farmers do face as they try to adapt and adjust to seasonal agricultural drought. Table 23 displays the results of the study that attempted to identify the difficulties faced by small-scale farmers.

Table 23: Challenge Affecting Small Scale Crop Farmers

Presence of challenge	Percentage (%)
No	4.6
Yes	95.3
Total	**100.0**

Table 23 indicates that there are challenges facing the small scale farmers as they try to adapt to seasonal agricultural drought. Majority of the respondents 95.3% agreed that they faced challenges while 4.6% disagreed with the statement.

4.6.2.1 Types of Challenges

The study sought to find out the type of challenges that small scale farmers do face and Table 24 below shows the findings.

It indicates that majority of the respondents 74.2% were affected by economic challenges, 15.5% faced social challenges while 8.7% were affected by geographical challenges and lastyly 1.6% were affected by political challenges.The bigger proportion of people impacted by economic difficulties acknowledge that asset endowments and wealth significantly influence the ability of small-scale farmers to embrace specific technical techniques(Reardon & Vosti, 1995; Nkonya et.al., 2008; Gbetibouo, 2009).These technological practices are very vital in their adaptation and adjustment to seasonal agricultural droughts and its effects.

Table 24: Challenges Mostly Experienced

Challenges affecting small scale farmers	Percentage (%)
Economic challenges	74.2
Social challenges	15.5
Political challenges	1.6
Geographical challenges	8.7
Total	**100.0**

4.6.2.1 Financial Challenges

This was establishes as is was noted as one of the major factor that determined the capabilities that the farmers had in adapting to effects of seasonal drought or to the random choice that the farmers will choose to use in addressing the issue of seasonal drought effects in their farms.

4.6.2.1.1 Inadequate Land

The size of the farm and the fertility of the soil are two of the agricultural factors that could have an impact on the decision-making process. The size of a farm has an effect on both the availability of resources and the choice to adopt them. This is because these systems are more suited to commercial farms; an increase in crop area is anticipated to increase exposure to information regarding site-specific crop management technology (Marenya & Barrett, 2007; Daberkow & McBride, 2003).

The study sought to find out how the small scale farmers acquired their farms and the finding are as shown in Table 25.Among those surveyed, 96.1% obtained land from their family, 1.6% leased, and 9.1% purchased. Furthermore, the survey found that cereals 83.9%, fruits 15%, and vegetables 1.1% was the most common crops planted in the study area.

Table 25: Inadequate Land

Land acquisition	Percentage (%)	Crop type	Percentage (%)
Owned	96.1	Vegetables	1.1
Rented	1.6	Cereals	83.9
Bought land	2.5	Fruits	15.0
Total	**100.0**		**100.0**

Daberkow and McBride (2003) suggest that since innovation is unpredictable and has fixed costs for transactions and information, there may be a minimum farm size below which smaller farms cannot adapt. This means that large, mechanised farms will be among the pioneers in implementing climate change adaptation strategies, while smaller, less mechanised farms will be among the underperformers.Asfaw et al. (2014) also asserted that the wealth of the farmer improved the probability of sustainable land management technology. Since affluence correlates with farm size, it stands to reason that more expansive farms would benefit from adaptive water management.

This low crop yield can be traced back to the shrinking quantity of arable land as a result of human population growth and other factors. Reduced arable land, rising populations, and shifting climates all pose serious threats to global food security (Kang et al., 2009). Desertification, global warming, unpredictable precipitation, and degraded soil all contribute to lower food yields in rural areas, especially in sub-Saharan Africa (Ngaira, 2007).

4.6.2.1.2 Inadequate Farm Tools

In their study, Knowler and Bradshaw (2007) found that increased household prosperity was associated with increased usage of agricultural technology. Thus, the farm tools possessed by the small scale farmers were found to influence their activities in this study.

Table 26: Farm Tools

Farm asset	Number of respondents	Percentage (%)
Hoe	344	90.5
Machete	262	68.9
Slasher	345	90.8
Water pump	54	14.2
Spade	332	87.4
Rake	110	28.9

Table 26 indicates that majority of the respondents had the basic necessary farm, domestic and vehicle tools and equipment that were very necessary to adapt to seasonal agricultural drought. For instance they had hoes 90.5%, slashers 90.8%, spade 87.4%, wheelbarrow 70.8% and bicycle 64.5%. However, they had less key tools such as water pump 14.2%, knap sprayer 29.2%, tractor 29.0% and lorry 2.6%. This therefore makes the small scale farmers to be very vulnerable to seasonal agricultural drought since they cannot use strategies such as irrigation, water from reservoir or carrying water from other sources to the farms.

This possession of resources can be associated with the income level of the respondents. There is evidence from studies indicating smallholder farmers and resource users will engage in some conservation activities even in the face of faulty credit (Reardon & Vosti 1995; Gbetibouo, 2009). This is due to the fact that investing in cutting-edge tech usually necessitates using money that is either borrowed or already owned. Therefore, efforts to adopt adaptation methods, such as irrigation, terracing, tree planting, and fertilizer use, may be hampered by a lack of financial capacity. Adoption technologies propagate through social networks, according to the studies, rather than due to physical closeness (Maddison, 2006).

4.6.2.2 Geographical Challenges

The study sought to establish the geographical challenges that the crop farmers faced. This was of great role as this determined the extent and financial capabilities of the crop farmers as they were trying to use various water strategies like irrigation, mulching, building of collection water dams. The slope of the land was of great impact as it was cheaper to adapt the strategies if the land was gently sloping and harder if the land was having steep slope or the farm was far away from the source of water for irrigation during dry seasons.

4.6.2.2.1 Inadequate Source of Water for Agricultural Production

The study established the available source of water that the crop farmers could use during dry season to irrigate their crops. The findings were as shown in table 27 below.

Table 27: Source of Water for Agricultural Production

Source of water	Percent (%)
Borehole/wells	6.8
Piped	1.1
Rivers	8.7
Others-Rain	83.4
Total	**100.0**

Table 27 indicates that majority of the respondents had their source of water in the farm being Rain 83.4%,rivers 8.7%, borehole/wells 6.9% and piped water 1.1%. This indicates that any slight change in the climate patterns causing seasonal agricultural drought will greatly affect the respondents crop production.This is support of the argument that,the majority of the Kenyan population is involved in subsistence agriculture which is vulnerable to weather shocks especially the lack of adequate moisture (Irungu et.al., 2009). This is due to the fact that,agriculture in Kenya is mainly rain fed and is practiced by smallholders, hence the need for various coping mechanisms (Macharia et.al., 2010).

4.6.2.2.2 Land Topography

The slope of the land and angle of inclination in relation to the water source was also established. This was of great impact as those farmers who did not have the finical capability were affected or favored by the nature of the land in relation to the source of water for irrigation.

Table 28 indicates that most of the land was fairly flat that is 50.5%, 35.8% was steep, fairly steep was 7.9%, 3.2% was very steep and 2.6% was flat. This was very essential in determining land topography challenges in terms of slope as they try to adapt to seasonal agricultural drought with practices such as irrigation, mulching, building of dams and water storage tanks. Those farmers who had fairly flat land were able to build the water collection dam with ease as the fairly flat land could collect a lot of water for irrigation during rainy season. In contrast, those who had steep land faced a lot of challenges as they had to pump or pull the water upslope to be used for irrigating their crops during dry season.

Table 28: Land Topography

Land topography	Percent (%)
Flat	2.6
Fairly flat	50.5
Fairly steep	7.9
Steep	35.8
Very Steep	3.2
Total	**100.0**

4.6.2.3 Less Land Dedicated to Crop Production

In addition the study sought to find out the land that was dedicated for crop production by the small scale farmers. The findings were as shown by Figure 4.6 below.

Majority of respondents 69.21% owned land measuring 0-5 acres. This was followed by 22.63% who owned 6 to 10 acres, 7.63% who owned 11 to 15 acres and a few 0.53% of small-scale farmers owned above 15 acres of land which was dedicated for crop farming. This is consistent with FAO (2012), which reported that the fragmentation of land holdings continues to reduce the average size of land holdings in various African nations.

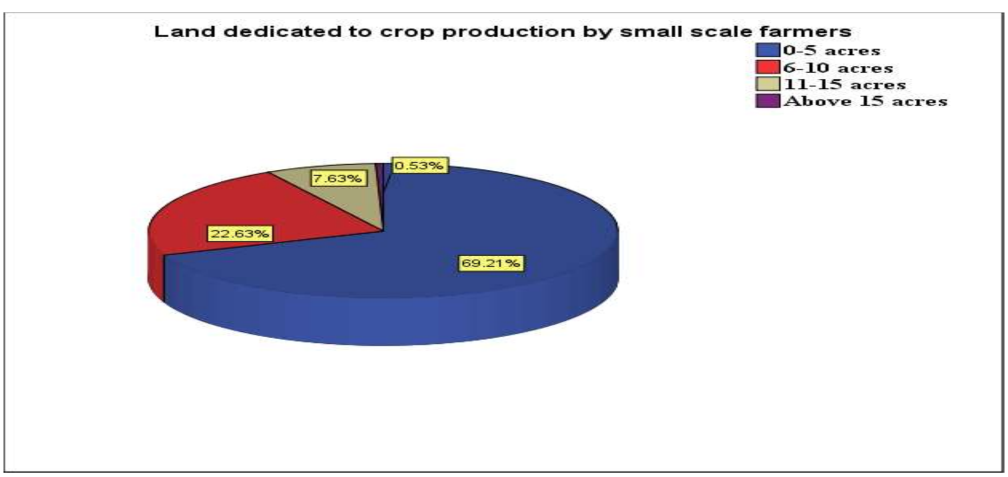


Figure 4.8: Land Dedicated to Crop Production by Respondents

4.6.2.4 Inadequate Irrigation

Deressa et.al. (2009) proposed that farmers will employ Soil and Water Conservation (SWC) to preserve moisture to adapt to rising temperatures, particularly in drier regions. An essential part of adaptive water management is the implementation of soil and water conservation practises. Cover cropping, low tillage, mulching, terracing, soil bund ridges, bench terraces, and grass strips are just a few examples of the many soil and water conservation techniques available.

Table 29: Irrigation

Irrigation method	Percentage (%)
No	86.3
Yes	13.7
Total	**100.0**

Table 29 indicates that a large number of the respondents 86.3% did not practice irrigation of crops during seasonal agricultural drought while a small percentage 13.7% only did irrigation in their farms during this time. This means that a good number of the small scale farmers have not utilized irrigation as one of the adaptation methods in adapting to seasonal agricultural drought. The 2006 Climate Change Convention in Nairobi, Kenya acknowledged rain water harvesting as a viable strategy for meeting the world's growing demand for water and ensuring the continent's resilience to future droughts (Mashood et.al., 2011).

Table 30 indicates that the main source of water for irrigation was rain 87.1%, followed by river 7.9%, well/Borehole 3.4%, constructed ponds/reservoirs 0.8%, spring 0.5%, and lastly pans 0.3%.This means that agricultural drought is a problem when there is climate change as it affects the rainfall pattern and consequently the water necessary for irrigation during seasonal agricultural drought. thus there is need to educate the famers on importance of other alternative methods of adapting to seasonal agricultural drought. This agrees with Nyangena (2007) who maintains that quicker progress can be made if farmers in Kenya are encouraged to use soil and water conservation techniques.

Table 30: The Source of Water for Irrigation

Source of irrigation water	**Percent**
River	7.9
Constructed ponds/reservoirs	0.8
Well/Borehole	3.4
Spring	0.5
Rain	87.1
Pans	0.3
Total	**100.0**

4.6.2.3 Social Challenges

4.6.2.3.1 Membership to Agricultural Group

Table 31: Membership to agricultural group

Membership to agricultural group	**Percentage (%)**
No	41.1
Yes	58.9
Total	**100.0**

The purpose of this research was to see if farmer groups can help their members adapt to climate change and how that would affect their approach to adaptive water management.Table 31 above shows the finding.

Table 31 indicates that majority of the respondents 58.9 % belonged to agricultural groups while 41.1% were none members. It is more likely that adaption strategies will be used if people have better access to formal and informal institutions and weather forecasting tools. Access to institutional extension services, farmer-to-farmer extension, and knowledge about future climate change increases the chances that households will improve their farming practises in response to climate change. (Smit et.al., 2001; Mariara & Karanja 2007). Having easier access to knowledge through extension is related to a greater propensity to recognise and respond to climate change (Deressa et.al., 2009; Nhemachena & Hassan, 2007).

4.6.2.3.2 Type of Group

Table 32 indicates that most of the agricultural groups that the respondents belong to are Self-help group 52.9%, Savings and Credit Association are 28.7%, Church group were 10.3%, and Women group were 8.2%.

Table 32: Type of Group

Type of Group (if yes) above	Percent
Self-help group	52.9
Women group	8.2
Savings and Credit Association	28.7
Church group	10.3
Total	**100.0**

The study found that farmers who were part of a group were better able to adjust to climate change and had a more flexible water management plan. For instance, Adger (2003) found that communities with high levels of social capital were better equipped to weather the effects of extreme weather.

Researchers have found that farmers who are part of a group are more likely to notice and respond to climate change (Deressa et al., 2009; Nyangena, 2007). Individual farmers may have trouble obtaining credit, but a group of farmers can help by providing informal saving and credit services and a forum for the sharing of farming knowledge and resources.

4.6.2.3.3 The Activities of Group

As indicated in Table 33 below the group activities that the respondents belonged to were marketing 42.5% , merry-go-round were 15.5%,both saving and credit was 14.5%,welfare 12.6% were,credit were 9.5% and savings was 5.5%. This indicates that the groups facilitated various activities such as marketing,capital provision ,credit savings and welfare services which are very essential for the finances needed by the smalll scale farmers to adapt to seasonal agricultural drought.

Table 33: The Activities of Group

Activities of the group	**Percent**
Marketing	42.5
Merry-go-round	15.5
Credit	9.5
Savings	5.5
Welfare	12.6

Both saving and credit	14.5
Total	**100.0**

Those with more disposable income and assets are more likely to try out innovative farming techniques than those with a lower standard of living (Shiferaw & Holden, 1998). Variables like the wealth index, annual income for a household of the same size as a farm, and availability of credit will stand in for the availability of economic resources. More readily available capital allows farmers to purchase the inputs essential for implementing adaptive water management strategies. Therefore, farmers who have more means to do so are more likely to have the many technology and water strategies at their disposal that are essential to coping with seasonal agricultural drought.

4.6.2.3.4 Inadequate Contact with Agricultural Extension Officer

The study sought to establish the period and regularity of the contact between the agricultural officers and the small scale farmers and the findings were as illustrated in Table 34.

Table 34: Contact with Agricultural Extension Officer

Contact	Percent	Last time of contact	Percentage (%)
No	80.8	2000-2010	81.8
Yes	19.2	2010-2020	18.2
Total	**100.0**	**Total**	**100.0**

Table 34 indicates that majority of the respondents 80.8% have not contacted the agricultural officers from the year 2000 to 2010 with a larger population of 81.8% while a small proportion of 19.2% have contacted the agricultural officers from the year 2010 to 2020 with 18.2% of the total population. This means the majority of the small scale farmers do not have enough information on current agricultural strategies necessary for the adaptation of seasonal agricultural drought in kakamega South sub-county. Farmers' ability to adapt to climate change would improve if they had better access to knowledge about the topic (Bradshaw et.al. 2004). Future extension agents could benefit from involving farmer cooperatives in the testing and demonstration processes through on-farm experiments and research. Since it is difficult for the government to provide extension services due to the inevitable heterogeneity of agricultural situations, trained farmers are able to spread the adoption of new technologies (Pannell, 1999). In this context, "social capital" refers to the study's conceptualization of the underlying resources present in social ties that have the potential to strengthen collective action. Social capital will be measured in terms of farmers' association membership.

4.6.2.3.5 Inadequate Sources of Agricultural Information

The study set to find out how the small scale famers accessed information concerning adaptation to seasonal agricultural drought and the findings were as shown in Table 35 below.

Table 35: Sources of Information to Respondents

Sources of information to the respondents	Number of respondents	Rank
Agricultural extension officers	6	1.57
Television	50	13.06
Radio	83	21.73
Farmers' own experience	97	25.50
Fellow farmers	85	22.26
Phone (What's up, short messages or calls)	60	15.88
Total	**380**	**100**

It was anticipated that farmers' ability to adjust to the effects of climate change would be influenced by their access to information. Table 35 shows that majority 64.4% of the respondents received agricultural information through their own experience while 56% received through fellow farmers and 54% from radio, 40% through their phones, 32.9% through television, and 3.2% through agricultural officer. Having easier access to weather reports through the media increased the possibility that farmers would make adjustments in response to changing weather patterns. One of the key informants said that small-scale farmers who have access to information on the effects of climate change are more likely to adapt to climate change than those who do not.

It is consistent with the findings that better access to official and informal institutions, as well as improved meteorological capability, increases the likelihood that adaption strategies will be implemented. Households are more likely to adapt their farming methods to climate change if they have access to agricultural extension from institutions, farmer-to-farmer exchanges, and projections of future climatic change (Smith et al., 2001; Mariara & Karanja 2007). Having easier access to knowledge through extension is related to a greater propensity to recognize and respond to climate change (Deressa et.al., 2009; Nhemachena & Hassan, 2007).Farmers' perspectives of climate change would be enhanced if they had access to more knowledge about climate change (Bradshaw et.al. 2004).

4.6.3 Correlation of Adaptation Strategies and Challenges in Kakamega South Sub-county.

The relationship between the adaptation strategies of seasonal drought and challenges faced by small scale crop farmers was established and the finding are as discussed below.

Table 36: Correlation of Adaptation Strategies Adopted and Challenges faced

Adaptive Water Strategies		Effects of agricultural drought on agricultural produce	Challenges affecting crop production
Protection of water catchment areas	Pearson Correlation	.176**	-.239**
	Sig. (2-tailed)	.001	.000
Dig bore holes/wells to supply water during dry season	Pearson Correlation	.190**	-.072
	Sig. (2-tailed)	.000	.164
Planting trees to reduce soil erosion	Pearson Correlation	.058	-.279**
	Sig. (2-tailed)	.258	.000
Water dams/pans for runoff water harvesting	Pearson Correlation	.171**	-.126*
	Sig. (2-tailed)	.001	.014
Rain water harvesting	Pearson Correlation	.141**	-.100
	Sig. (2-tailed)	.006	.050
Introducing improved irrigation (water efficiency)	Pearson Correlation	.167**	.013
	Sig. (2-tailed)	.001	.806
Planting of drought tolerant crop variety	Pearson Correlation	.083	-.328**
	Sig. (2-tailed)	.107	.000
Mulching of crops to reduce water loss	Pearson Correlation	.082	-.113*
	Sig. (2-tailed)	.112	.027
	Sig. (2-tailed)	.889	.000
Do nothing	Pearson Correlation	-.089	.216**
	Sig. (2-tailed)	.083	.000

***. Correlation is significant at the 0.05 level (2-tailed).(n=380)**

Rain water harvesting is positively correlated with Effects of agricultural drought on agricultural produce ($r = 0.141$, $p < 0.05$). Introducing improved irrigation (water efficiency) is positively correlated with effects of agricultural drought on agricultural produce ($r = 0.167$, $p < 0.05$). Planting of drought tolerant crop variety is negatively correlated with challenges affecting crop production ($r = -0.328$, $p < 0.05$).Mulching of crops to reduce water loss is negatively correlated challenges affecting crop production ($r = -0.113$, $p < 0.05$).Doing nothing is positively correlated with challenges affecting crop production ($r = .216$, $p < 0.05$).

The study findings concurs with the research that the first step in adapting to climate change is being aware of the shift, followed by the second step of determining whether or not to make any changes (Maddison, 2006). The farmers can choose an adaptation method in relation to their financial, social and geographical abilities and capabilities so as to mitigate the effects of climate change and agricultural drought.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This section entails the summary of the major findings and the findings on the four objectives as well as the conclusion and summaries drawn from the study and the recommendations made.

5.2 Summary of Major Findings

The main objective of this study was to establish adaptive strategies to agricultural drought effects on small scale crop production in Kakamega South Sub-county. From the findings majority 75.0% of the respondents agreed that changing planting dates will help them in adapting to seasonal agricultural drought. Others 8.7% agreed that seeking agricultural drought information, growing drought resistant crops 6.6%, getting off farm job 4.5%, pray to God to intervene 3.9%, reducing the farm size 1.3%.All these combined if implement and followed to the later will help the small scale farmers to be less vulnerable to seasonal agricultural drought effects.

5.2.1 Climate Change and Agricultural Drought in Kakamega South Sub-county.

The findings indicated that there was evidence of climate change and agricultural drought in kakamega South sub-county. There was a positive linear trend in annual mean precipitation as from 1985 to 2020 and a regression coefficient of 15.16.The coefficient of determination (R^2) of the annual precipitation is 0.3693 which implies 34.0 % of variation in precipitation amounts over period in time (1985-2020). This implies that as the years went by, the annual mean precipitation increased and for every additional year, the annual mean precipitation increased by 15.16 mm. This prediction shows that there is likely to be an increase in annual mean precipitation in the future years in the area.

There was a positive linear trend in annual mean temperature as from 1985 to 2020 as and a regression coefficient of 0.0208.The coefficient of determination (R^2) of the annual temperature is 0.4259 which implies 42.6 % of variation in temperature amounts over period in time (1985-2020). This implies that as the years went by, the annual mean temperature increased and for every additional year, the annual mean temperature increased by 0.02 ºC. This prediction shows that there is likely to be an increase in annual mean temperature in the future years in the area.

From the above summary, it is evidence that there is relationship between Climate Change and Seasonal Agricultural Drought among small scale farmers. Thus, since p values of th discused variables are < 0.05 we reject the Ho (Null hypothesis) that there is no relationship between Climate Change and agricultural drought among small scale farmers in Kakamega South Sub-county and accept the H_1 (Alternative hypothesis) that there is positive relationship between agricultural drought and climate change.

5.2.2 Agricultural Drought Effects on Crop Production in Kakamega South Sub-county.

Majority 96.1% of the respondents agreed that there are effects of seasonal drought on crop produce and a few 3.9% of the respondents disagreed with the above statement. An increase in agricultural drought reduces the agricultural produce of the small scale farmers. When there is agricultural drought as we have seen in the evidence of climate change and agricultural drought in objective one in 4.5 above there is increase in atmospheric changes such as reduced rainfall, increased temperature, and prolonged drought reduced soil moisture content among others. This supports Dariush et.al. (2010) who states that drought was a problem that consistently affected farming in Iran. As a result, in areas where restocking water was difficult, farmers were forced to reduce their operations, leading to increased human suffering and lower crop yields.

Economic decline is positively correlated with decrease in crop production ($r = 0.245$, $p < 0.05$) ,low GDP/income ($r = 0.312$, $p < 0.05$) increase in food prices ($r = 0.342$, $p < 0.05$), unemployment ($r = 0.346$, $p < 0.05$) , natural disaster ($r = 0.324$, $p < 0.05$) ,decrease in vegetation cover ($r = 0.619$, $p < 0.05$) and reduced water availability ($r = 0.499$, $p < 0.05$).

From the above summary on the effects of seasonal agricultural drought on small scale famers' agricultural production, it is true that there is correlation. Thus, since p values < 0.05 we reject the Ho that there are no effects of seasonal agricultural drought on small scale farmers' agricultural production in Kakamega South Sub-county.

5.2.3 Adaptation Strategies to Seasonal Agricultural Drought Effects and Challenges Faced in Kakamega South Sub-county.

The findings established that most respondents15.4% saw changing planting dates very important as a strategy that would help them adjust to seasonal agricultural drought. Planting of drought tolerant crop variety was considered second most important as it had 14.9%.Protection of water catchment areas was considered third most important strategy in adapting to seasonal agricultural drought as it had 13.7%.Planting trees to reduce soil erosion was considered the fourth most important strategy it had 12.9%.Diggging bore holes/wells to supply water during dry season was considered the fifth most important 11.6% and this was followed by Water dams/pans for runoff water harvesting as it 9.6%.

Majority of the respondents 74.2% were affected by economic challenges, 15.5% faced social challenges while 8.7% were affected by geographical challenges and lastly 1.6% were affected by political challenges. The bigger proportion of people impacted by economic difficulties agree that small-scale farmers' asset endowments and wealth significantly affect their ability to embrace specific technical techniques (Reardon & Vosti, 1995; Nkonya et al., 2008; Gbetibouo, 2009).

5.3 Conclusion

In conclusion, this study established that most small-scale farmers acknowledged the presence of periodic agricultural drought, as evidenced by a variation in precipitation and an accompanying rise in temperature. Crop failure, insufficient forage, skyrocketing food costs, widespread hunger, and record unemployment were the direct effects.

Farmers in the Kakamega South sub-County acknowledged that there is evidence of climate change and agricultural drought. They are aware that temperatures are rising and rainfall are becoming less reliable and shorter in duration from 1985 to 2020.This was established by comparing the crop production of maize and beans in relation to the temperature and rainfall cchange a period of 35 years.

Crop production in Kakamega South sub-County is affected as temperatures are rising and rainfall are becoming less reliable and shorter in duration because they have access to data on the impacts of seasonal agricultural drought. Crop failure, greater poverty, livestock health issues, and seasonal droughts are all consequences.

This demonstrates that small-scale crop production is affected by agricultural drought effects which results from climate change. These effects of agricultural drought can be managed by farmers implementing the various adaptation strategies established and suggested in the study.Farmers in the Kakamega South sub-county can benefit from these findings in any strategy, plan, or policy that seeks to improve their ability to adapt to changing climatic conditions.

5.4 Recommendations

Based on the above conclusion, the study gave the following recommendations:

i) In order to improve the sustainability of agricultural production in the Kakamega South sub-county, it is necessary to use drip irrigation, rainwater collecting (including roof water and floods collection), and green house techniques in addition to the traditional method of farming, which relies on rain. Most rivers in the Kakamega South sub-county may be traced back to water catchment regions, which should be repaired using native trees like bamboo. This is due to the fact that sub-Saharan African farmers' ability to provide for their families through rain-fed agriculture is threatened by the rising influence of climate unpredictability on ecosystems, as predicted by experts.

ii) The Kenya Meteorological Department and the Ministry of Agriculture should work together to provide farmers with up-to-date weather forecasts and warnings that are based on their specific locations and operations. Farmers will then be able to plan when, what, and how much to plant based on the quantity of precipitation they anticipate receiving. Brochures, fliers, and local radio are just some of the many possible outlets for disseminating this data.

iii) Farmers should have the autonomy to implement the suggested adaptation measures. Adaptive techniques can help minimize farmers' susceptibility, and the government and civil society should offer resources like financial aid and technical assistance to farmers so they can apply these strategies. Despite the fact that these studies highlight the need for farmers in semi-arid regions to adapt their methods to a changing climate, they rarely pinpoint techniques that are unique to the region's production system and individual farms. For instance, in regions where rainfall is consistent throughout the year, the phenomenon of agricultural dryness during specific seasons has received less attention from researchers.

5.5 Areas for Further Research

The study proposes the following as areas for further research:

i) Research should be conducted focusing on reducing farmers' vulnerability by offering financial support in form of loans.

ii) Research should be conducted to assess other cheaper strategies in adaptation to climate change like use of solar water pumping and use of green houses.

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https://articles.extension.org/pages/64792/what-is-agricultural-drought

APPENDICES

Appendix I: Letter of introduction

Chelangat Winnie

P. O Box 1734-50100,

Kakamega.

Dear Sir/Madam

REF: PARTICIPATION IN RESEARCH

I am a postgraduate student pursuing Master's Degree of Arts in Geography in Masinde University of Science and Technology. My study is focusing on the adaptation strategies for small scale farmers to seasonal agricultural drought in Kakamega South Sub-County, Kenya.

I respectfully request access to your ward in order to collect crucial data for my research. The respondent's identity will be kept strictly confidential and will not be revealed without cause. All data collected will be used exclusively for the purpose of this research.

Your help and cooperation are much appreciated.

Yours Faithfully,

…………………

Chelangat Winnie

Appendix II: Respondents Informed Consent

Dear Respondent,

Re: Data on Adaptive Strategies to Seasonal Drought Effects on Small Scale Crop Production in Kakamega South Sub-County, Kakamega County, Kenya.

My Name is Chelangat Winnie a student of Masinde University of Science and Technology, undertaking a Master's Degree of Arts in Geography. As part of my Master Degree proposal, I am conducting research on the aforementioned topic and would really value your thoughts and input. All data collected will be kept in strict confidence and used solely for scientific research.

It is my sincere hope that you would be able to provide me with the necessary data for my study. All information regarding your identify will be kept strictly confidential. Such data will be kept confidential and used for the sole purpose of this research.

Your assistance and cooperation will be greatly appreciated. Please confirm that you are in agreement with the researcher to provide the needed information willingly by signing below. Thank you.

Yours respondent,

…………………

Appendix III: Questionnaires

Dear Respondent,

Re: Questionnaire on the adaptation strategies for small scale farmers to agricultural drought in Kakamega South Sub-County, Kenya.

My Name is Chelangat Winnie a student of Masinde University of Science and Technology, undertaking a Master's Degree of Arts in Geography. As part of my Master's degree proposal, I am conducting research on the aforementioned topic; Your comments are much valued. The data will only be used for academic and scholarly reasons. For further information on how to submit a completely filled-out questionnaire, you write to winniechelakigen@gmail.com or call 0725058268.

Questionnaire identification

Enumerator's code:……………Date of the interview:…………………

Ward:………………Location:…………Sub-location:…………Village:……………

Section A: Demographic information of respondents

1. What is your gender? (a) Male [ ] (b) Female [ ]
2. What is your age? (a) 15-25 years [ ] (b) 26-36 years [ ] (c) 37-47years [ ]

   (d) 48-58 years [ ] (e) 57 & above [ ]
3. What is your highest education level? (a)No schooling [ ] (b) Primary Level [ ] (c) Secondary Level [ ] (d) Tertiary level [ ]
4. Are you employed? (a) Yes [ ] (b) No [ ]

5. 5. Please specify your marital status? 01 = Single, 02 = Married, 03 = Divorced/Separated, 04 = Widow/ Widower, 5 = No answer, 6 = Don't know…………….

6. How many children do you have? Record exact number……………………………..

7. Are there other people that you support in your household?

   (a) Yes [ ] (b) No [ ]

8. How many individuals reside in your home?

   a.) 1-5 people [ ] b.) 6-10 people [ ] c.) 11-15 people [ ] d.) 16-20 people [ ]

   e.) Above 21 people [ ]

9. Agricultural production information

   i. Are you a full-time farmer? (a) Yes [ ] (b) No [ ] (c) Part-time farmer [ ]

   ii. What form of agriculture do you practice?

   (a) Irrigated farming [ ] (b) Rain-fed farming [ ] (c) Livestock [ ] (d) Mixed-farming [ ]

Section B: Evidence of Climate Change and Seasonal Drought

1. Please answer the following statements by ticking the following **SD- Strongly Disagree, D-Disagree, UD-Undecided, A-Agree, SA-Strongly Agree**

No.	**Statement**	**SD**	**D**	**UD**	**A**	**SA**
		1	**2**	**3**	**4**	**5**

1.	Water sources at farm level have been affected by climate change					
2.	There is an increased incidence for crop wilting					
3.	Increased long period of dry season annually is experienced					
4.	There is decrease in crop yield due to rainfall shortage					
5.	Volume of water in streams/ rivers during dry seasons reduces					
6.	Increase in population cause climate change					
7.	Population increase affects agricultural produce by increasing climate change					

2. Provide the following data on rainfall amount and crop production in bags per acre

YEAR	**VARIABLE**		
	Rainfall Amount (in mm)	**Beans Production Amount (in bags)**	**Maize Production Amount (in bags)**
2010			
2011			
2012			
2013			
2014			
2015			
2016			
2017			
2018			
2019			
2020			

Section C: Effects of agricultural drought on agricultural produce of small scale farmers

1. Are there effects of agricultural drought on Agricultural produce?

   a.) No[ ] b) Yes [ ]

2. Please answer the following statements by ticking the following: **SD-Strongly Disagree, D-Disagree, UD-Undecided, A-Agree, SA-Strongly Agree**

NO.	**Social economic effects of agricultural drought**	**SD**	**D**	**UD**	**A**	**SA**
		1	**2**	**3**	**4**	**5**
1.	Agricultural Drought results to depletion of economic resources.					
2.	Agricultural Drought results to decrease in crop production.					
3.	Agricultural Drought results to poverty due to low GDP/income.					
4.	Agricultural Drought results to increase in food prices.					
5.	Agricultural Drought results to unemployment.					
8.	Agricultural Drought results to natural disasters such as famine.					
9.	Agricultural Drought results to refugee crisis and internal migration.					
10.	Agricultural Drought results to decrease in vegetation cover.					
11.	Agricultural Drought results to reduced water availability and accessibility.					

12.	Agricultural Drought results to economic decline in the sub-county and country at large.					

1. Which crops do you grow mainly? *(Tick either **No(1) or Yes (2)**)*

No.	Crop	No	Yes
a)	Maize		
b)	Beans		
c)	Vegetables		
d)	Sorghum		
e)	Sweet potatoes		
f)	Cassava		
g)	Sugar cane		
h)	Yams		
i)	Fruits		
j)	Tea		
k)	Arrow roots		
l)	Maize		
m)	Beans		
n)	Vegetables		
o)	Sorghum		
p)	Sweet potatoes		
q)	Cassava		
r)	Sugar cane		
s)	Yams		

t)	Fruits		
u)	Tea		
v)	Arrow roots		

Section D: Challenges small scale farmers face as they adapt to seasonal agricultural drought in Kakamega South Sub-county

1. Do you experience any challenge in the process of adjusting to seasonal Agricultural Drought? a.) Yes [ ] b. No [ ]

2. Which challenge affects you mostly?

a.) Economic challenges [ ] b.)Social challenges [ ] c.) Political challenges [ ]

d.) Geographical challenges [ ]

3. Answer the following questions in **section A to C** below:

A.) LAND OWNERSHIP

1. Answer the following questions by filling in your response below.

No.	**Variable**	**Code**	**Response**
1.	How is land acquired? (Acres)	1=Owned, 2= Rented, 3 Communal land.	
2.	What is the most important source of water for agriculture?	1=Borehole, 2= well,3=Tank 4=Piped 5=River6=Others(specify	

3.	What is the distance to the nearest water source from the farm? (km)	1=1-5, 2= 6-10, 3=11-15, 4=16-20 5=21-24 ,6=Above 25	
4.	What is the distance to the main produce and input market from the farm? (km)	1=1-5, 2= 6-10, 3=11-15, 4=16-20 5=21-24 ,6=Above 25	
5.	What is the distance to the nearest tarmac road from the farm? (Km)	1=1-5, 2= 6-10, 3=11-15, 4=16-20 5=21-24 ,6=Above 25	
6.	The enumerator should describe the topography of the land cultivated.	0=flat 1= fairly flat 3 = fairly steep 4 = steep 5 = very steep	

B.) HOUSEHOLD ASSETS

1. Name the Asset that you own. **(1=No, 2= Yes) Number your response.**

	HOUSEHOLD ASSETS OWENED			**Response**		
NO.	**A. FARM**	**B. DOMESTIC**	**C. VEHICLE**	**A**	**B**	**C**
1.	Hoe	Knapsack sprayer	Tractor			
2.	Machete	Wheelbarrow	Motorbike/Motorcycles			
3.	Slashed	Push cart (Mkokoteni)	Pick-up/Car/Lorry/Taxi			
4.	Water pump	Solar panel	Bicycles			
5.	Spade/shovel	Ox-plough				

6.	Rake					
7.	Water pump					

2. How many years have you done agriculture? (a)1-5 years [ ] (b) 6-10 years [ ] (c) 11-15years [ ] (d) 16-20 years [ ] (e) 21 and above [ ]
3. What is total land owned? a.) 0-5 Acres [ ] b.) 6-10 Acres [ ] c.) 11-15 Acres [ ] d.) Above 15 Acres
4. How much land is dedicated to crop production? a.)0-5 Acres [ ] b.) 6-10 Acres [ ] c.) 11-15 Acres [ ] d.) Above 15 Acres
5. What are your sources of knowledge about agriculture and climate change? Please Rank the sources on a scale of 1-5 by ticking in the appropriate box.

(**Rank (*1= Not at all important 2= Not important 3= Average 4= Important 5=Very important***).

NO.	Source of information	1	2	3	4	5
1.	Agricultural extension officers					
2.	Television					
3.	Radio					
4.	Farmers' personal knowledge					
5.	Fellow farmers					
6.	Phone (What's up, short message, calls)					

C.)INSTITUTIONAL FACTORS

1. Are you a part of an agricultural organization? a) Yes [ ] b) No [ ]

2. What type of an agricultural group ***(if yes)?*** a) Self-help group [ ] b) Women group [ ] c) Saving and Credit Association [ ] d) Church group [ ]

3. What kinds of activities does the group participate in?

a.)Marketing [ ] b) Merry go round [ ] c) Credit [ ] d) Savings [ ] e) Welfare [ ]

4. Have you interacted with an extension agent during the past three years?

a) Yes [ ] b) No [ ]

5. If yes in 4, state when was the last contact (name the year)……………………………

Section E: Adaptation strategies of agricultural drought that needs to be put in place Kakamega South Sub-county

1. What impact, if any, does climate change have on water availability for your agricultural production on an annual basis, given the concerns voiced earlier? a.)Yes [ ] b) No [ ]
2. Do small-scale farmers benefit from training in agriculture to help them cope with seasonal agricultural drought?(a) Yes [ ] (b) No [ ]
3. To the extent that changes in water availability have impacted agricultural output and your capacity to make a living, how would you grade the following techniques your family has used to adapt with seasonal agricultural drought in last the 10 years according to their importance? Tick the appropriate box.

Adaptive Water Strategies	**Rank** ***(1= Not at all important 2= Not important 3= Average 4= Important 5=Very important***				
	1	**2**	**3**	**4**	**5**
1.Do Nothing					
2. Changing planting dates					
3.Mulching of crops to reduce water loss					
4. Planting of drought tolerant crop variety					
5.Introduced improved irrigation (water efficiency)					
6. Rain water harvesting					
7.Water dams/pans for runoff water harvesting					
8. Plant trees to reduce soil erosion					
9. Dig bore holes/wells to supply water during dry seasons					
10. Protection of water catchment areas					

ii)Others, specify…………………………………………………………………………

3. i) Do you irrigate your crops in the farm? a) Yes [ ] b) No [ ]

ii) If yes, where does irrigation water come from? a) River [ ] b) Stream [ ] c) Constructed pond/reservoir/pans [ ] d) Well/borehole [ ] e) Spring [ ]

4. What method of irrigation do you employ?

a) Sprinkler [ ]   b) Drip [ ] c) Furrow [   ] d) Flood [   ]

5. What additional adaptation methods besides water adaptation strategies has your home adopted?

a.) Leave your farm work b) Purchase weather index insurance c.) Changing planting dates [ ] d.) Reduce the size of the farm (.) Seeking climate-related data [ ] f.) Beseech God [ ] g.) Other (details)………………………………

THANK YOU FOR YOUR COOPERATION

Appendix IV: Interview schedules

AGRICULTURAL OFFICERS INTERVIEW SCHEDULE

1. Do you normally visit farmers to provide agricultural training requirements?

   (a) Yes [ ] (b) No [ ]

2. How regularly do you train farmers on climate change effects on agricultural produce?

   a) Weekly [ ] b) Monthly [ ] c) Annually [ ]

3. Is there relationship between climate change, water resources, agriculture and population? (a) Yes [ ] (b) No [ ]

4. If yes, briefly explain the relationship:

i. Between climate change and water resources in terms of agricultural production;

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………

ii. Between population increase and agriculture in terms of agricultural land coverage;

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………….

iii. Between water resources and agriculture in terms of agricultural production ;

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………..

5. Is climate change affecting agricultural production? (a) Yes [ ] (b) No [ ]

6. If yes, state how climate change affects agricultural production.

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7. Do farmers face challenges as they try to adapt to seasonal agricultural drought?

(a) Yes [ ] (b) No [ ]

8. If yes, what are some of the challenges that farmers face as they try to adapt to seasonal agricultural drought?

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………

9. Has the ministry of agriculture been providing support to help you educate/train farmers on how to adapt to seasonal agricultural drought? (a) Yes [ ] (b) No [ ]

10. If yes, how has it been supporting your services?

i. …………………………………………………………………………………………

…………………………………………………………………………………………

………………

ii. …………………………………………………………………………………………

…………………………………………………………………………………………

…

iii. …………………………………………………………………………………………

…………………………………………………………………………………………

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iv. …………………………………………………………………………………………

…………………………………………………………………………………………

……

11. Name any other organization that has been supporting programs on training farmers to how to adapt to seasonal agricultural drought and cope with climate change effects?

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………

12. Explain the kind of support that has been offered by the organization mentioned above:

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………

13. Which adaptation measures are most farmers using to adapt to seasonal agricultural drought?

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………

14. Name the adaptation measures that you recommend farmers to use so as to adapt to seasonal agricultural drought and climate change.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

THANK YOU FOR YOUR COOPERATION.

CROP SELLERS INTERVIEW SCHEDULE

1. In your own view what do you think causes agricultural drought?

   ....

2. Have agricultural drought affected your business?

   ……………………………………………………………………………………

   ……………………………………………………………………………………

   ……………………………………………………………………………………

3. Do you think climate change is the cause behind prolonged and unpredictable seasonal agricultural drought?

   ……………………………………………………………………………………

   ……………………………………………………………………………………

   ……………………………………………………………………………………

4. Name the challenges that farmers have been facing as they try to adapt to seasonal agricultural drought.

   ……………………………………………………………………………………

   ……………………………………………………………………………………

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   ……………………………………………………………………………………

   ……………………………………………………………………………………

5. Do agricultural products become expensive during seasonal droughts?

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

6. Is there ready market for your agricultural products during seasonal agricultural drought?

   …………………………………………………………………………………

   …………………………………………………………………………………

   …………………………………………………………………………………

7. Do most of your customers have inadequate agricultural products during seasonal drought?

   …………………………………………………………………………………

   …………………………………………………………………………………

   …………………………………………………………………………………

8. Is there shortage of agricultural products during agricultural drought?

   …………………………………………………………………………………

   …………………………………………………………………………………

   …………………………………………………………………………………

9. Has agricultural drought affected your daily income and livelihood?

   …………………………………………………………………………………

   …………………………………………………………………………………

   …………………………………………………………………………………

10. How has agricultural drought affected your economic activities?

    …………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

11. How has agricultural drought affected your social life?

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

12. What do you think are some of the recommend measures that the farmers should take in order to adapt to seasonal agricultural drought?

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

THANK YOU FOR YOUR COOPERATION

Appendix V: Map of the study area

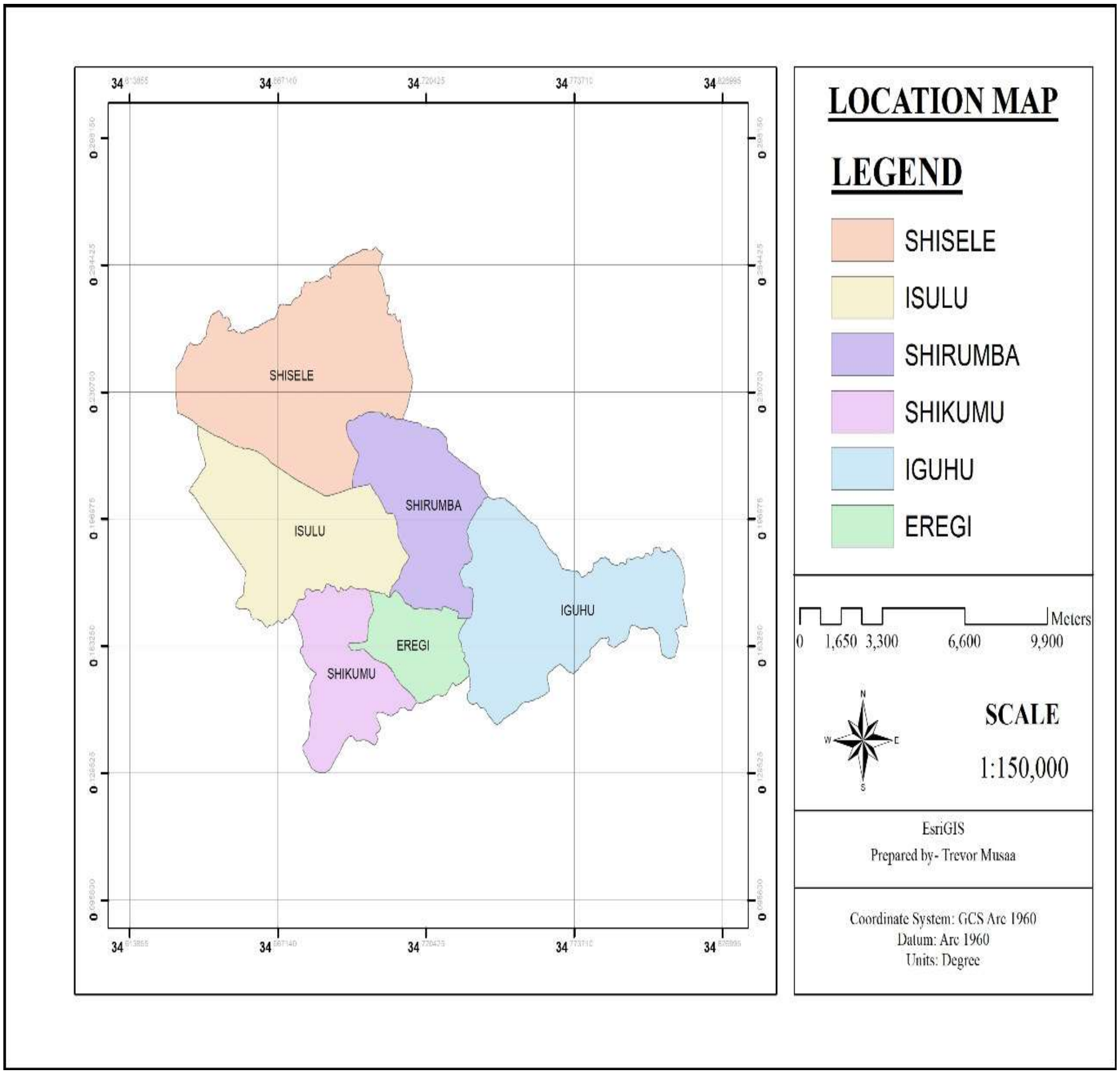

Figure 3.0: Map of Kakamega South/Ikolomani Sub-county

Source: *Based on ESriGIS*

Appendix VI: Morgan and Krejcie sampling table

Table for Determining Sample Size from a Given Population

N	*S*	*N*	*S*	*N*	*S*
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Note.—*N* is population size.
S is sample size.

Source: *Research Advisor 2006*

Appendix VII: 2019 Kenya Population and Housing Census Volume II

Table 2.4: Distribution of Population by Sex, Number of Households, Land Area, Population Density and Sub Locations

	Sex*			Households			Land Area	Density
	Total	Male	Female	Total	Conventional	Group Quarters	Sq. Km	Persons per Sq. Km
MAHIRA	16,879	8,261	8,617	3,527	3,489	38	29.6	570
MUKHONJE	3,698	1,814	1,884	743	743	-	6.7	552
MUTING'ONG'O	3,043	1,510	1,532	665	627	38	5.9	517
MWERA	4,790	2,309	2,481	947	947	-	8.2	583
SHILONGO	5,348	2,628	2,720	1,172	1,172	-	8.8	607
SHAMBERERE	11,044	5,613	5,430	2,932	2,921	11	13.6	815
BUKHAKUNGA	2,994	1,481	1,513	703	692	11	4.8	630
SASALA	3,317	1,699	1,617	849	849	-	4.7	700
SHAMBERERE	4,733	2,433	2,300	1,380	1,380	-	4.1	1,165
SHIANDA	12,311	6,083	6,227	2,546	2,546	-	16.6	742
LUNYINYA	5,727	2,824	2,903	1,144	1,144	-	7.7	747
SHAMONI	6,584	3,259	3,324	1,402	1,402	-	8.9	737
KABRAS WEST	30,718	14,895	15,822	6,317	6,317	-	47.3	649
BURUNDU	11,955	5,761	6,194	2,424	2,424	-	20.9	571
BURUNDU	3,384	1,651	1,733	679	679	-	6.9	492
MUTSUMA	2,448	1,143	1,305	520	520	-	4.7	526
SAWAWA	3,450	1,678	1,772	680	680	-	5.0	685
SHIMULI	2,673	1,289	1,384	545	545	-	4.4	612
LUKUME	10,341	4,988	5,352	2,110	2,110	-	13.7	754
LUKALA WEST	4,490	2,160	2,329	929	929	-	6.3	711
LUKUME	5,851	2,828	3,023	1,181	1,181	-	7.4	791
SHIKUTSE	8,422	4,146	4,276	1,783	1,783	-	12.7	664
INDULUSIA	3,595	1,754	1,841	767	767	-	5.8	621
SHIKUTSE	4,827	2,392	2,435	1,016	1,016	-	6.9	699
KAKAMEGA SOUTH	111,743	53,219	58,524	26,964	26,940	24	146.2	764
IKOLOMANI NORTH	66,551	31,713	34,838	15,994	15,970	24	89.3	745
ISULU	20,337	9,677	10,660	4,827	4,827	-	26.9	755
LUNERERE	5,969	2,806	3,163	1,419	1,419	-	6.2	956
MUKONGOLO	4,388	2,129	2,259	1,054	1,054	-	5.1	855
MUSOLI	6,499	3,113	3,386	1,513	1,513	-	9.7	672
SHIBUNAME	3,481	1,629	1,852	841	841	-	5.9	592
SHIRUMBA	18,080	8,671	9,409	4,544	4,520	24	19.5	925
MALINYA	5,901	2,865	3,036	1,541	1,541	-	5.3	1,109
SHITOLI	5,125	2,477	2,648	1,285	1,261	24	6.7	769
SHIVAGALA	7,054	3,329	3,725	1,718	1,718	-	7.6	933
SHISELE	28,134	13,365	14,769	6,623	6,623	-	42.8	657
MUTAHO	6,847	3,259	3,588	1,604	1,604	-	11.4	603
SHIKULU	6,010	2,796	3,214	1,457	1,457	-	9.1	662
SHIMANYIRO	8,355	3,994	4,361	1,902	1,902	-	13.5	619
SHISESO	6,922	3,316	3,606	1,660	1,660	-	8.9	776
IKOLOMANI SOUTH	45,192	21,506	23,686	10,970	10,970	-	56.9	794
EREGI	8,171	3,928	4,243	2,021	2,021	-	9.4	872
LUKOSE	2,297	1,123	1,174	543	543	-	3.0	766
SHANJETSO	2,997	1,419	1,578	739	739	-	3.2	938
SHISEJERI	2,877	1,386	1,491	739	739	-	3.2	905
IGUHU	23,766	11,320	12,446	5,658	5,658	-	32.9	721
IVONDA	6,463	3,086	3,377	1,537	1,537	-	10.0	649
LIRHEMBE	3,306	1,612	1,694	835	835	-	3.0	1,110
MAKHOKHO	5,544	2,555	2,989	1,352	1,352	-	6.0	925
SAVANE	4,704	2,311	2,393	1,101	1,101	-	8.2	573
SHIVEYE	3,749	1,756	1,993	833	833	-	5.8	645
SHIKUMU	13,255	6,258	6,997	3,291	3,291	-	14.6	909
KALUNI	4,380	2,016	2,364	1,081	1,081	-	4.8	922
MADIVINI	5,325	2,543	2,782	1,342	1,342	-	5.0	1,068
SHABWALI	3,550	1,699	1,851	868	868	-	4.8	733
KHWISERO	113,476	53,670	59,803	27,681	27,681	-	145.6	779
KHWISERO EAST	42,711	20,208	22,502	10,105	10,105	-	63.2	676
KISA EAST	12,665	5,968	6,697	2,966	2,966	-	16.9	749
EMASATSI	5,957	2,781	3,176	1,409	1,409	-	8.0	744
EMURUBA	3,388	1,599	1,789	800	800	-	4.2	799
MUNJITI	3,320	1,588	1,732	757	757	-	4.7	713
KISA NORTH	18,608	8,824	9,783	4,369	4,369	-	26.2	709
MUNDOBELWA	12,226	5,836	6,389	2,919	2,919	-	16.0	766
MWIKALIKHA	6,382	2,988	3,394	1,450	1,450	-	10.3	621
KISA SOUTH	11,438	5,416	6,022	2,770	2,770	-	20.1	570

*Intersex figures are too few to be distributed at sub national level. Totals may therefore differ slightly

1[illegible]

Source: *2019 Kenya Population and housing Census Volume II*

Appendix VIII: Research Permit

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