CLIMATE VARIABILITY ADAPTATION USING FODDER CROPS: A CASE STUDY OF MARAKWET EAST SUB -COUNTY, ELGEYO – MARAKWET COUNTY

BY

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DECLARATION

CANDIDATE DECLARATION

This research project is my original work and to the best of my knowledge, it has never been submitted for a degree award in any University.

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SUPERVISORS APPROVAL

This research project has been submitted to graduate school for examination with our approval as University Supervisors.

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DEDICATION

I dedicate this work to my father Kiptoo Murkomen, my late mother, Kobilo Murkomen and my siblings Nelly, Batency, Beno, Peris, Gladys, Kipkosgei and Kiplagat for the sacrifices they made to make me achieve the best.

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ACRONYMS

ASALs	- Arid and Semi - Arid Lands
ENSO	- El Nino – Southern Oscillation
FAO	- Food and Agriculture Organisation
GCM	- Global Circulation Models
GDP	- Gross Domestic Product
GoK	- Government of Kenya
IPCC	- Inter – Governmental Panel on Climate Change
ITCZ	- Inter-Tropical Convergence Zone
KALRO	- Kenya Agriculture and Livestock Organisation
KIPPRA	- Kenya Institute for Public Policy Research Analysis
KVDA	- Kerio Valley Development Authority
NASA	- National Aeronautics and Space Administration
NDMA	- National Drought Management Authority
NGOs	- Non-Governmental Organizations
OCHA	- Coordination of Humanitarian Affairs
SDGs	- Sustainable Development Goals
UNDP	- United Nations Development Programme
UNFCCC	- United Nations Framework Convention on Climate Change

ABSTRACT

This study was done to assess climate variability adaptation by farmers using fodder crops in arid and semi - arid lands of Marakwet East Sub - County. This study sought answers to the following research questions; what are the causes and effects of climate variability in Marakwet East Sub –County? What is the influence of rainfall variability on fodder production and livestock keeping? What are drought frequencies in Marakwet East sub-county? What are the main socio-economic factors that affect fodder production?

The overall objective of the study is to assess climate variability adaptation using fodder crops in the dry lands of Marakwet East sub-county. The specific objectives were: To establish causes and effects of climate variability; To determine the influence of rainfall on fodder production and livestock keeping; To establish drought frequencies in Marakwet East sub-county; and To establish the main socio-economic factors that affect fodder production. This study was guided by resilience theory. Data were collected from both primary and secondary sources. Tools used included questionnaires, interviews and direct observation. The sample size was 100 households that were given questionnaires to answer them.

The study employed both inferential and descriptive statistical techniques in data analysis. Qualitative data was presented using graphs and tables while inferential or quantitative techniques involved correlation analysis that assessed the relationship between climatic variables and livestock production.

The results indicated that most households understood climate variability as reduction in rainfall, changing in rainfall patterns and increased temperatures. From the key informants, the respondents indicated that they had experienced prolonged droughts, shortage of rainfall and reduced river flows as some streams had dried up. This hastened drying up of pasture hence increased number of livestock deaths. Limited pasture and water supply had also increased conflict along the borders of the sub – county and its neighbouring sub – counties.

Due to climate variability, the community devised their own traditional ways which they believed that it was helping them cope with variability. For instance, farmers sold their livestock during drought season to reduce pasture competition, planted drought resistant crops, changed planting seasons, improved fodder production and practised culling.

Fodder production led to increment in milk production as napier acts as stimulant, improved livestock health and reduction in livestock deaths. The surplus fodder was sold to earn income for the household. The entire adaptation process has helped the community to improve livestock production and reduced climate variability effects.

Hypothesis testing confirmed that annual rainfall is important factor in determining livestock sales. The relationship between annual rainfall and livestock sales is negative linear because as rainfall increases, livestock sales decreases and vice versa.

To conclude, other factors led to livestock sales. For example livestock is sold to get school fees, medical fees, dowry and for food. The months of January, May and September had increased number of livestock sales each year because it was the time when students and pupils are getting back to schools.

CHAPTER ONE: INTRODUCTION

1.1.**Background to the study**

Climate variability is defined by IPCC, (2014) as variations in the mean state of climate on all temporal and special scales beyond that of individual weather events. It is a major threat facing humanity today as it has led to abrupt disruptions such as floods, extended droughts, tropical storms and conditions that result from periodic El Niño and La Niña events. These disruptions can take a major toll on a country's economy if a significant part of economic activity is sensitive to the weather and climate. For instance when agriculture is accounting for half of country's GDP, the economy is therefore sensitive to climate variability, particularly variations in rainfall.

Climate variability affects poor people in developing countries more significantly than those living in more prosperous nations such as India. This is because poor people are mostly depends on economic activities that are sensitive to climatic events. For example, agriculture and forestry activities depend on local weather and climate conditions; a change in those conditions could directly impact productivity levels and diminish livelihoods. The effects of climate variability on societies are a result of extreme events, which vary from one region to another basing on the amount of energy from the sun and the circulation of the atmosphere and oceans which carry heat and moisture from one place to another. Many long term changes in climate at continental and regional levels have been seen. These changes included the widespread alteration in amounts and distribution of rainfall, salinity of oceans, patterns of wind and aspects of extreme weather events that result to prolonged droughts, heavy rainfall, high temperatures and the intensity of tropical cyclones (Wato, 2016).

Climate variability occurs as result of both natural and human activities. Natural variability is divided into internal and external variability. External variability activities are variations in the sun, volcanic eruptions and changes in the orbit of the Earth around the sun. Internal variability is influenced by processes that are within the climate system that arise from interactions between the atmosphere and ocean, such as those occurring in the tropical Pacific Ocean during an El Niño oscillation.

The human activities that cause climate variability include burning of fossil fuels and increase in greenhouse gases that is facilitated by rapid population growth and urbanization, rapid industrialization and degradation of the environment for instance deforestation and intensified

agricultural practices, destruction of wetlands. IPCC (2014), states that concentrations of carbon dioxide for example, have increased in the last forty (40) years. In this regard, it rises the transmission of incoming solar radiation while diminishing its radiation back to space resulting to greenhouse effect and climate variability.

According to the annual assessment of risks survey of 750 experts in the year 2016, conducted by the World Economic Forum, catastrophe caused by climate variability is seen as the biggest potential threat to the global economy. It has resulted in the rise of the frequency, intensity and duration of climate related natural disasters in the 21st Century. For instance, heat-related illnesses like heat exhaustion and heat stroke are expected to increase.

In the recent two decades, several studies have consistently presented forecasts and demonstrations rise in the frequency and intensity of hydrological, climatic and meteorological related natural disasters (Mata-Lima et al, 2013). This particularly held interest in the year 2007 in the report by IPCC, which declared that one of the consequences of climate variability is the occurrence of extreme climatic events. Herring et al., (2018), stated that climate variability has the ability to worsen the intensity and speed of tropical storms, rising sea levels and weakens the world's circulatory winds, which in turn, leads to slow speed at which tropical storms move forward. For example, the speed of hurricanes fell by an average of 10% between 1949 and 2016.

Africa, like the rest of the world is already affected by climate variability. The whole continent of Africa is facing extreme climatic stresses and her people are vulnerable to its associated effects (Murungi, 2013). Climate variability has worsened effects on the environment, especially on availability of water, biodiversity, human health, farming and food availability. The effects of climate variability include ecological effects such as loss of biodiversity; melting of ice-caps which according to NASA (2015) globally, the seas have increased by an average of nearly three inches since 1992 mainly due to increased temperatures. For example, Egypt experienced a sea level rise of 1%, Netherlands with a rise of 6% and Bangladesh with a rise of up to 17.5%; destruction of forests and loss of precipitation due to high temperatures increased moisture loss from the soil making the soil to dry up. The dry soil does not support growth of crops; social-economic effects resulting in the destruction of property and loss of lives and forced many people including men, women and children to move away from their motherland and homes. According to Norwegian Refugee Council, an average of twenty six

(26) million people is displaced every year by both natural and human – induced disasters such as floods, storms, drought, heat waves and fires every year. The Guardian 2018, states the following social economic impacts of disasters: wild fires in Australia which occurred in 2009, and lead to nearly half a million hectares razed leading to over 200 deaths, 500 injured in urban, rural area including natural reserve and national park areas.

In the year 2003, Europe experienced heat waves that resulted in health problems especially to the poor and elderly, that over fifty two (52,000) deaths were recorded in the past sixteen (16) days of consecutive heat wave. The recent heat wave which was experienced in India in 2015 killed 2,500 people while in Seoul North Korea more than 42 people died and 3,400 were treated for heat-related illnesses, such as heat stroke since the end of May 2018. The temperatures reached 39.6^{o}C which is the hottest temperature in past one hundred and eleven (111) years in early August in Seoul which is home to about half of the country's population.

Other effects of climate variability included displacement and migration of people from one place to another in search of green pastures and water for livestock. This effect indirectly increased risks of violent conflicts in the form of civil war and inter-group violence. However, due to poverty, many vulnerable groups in climate vulnerable areas do not have the resources to migrate to avoid the effects of floods, storms and droughts. It was estimated that in 2000, a total of 700,000 populations in urban coastal areas migrated in Sub Saharan Africa due to climate related disasters (Geddes, 2016). The GDP of Ethiopia rises or falls due to rainfall variations because agriculture accounts for more than half of country's GDP and approximately 80% of employment opportunities. According to Nicholls et al., (2004), the number of people affected by floods every year in the world is expected to increase from 10 and 25 million by 2050s.

Climate variability has become a serious global threat that have been causing abrupt disruptions. The disruptions have affected economies of countries such as Kenya that are sensitive to the weather and climatic events. For instance, GCMs in Kenya predict that global warming have resulted to variability of rainfall by up to twenty (20) percent and may lead to increased temperatures to about 4 degrees Celsius by the year 2030, (KIPPRA, 2015). According to the predictions, drought and floods are the extreme climatic events that have affected agriculture in low, medium and high potential areas (Kabubo - Mariara and Karanja, 2006). Drought in Kenya is a major climatic hazard affecting agriculture and livelihoods in

rural areas. It has had major devastating effects on the economy of the local community. Its frequency as at now averages between 2 years to 3 years as opposed to past that was averaging from 5 years to 7 years in the 1960s and 1970s. So far, five severe droughts have been realized over the past two decades such as 1996/1997, 1999/2001, 2004/2006, 2008/2009 and 2010/2011 (KIPPRA, 2010; Government of Kenya, 2013; UNDP, 2013).

Livestock production is the mainstay of agro-pastoral and pastoral communities in Kenya and contributes a lot to their livelihoods. Over sixty (60) percent of Kenya's livestock is found in ASALs, where many people indulge in livestock production as a form of employment. Livestock in Kenya contributes 40% of the gross domestic product (GDP) and provides livelihood to over 10% of the population (GoK, 2015). On the other hand, crop production contributes about 25% of the agricultural GDP and in total contributes 80% of the total Gross Domestic Product. Approximately, seventy (70) percent of the country's livestock population is found in ASALs which occupy above eighty nine (89) percent landmass (GoK, 2015). This means that ASALs depend on livestock for food, income and employment. MacOpiyo et al., (2013), states that the dominant livestock holdings in dry areas include sheep, camels, donkeys, goats and cattle. ASALs of Kenya have been experiencing frequent climatic extremes. These extremes include reduction of clean water and agricultural produce that have resulted to malnutrition. Communities that live in such areas are mostly poor, thus, are always vulnerable to climatic factors such as drought (Opiyo et al., 2015).

Adaptation has been regarded as the best way of dealing with climate variability. It was termed by researchers on climate effects as a way of reducing vulnerability of communities as well as preparing them for any possible future climatic events that may be extreme. Adaptation has three objectives which include reducing exposure to the damage risks; developing the capacity to withstand unavoidable damages; and utilizing new opportunities from climate variability. Opiyo et al., (2015), stated that agro-pastoralists and pastoralists are now diversifying their sources of livelihood by reducing overdependence on livestock production. The most common complimentary activities are engagement of small businesses and wage labor, trading in wood, charcoal and non-timber products such as honey, gum and resins.

Fodder production has been confirmed as one of the lasting intervention for improving livestock production (Catherine et al., 2014) in ASALs. The Kenya government, through KALRO introduced fodder crops and technologies which are being adopted by smallholder

farmers in dry areas. The fodder crops have increased feeds especially during dry seasons which can as well be sold to earn income (Lugusa et al., 2016). Livestock production creates opportunities, improves livelihoods and facilitates economic development among the poverty stricken livestock keepers. This study therefore assessed climate variability adaptation using fodder crops in dry lands of Kenya.

1.2. **Statement of the Problem**

Climate variability is a big threat to development especially in developing countries whose main development priority is provision of basic needs. It is acknowledged in Vision 2030 as a threat to the achievement of the annual economic growth of 10% (KIPPRA, 2015). Climate variability threats have undermined the progress of the country. For instance, in prevention and treatment of diseases, malnutrition and early deaths, and benefits associated with agricultural productivity. According to IPCC 5th Assessment Report (2014), climate variability could increase inequalities, exacerbate poverty and may trigger new vulnerabilities and better opportunities for individuals and communities.

Disasters exacerbated by climate variability result in slow economic growth due to diversion of funds towards reconstruction of infrastructure and provision of basic human necessities making poverty reduction more difficult, hence eroding food security, as well as creating new poverty traps. Rise in the intensity and duration of disasters related to climatic events threaten the achievement of the seventeen (17) SDGs since it leads to diversion of development efforts (funding) towards achieving these goals. In 1997, Kenya experienced its worst El Niño rains which led to 2,000 deaths reported and displaced about 1.5 million people; it also led to the destruction of infrastructure resulting to a 40 Million USD credit for reconstruction from the World Bank (Standard, 2015). According to the United Nations Office for the Coordination of Humanitarian Affairs (OCHA), during the subsequent 2015 El Niño rain, 100 people lost their lives with an additional 70,000 displaced in Tana Delta, Nyanza, Garissa and Turkana regions.

The scarcity of pasture in ASALs of Kenya has in the past and continues even today to adversely affect livestock production (GoK, 2015). Through the National Disaster Management Authority (NDMA), the government has focused on various short term interventions such as livestock off-take, feed provision as well as restocking programmes with an aim of minimizing the effects of climate variation on livestock farmers particularly in the low and medium potential areas.

Challenges facing livestock farmers are still severe despite the rigorous efforts by the government. This is because loss of livestock at the household level is still a serious national concern. Extreme climatic events have persistently led to massive loss of livestock, hence negatively affecting the livestock industry and raising concerns on how to secure livelihoods for the livestock farmers. This could be attributed to climate variability that results in little rainfall and prolonged droughts leading to death of livestock. For instance, in 2009 and 2011, a large number of livestock perished (Ouma, 2017). The main effect of such losses is impoverishment that leads to more vulnerable pastoral and agro-pastoral households (Joosten et al., 2014).

Marakwet East Sub - County receives annual rainfall that averages between 400mm and 1300mm. Long rains are received mostly from the month of April up to and including June while inadequate rains are received from October to November every year. From December to March, it is a dry season with little or no rain (Chebet, 2010). Previous studies state that fodder production and conservation is the lasting solution to the households in ASALs of Kenya (Catherine et al., 2014). Studies have been done on fodder production in West Pokot County (Mureithi et al., 2015; Wairore et al., 2015) and Baringo County (Wasonga, 2009), but nobody has attempted the study it in Elgeyo - Marakwet County which has the same environmental characteristics as Baringo and West Pokot Counties. This present study investigated the adaptation of climate variability using fodder crops in ASAL and by doing so, it will contribute more to the existing literature on the agricultural sector and help in planning policies.

1.2.1. **Research Questions**

1. What is the influence of rainfall variability on fodder production and livestock keeping?
2. What are drought frequencies in the sub – county?
3. What are the main socio-economic factors that affect fodder production?

1.2.2. **Research objectives**

1.2.2.1. **General objective**

The general objective of the study was to assess climate variability adaptation using fodder crops in the dry lands of Marakwet East sub-county.

1.2.2.2. **Specific objectives**

1. To determine the influence of rainfall variability on fodder production and livestock keeping.
2. To establish drought frequencies in Marakwet East sub-county.
3. To establish the main socio-economic factors that affect fodder production.

1.2.3. **Research hypothesis**

1. There is no significant relationship between rainfall variability and livestock sales.
2. There is significant relationship between rainfall variability and livestock sales.

1.3. **Significance of the study**

Livestock production has been identified has the most important farming activity that contributes immensely in the livelihoods of Marakwet community. This type of farming depends on natural systems which makes it very sensitive to climatic variables such as changes in temperature and rainfall. High temperature for instance degrades resources in the rangelands, thus causing starvation and death of livestock. The decimation of livestock has severe effects for livestock households as their `survival depends predominantly on their livestock (Mwiturubani and Van Wyk, 2010). Rainfall however could benefit livestock households in that more rainfall could result to longer access to wet season wild pasture. It could also lessen frequent drought hence providing more time for people to rebuild their assets between lean and good times. Rainfall also increases the quantity of fodder crops that are grown in the area which in most cases, is used during dry season to supplement wild pasture that livestock forage for themselves.

The study informed the agro-pastoral development stakeholders and policy makers on the current status of climate variability effects on livestock production in the study area. The study results will thus guide the policy options, interventions and essential support necessary for sustainability of the agro-pastoralists. Development actors like the Ministry of Agriculture, Livestock and Fisheries, National Drought Management Authority (NDMA), private organizations like Kerio Valley Development Authority (KVDA) and Non-Governmental Organizations (NGOs) will utilize the findings and recommendation of the study to improve their interventions. Government agencies can utilize the findings of the study to formulate and target awareness and sensitization programmes aimed at influencing the appropriate coping

strategies for the agro-pastoral and pastoral communities. Finally, it will help reduce livestock losses, thereby increasing income, employment opportunities as well as boosting welfare of livestock households.

1.4. **The Scope and Limitations of the Study**

This study was geographically confined within the boundaries of Marakwet East sub - county. It targeted agro-pastoralists that were affected by frequent climate related disasters due to climate variability. This study relied on the data of fodder production, livestock sales, temperature and rainfall patterns to determine patterns of drought of climate variability that had affected livestock and crop production. The study focused on climate variability adaptation since it had become a disaster in the area. It was environmental in approach and emphasis was in the field of geography and would add literature on the same.

The limitations of this study included:

- Constraints of accessibility in the area due to distance and terrain as people live apart.
- Scarcity of secondary data as some of the necessary records and publications were not readily available
- Memory lapse of old participants.
- Insecurity interfered with the work because Kerio Valley is prone to attacks.

1.5. **Operational Definitions**

Adaptation – Ability of a system to adjust to climate variability in order to moderate potential damages, taking advantage of the opportunities or coping up with the consequences that may arise due to climate conditions (IPCC, 2007).

Climate variability – It is the tendency of the weather conditions of a place to vary and the variation is indicated by extreme rainfall patterns, temperatures, floods and droughts.

Drought – Period without rain for one or successive rainy seasons.

Livelihood – It is a social wellbeing, environment, food security, livestock and human health.

Occupation - Daily activity that a household may engage in

Prolonged drought – It is defined in this study as drought that takes more than a year.

Resilience – Ability of a system to remain functionally stable in the time of stress, and/or to recover due to disturbance. It is also ability to become flexible.

Vulnerability – Level of exposure, sensitivity and ability to cope to some hazard such as climate variability (IPCC, 2007).

CHAPTER TWO: LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1.**Introduction**

This chapter presents synthesis of literature related to the research problem. It focuses on climate variability, its causes, impacts on agro-pastoral livelihoods and its adaptation strategies using fodder crops. The chapter also discusses theoretical framework and conceptual framework.

2.2. **Climate variability**

According to IPCC report of 1990, it was pointed out that global average increase in temperature ranges between 0.15 to 0.3 degrees Celsius per decade. On the other hand, greenhouse gas emissions could rise averaging from 25% to 90% globally, while temperatures could rise by 3% by 2030. In addition, it was further predicted that even when there is small increase in temperature (about 1% to 3%) the consequences might still be worse, exerting severe effects on the livelihoods of many households (IPCC, 2007).

Nonetheless, it is now widely accepted that there is climate variability all over the world. For example, 1990s were particularly hot years and then global temperature rose by 0.6°C (IPCC, 2002:101). The impact of global climate variability includes increased intensity and frequency of storms, as well as alteration of amounts and patterns of rainfall. Other factors included altered hydrological cycles, rising temperatures, persistent droughts and flooding (Kitiem et al., 2008:1).Climate variability is caused by spatial and temporal variation in climate due to ENSO phenomenon, fluctuation of sea surface temporal, changes in wind direction and shift in ocean currents.

According to Murungi (2013), climatic zones of a country in the world is influenced by its equatorial location, the Indian Ocean and the Inter-Tropical Convergence Zone (ITCZ) and topography. The influence of the ITCZ is modified by the altitudinal differences, giving rise to varied climatic regimes. Rainfall varies from over 2000mm in the humid to less than 300mm annually in the very arid zones.

According to Kotir (2010), climate variability affects precipitation, increases frequency of drought and may lead to temperature rise, which may threaten availability of water that is fresh

and good for crop production, livestock production, industrialization and domestic uses. IPCC (2007), concluded that climate variability may severely compromise food production and food security in many third and fourth world countries such as those found in African. This happens mainly because farming in Africa is highly dependent on rain. Farming is done either through crop production or livestock rearing.

According to KIPPRA, (2015), Africa being a continent that is occupied by many countries that are developing is under pressure from climatic variables. The inhabitants are highly vulnerable to climate variability. Africa continent is generally noted to be hot and dry with nowadays trends becoming warmer as opposed to one hundred (100) years ago (Kotir, 2010). Warning trend has been noted likewise since 1960s (Wato, 2016). Sub-Saharan Africa (SSA) is anticipated to warm as it is found in tropical and subtropical latitudes, where temperatures remain higher whole year round (Kotir, 2010). In future, the whole Africa continent is expected become warmer across all seasons throughout the century (Kotir, 2010). By 2100, the temperature rise will be about 2 - 4.5^{o}C which will be stronger as expected and it will be higher than global average (Muller, 2009).

Furthermore, rainfall pattern is mainly influenced by El – Nino Southern Oscillation and La - Nina events. These often result into unpredictable rainfall patterns that result into frequent droughts and/or floods that lead to reduced food production causing severe food shortages (Wato, 2016). According to observations, ENSO influences contrasting rainfall variability in Sahel, East Africa and South East Africa with Sahel becoming drier, East Africa being wetter and South East Africa being stable (Kotir, 2010). Past researches on climate variability suggested that there is potential decrease in rainfall over Kenya in future (Wato, 2016). The recent studies has shown increasing drought and the country as whole is exposed to water security problems.

However, it was estimated that one third of the entire population of Africa is already living in areas that are prone to drought. This means that two twenty (220) million people are exposed to drought throughout the year. This is because most of its countries often lack adaptive measures to climate variability and greater percentage of the entire population lives in remote areas. Households in the rural areas depended so much on livelihoods that were sensitive to climate such as crop and animal production (Nkondze et al., 2014; UNFCCC, 2007).

According to Wato (2016), climate variability is evidenced by increasing climate instability in East Africa. That was indicated by frequent and intense weather extremes all over the region. For example, the report of GoU (2002) recorded temperature analysis which showed that sustained warming in Uganda particularly southern parts is increasing faster than the maximum temperature. Variability is also indicated by melting of the snow caps in Mount Kilimanjaro in Tanzania, Mount Kenya in Kenya and Mount Ruwenzori peaks which indicated that there was strong evidence of warming trends in East Africa.

In Kenya, the annual average rainfall ranges from 500 mm and 2300 mm in total. Annual average rainfall is largely influenced by altitude and exposure to moisture – laden winds. Rainfall diminish at higher altitudes due to lower moisture content of trade wind inversion. ASALs are known to receive limited rainfall that cannot support pasture growth throughout the year and crop production. This is evidenced by a series of droughts and floods of varying magnitudes, duration, and spatial extent, with diverse consequences that have had unpleasant socio - economic and environmental outcomes. This therefore, makes the communities in such areas to face several problems that need to be adapted.

Climate variability in Kenya is likely to manifest itself through warming and sea-level rise, characterized by an increase in mean annual temperature ranging from 2.5ºC –5ºC with a 0% to 25% increase in precipitation. The spin-offs of these changes would include changes in evaporation rates and rainfall patterns resulting in acute water shortages and increased water conflicts, especially in the ASALs of Kenya. In the high rainfall areas, increased flooding and general deterioration of water quality are experienced. However, possible effects of climate variability on water resources are still uncertain. The magnitude of such impacts will depend on how the changes are managed. Increases in mean temperatures could result in significant changes in rainfall, evaporation and hydrology generally.

Marakwet East Sub - County as one of the ASALs receive insufficient rainfall which is unpredictable, and cannot support pasture growth throughout the year. This makes animals graze on shrubs by feeding on their roots and fruits to survive and they mostly concentrate on small grazing grounds. This resulted in land degradation, increased wind and hydrological erosion mostly at the start of the rains. Climate variability problems include widespread poverty, human and animal mortalities, drought, increased aridity and disease incidences such as yellow fever and Malaria.

2.2.1. **Effects of climate variability**

The effects of climate variability vary from one region to another basing on the geographical location of the region. For instance many regions experience frequent and prolonged droughts while others receive high amount of rainfall which is unpredictable and may lead to flooding in the region (Kagunyu, 2017). Both prolonged drought and unpredictable rainfall undermine food security and may also lead to increased vulnerability of the affected societies. Fresh water supply is also affected by rise in the occurrence of droughts and rise of sea water in flood prone regions and along coastal areas of the world. The current climate variability has significant effects on farming, straining agricultural income and forcing farmers to adopt new agricultural practices as response to altered conditions of weather events. The risks of future climatic variations such as changes in rainfall and temperatures can result in significant effects on both crops and livestock (Molua et al., 2010). In Tanzania and Kenya for example, these extreme weather conditions led to crop failure, scarcity of pasture, livestock deaths and conflicts over resources among neighbouring communities. These have resulted in economic losses leading to dependence on emergency relief food supply and water (Serigne and Verchot, 2006: 11).

2.3. **Influence of rainfall variability on livestock keeping and fodder production**

2.3.1. **Livestock production**

Livestock production is main source of livelihoods for ASAL households. Low and medium potential areas of the world have large numbers of livestock especially in mixed systems, with some being dairy animals and free ranging sheep and goats (KIPPRA, 2015). ASALs of the world have livestock of over 60 per cent, where livestock farming employs about 90% of the entire population. Livestock farming is a source of income in the family and may also provide food security. It also supplies necessary requirements such as milk, meat and other dairy products such as yoghurt, hence providing for about 30% of the total marketed agricultural products (KIPPRA, 2015). In addition, livestock production also earns the country substantial foreign exchange through export of processed pork products, dairy products, meat, hides, skins and live animals (KIPPRA, 2015).

Livestock production in Kenya is very important as it provides employment for about fifty percent of the country's agricultural sector labour force. It provides raw materials for agro-industries, thus contributing good income to household through sale of livestock and its products (GoK, 2014).

FAO (2005), stated that livestock farming in Kenya has been affected by poor governance of agricultural institutions, insufficient markets, inadequate infrastructure, weak marketing systems, lack of access to farm credit, inappropriate technology, high costs of farm inputs, and inadequate funding for research and extension. Other indirect effects resulted due to alterations in livestock feed resources linked to the carrying capacity of rangelands, increased scarcity of water resources, affecting abilities of ecosystems and rising desertification. These effects end up in decreasing livestock population, hence affecting production of meat, milk and milk products (FAO, 2008).

2.3.2. **Influence of rainfall variability on livestock production**

According to Fitzgibbon (2012), dry lands experience low and unpredictable rainfall patterns which is worsened by increasing climate variability. For instance, in the recent past, droughts have been experienced more often than before and seem to be worsening. Kagunyu (2017), stated that droughts have resulted in serious losses such as loss of resources and have affected livelihoods of many who rely on the ecosystem for survival, particularly the agro-pastoralist and pastoralists. The enormous changes due to unreliable rainfall means forage is affected as the ground remains dry and nothing grows. This affects forage quality and quantity, the time it takes to grow and it also affects water quality and quantity. As a result of this, livestock productivity goes down and sometimes the livestock die. In Kenya pastoral communities have suffered most from recent climate extremes in the country.

Livestock is likely to face serious effects of climate variability, the worst being threat of extinction of between twenty (20) to thirty (30) per cent of all animal species (KIPPRA, 2015). This is because most of livestock populations are concentrated in the ASAL regions in the country. Due to the large stock, there is high demand of fodder in both dry and wet seasons. In addition, communities living in ASALs still have high population growth rate which makes them have many livestock to meet their demand that exceeds carrying capacity of the area. This leads to high pressure on the resources which undermine the capacity to provide services such as water and pasture (Wairore et al., 2015). The end effect of this is poor yields and limited biomass production especially during dry seasons because of limited pastures and inadequate water supply. This eventually can lead to poor and malnourished pastoral households and has also triggered conflicts especially along border of Marakwet East sub-county and Baringo County.

2.3.3. **Impacts of rainfall variability on fodder production**

Fodder quantity and quality is affected by rainfall variability. Fodder production as one of agricultural activities in Marakwet sub – county remains the largest employer as most households depend on crops and livestock production for their food needs and income. Fodder production is characterized by poor use of modern agricultural inputs that end up in low productivity. Fodder relies on rainfall and traditional irrigation in the sub county. Irrigation was widely used in the sub county to water crops but still cannot produce enough harvest to feed livestock throughout the year. It might be because ground and surface water is not adequately explored due to limited human capital and financial capabilities. This was also attributed to rainfall inadequacy and unpredictability which affects planting and harvesting seasons.

According to Ndamani et al., (2014)), rainfall variability remains a critical challenge confronting small - holder farmers in Sub – Saharan Africa. The changes on the rainfall frequency and intensity greatly affect fodder production. It affects societies that practice rain-fed agriculture. Climate variability have affected rainfall distribution in equatorial East Africa. For example some parts will record 5% to 20% rainfall increase between the months of December and February while about between June and August, there will be decrease ranging from 5% to 10% (Alboghdady et al., 2016)

2.4. **Drought frequencies**

According to Opiyo et al., (2015), drought is the main and one of the most devastating, but least understood weather phenomenon simply due to its associated impacts that may accumulate over time. Droughts are classified as meteorological, agricultural, hydrological and socio – economic (Hounam et al., 1975). Meteorological drought is the one which is lack of rainfall in a place for a period of time while agricultural drought is the period in which there is declination of moisture in the soil with consequent crop failure as a result of inadequate surface water supply (Hounam et al., 1975). Hydrological drought refers to a situation with inadequate sub – surface and surface water resources while socio – economic drought refers to period with failure of water resource systems that could meet demands and effects human activities both directly and indirectly (Hounam et al., 1975).

Drought occurrence in the Horn of Africa had become increasingly severe during the last decade, with annual rainfall totalling to at least 50% – 75% below average. Rainfall received in most areas could not sufficient to support crop and pasture growth (Nicholson, 2014).

The frequency of droughts in the years 1960 and 1970 were averaging between five and seven year cycles. At present, the frequency changed to between two to three years (KIPPRA, 2015). For instance, five severe drought cycles have been realized over the past two decades such as 1996/1997, 1999/2001, 2004/2006, 2008/2009, and 2010/2011 (KIPPRA, 2010; GoK, 2013 and UNDP, 2013). According to IPCC (2012), there was marked increase in drought risk in most areas of Eastern Africa in which by the year 2050s it will automatically affect economic sectors that are sensitive to climate.

Past studies have shown that drought posed serious challenges for populations whose livelihood depend majorly on natural resources (Below et al., 2010; Nicholson, 2014). According to the United Nations (2012), countries have been experiencing drought related disasters. For instance, Somalia was affected by drought that led to an estimated 250,000 deaths, 18% of them being children younger than five in the regions of Lower Shebelle, Mogadishu and Bay. In the year 2011, Mexico experienced worst drought that led to death of loss of more than 2 million acres of crops; infectious tropical diseases such as Rift valley Fever, cholera and Malaria. Economic losses were estimated to be three billion USD.

The third and fourth world countries have been and still experiencing the adverse effects of climate variability despite their low contribution to the greenhouse gases (Wato, 2016). Kenya being an agricultural economy has also been experiencing drought seasons as a result of change in rainfall patterns. For instance in the year 2000, drought was declared a disaster. ASALs of Kenya are the most vulnerable regions and are drought – prone areas in the country which have been facing increased drought frequency and intensity since 1960s (Nkedianye et al., 2011). Kenya ASAL Policy (2012), stated that pastoral and agro- pastoral economies of ASALs in Kenya account for ninety (90) percent of all employment opportunities, family income and livelihood security. Thornton and Lipper (2014), stated that as a result of varying climate and increased evapotranspiration due to rising temperatures, ASALs are expected to experience frequent climatic stresses such as climatic extremes, increased aridity, increased water stress and reduced yields from rain-fed agriculture.

Marakwet East sub-county is periodically plagued with hunger (Kipkorir and Kareithi, 2013). The sub-county experiences annual rainfall ranging from 400-950mm per year which mostly falls in the months of May and August with intermittent dry spells within the months (Kipkorir and Kareithi, 2013). This has affected production of agricultural products which is a major income generating activity for many households. Food production in the area has been gradually declining. For example from 2004 to 2007, the production of drought resistant crops such as cassava, finger millet, maize and sorghum decreased by an average of 2.8 percent, 15 percent, 21.3 percent and 30.8 percent respectively (GoK, Marakwet Development Report, 2002-2008). Due to this, the sub-county received a lot of relief food to meet their food demands.

In addition, frequent and severe droughts were perceived to be responsible for the reduction of river flows such as rivers Embomon, Embobut, Embolot, Enou and Chesegon (Kipkorir and Welbourn, 2008) which were permanent in the past. The problem has been made worse by the fact that their livelihood systems have been constrained by frequent conflicts along Kerio Valley over natural resources (Rettberg, 2010). Conflicts and drought of climate variability have reduced the number of livestock in the area worsening the livelihoods of households. It is therefore important to adapt, cope and live with climate variability associated stresses in order to reduce vulnerability of ASAL communities.

2.5. **Climate variability adaptation**

The Intergovernmental Panel on Climate Change report (2012), defined adaptation as an adjustment in natural and/ or human systems in response to actual or expected climatic stimuli which moderates harm and exploits beneficial opportunities. Adger et al., (2007) defined adaptation as an adjustment in reducing vulnerability of farmers to climate variability. Eriksen et al., (2005) and Migosi et al., (2012) stated that adaptation involves long – term shifts in livelihood strategies

Arid and semi-arid lands depend mostly on livestock production because it is mainly the mainstay of the economy. Marakwet East Sub-county like the rest of the ASALs is constrained by feed shortage which results in low livestock production. Dry lands are characterized by low and unreliable rainfall, low productivity, large human and livestock populations.

Fodder production in ASALs is increasingly being explored and recognised. Examples of fodder crops that are grown in ASALs include napier grass, acacia, leucaena, *Cynodon dactylon* (Star grass) and maize. The importance of fodder crops include: used as supplements to

livestock especially during dry season and fodder stress periods, provide food, drugs, and firewood, building poles and recycling of nutrients. However, although the role and importance of fodder crops in ASALs have been widely recognised especially for livestock feed supplementation during dry seasons; this potential has not been exploited effectively due to shortcomings such as; fodder crops are affected by pests and diseases; lack of knowledge on propagation, establishment and management of various species; narrow range of proven trees species in cultivation; and lack of effective management in natural rangelands because most lands are communally owned and no one takes responsibility for their management.

According to McCabe (2006), the adaptation strategies of agro - pastoral and pastoral communities to their changing environmental conditions have been studied for many years. For instance, livestock producers have however adapted their environment and climate variations by building on their in-depth knowledge of the surrounding in which they have been living in. (Sidahmed, 2008), identified several ways of increasing adaptation in livestock production in ASALs of Kenya. These ways included changing livestock practices such as diversification, intensification and/or integration of pasture management, livestock and crop production; changing operations time; conserving nature and ecosystems traditionally; modification of stock routings and distances; introduction of mixed livestock farming systems such as stall-fed systems and pasture for grazing. The adaptation strategies that were applied by agro – pastoralists and pastoralists included use of emergency fodder in times of drought, rearing various species of herds that may withstand climate extremes and culling of weak livestock for food during periods of drought (Sidahmed, 2008).

During drought seasons, agro-pastoralists and pastoralists moved their livestock to where they can easily get enough water and pasture (Chebet, 2010). Herders sometimes leave behind sheep and goats because their feed requirement is less as compared to that of cattle. Many indigenous breeds of livestock already adapted harsh living conditions of their environment. The adaptation strategies address livestock tolerance to heat, and their ability to survive, grow and reproduce in conditions of poor nutrition, presence of parasites and areas prone to disease prevalence (Hoffmann, 2008). The adaptation methods included identification and improving local breeds of livestock that have already adapted their local climate and feed resources, improving local breeds by cross-breeding with high temperatures and epidemic disease tolerant breeds. Hoffmann (2008) stated that if climate variability takes place quickly compared to natural selection, the risk of survival and adaptation of the new breed is greater.

In addition, very efficient and low-priced adaptation strategies must be developed for poor people living in rural areas who cannot afford very expensive adaptation technologies. These affordable technologies included reduction of livestock population which may lead to more efficient production and lowers greenhouse gas emissions from livestock farming (Batima, 2006); changing livestock composition; proper management of water resources by introducing simple techniques for localized irrigation accompanied by infrastructure to harvest and store rainwater. The rainwater may be stored in tanks that are connected to the roofs of houses, on the surface such as dams and also underground water reservoirs. Training is also important for farmers to understand agro-ecological technologies and practices for the production and conservation of fodder that may in turn improve the supply of livestock feed and diminish malnutrition and mortality in livestock.

2.6. **Main socio-economic factors affecting fodder production**

The factors that determine participation are inner drivers that motivate every household to be part of fodder producers. These factors may be different from one farmer to another and from one geographical location to another (Singh et al., 2012). Development agencies such as KALRO motivate communities to participate in fodder production as one of the ways of adapting climate variability. For instance, in Garissa county (Ijara Sub-county), Agricultural productivity and climate change project was facilitated to produce African fox tail grass (*cenchrus cirialis*) and sudan grass (*Sorghum sudanese*) (Lugusa, 2015).

There is reduction of not only the cultivated areas, but also the suitable ones that would significantly increase the number of individuals without adequate food supply. This is believed to be one of the factors which drive households living in the marginal areas to participate in fodder production. From the study of Baringo County conducted by Lugusa (2015), the factors that drive households to participate in fodder production include livelihood options, past experience with drought, herd size, age of household head and access to communal grazing reserves. The main socio – economic factors that affect fodder production in Marakwet East sub - county include age, education level, marital status, occupation, environmental factors and income level.

2.7. **Sustainability of climate variability adaptation strategy**

The adaptation strategies observed to be commonly used by the agro-pastoralists to cope with the main hazard of drought include; buying food, getting assistance from relatives, seeking for

relief food, selling livestock and other household assets to buy food, borrow food, seek for casual work from within and outside their community, reducing number of meals, skipping meals, engage in petty businesses, and moving to market centres (Gwambene and Majule, 2009). It is worth noting that a successful coping strategy usually develops to an adaptation mechanism. An example is the mobility of pastoralism. This was a coping strategy that developed and became a characteristic adaptation of pastoralists. In face of increased rainfall variability and scarcer resources of pasture and water, the pastoralists have intensified their mobility. Other strategies include separation of livestock herds and charcoal burning.

2.8. **Identification of research gap**

Several studies have been done in Marakwet East sub-county such as role of irrigation in improving food security and assessment of indigenous knowledge in water and watershed management. However, researchers did not exhaust issues associated with climate variability, coping strategies and suitable strategies. For instance, the work of Chebet (2010), focused on conservation strategies and techniques, Kipkorir and Kareithi (2013), focused on traditional furrows and discussed few issues on climate variability. These studies discussed little on drought but did not mention the causes of drought and its effects including adaptation strategies. There is no study which has been conducted on climate variability adaptation using fodder crops. Despite the importance of the indigenous forecasting methods used by the Marakwet East community to predict seasonal climatic events, there is very little information documented. Therefore, this present study investigated climate variability adaptation using fodder crops and provides the relevant literature on the same.

2.9. **Theoretical and conceptual framework**

2.9.1. **Theoretical framework**

This study used resilience theory which is defined as the ability of a system to remain functionally stable in case of stress and can recover following a disturbance. According to Galaz (2005), resilience is the capacity of an ecosystem to tolerate disturbance without changing into a different state that is regulated by a different set of processes. When a system is resilient it withstands shocks and might bring itself back when affected.

The scholars of resilience theory emphasized on four aspects: adaptation, adjustment, transformation and reorganization. Resilient theory is concerned with adaptations. Systematic adaptations imply that new coping systems are created over time. Njiru (1994), observed that

the precise nature of a people's adaptation to the geographical site is equivalent to their adaptations within their culture. For instance, in the case of the Marakwet - East sub – county households, they have been known as agro-pastoralists but with recurrent droughts they have opted to keep local breeds of livestock such as cattle, goats and sheep. The underlying principle was that in the cause of their interactions with their environment, people acted towards things based on their meaning.

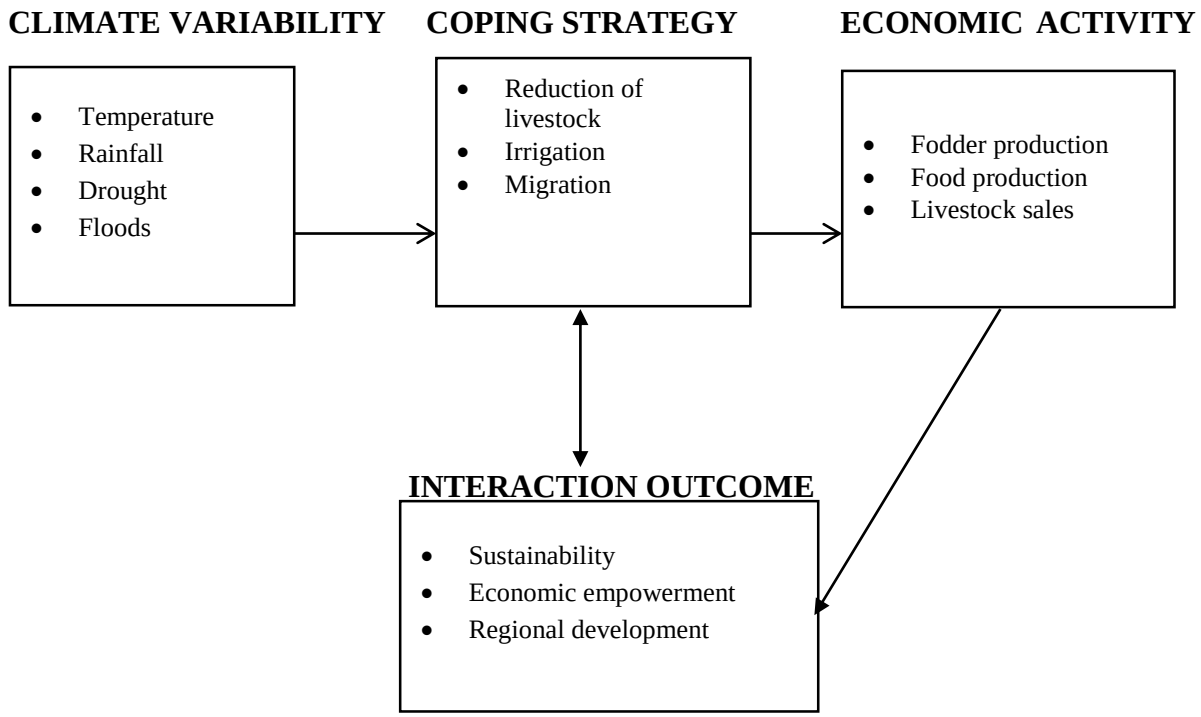
Resilience theory also emphasized on adjustment that if the situation deteriorates and this was what had happened among the Marakwet East agro-pastoralists who had been forced to adjust to some non–pastoral pursuits due to climate variability. Those non-pastoral activities included small trade, small-scale farming, casual labour and formal employment. The action taken by human beings when they were hit hard by disaster depended on how hard they were hit and the options available for them.

On transformation, there was influx of movement of young men and women from rural to urban areas such as Nairobi, Eldoret, Iten, Kapcherop and Kapsowar in search of jobs. Families that had lost their livestock as a result of droughts and conflicts also migrated. On reorganization, resources were set into a new system that took advantage of opportunities. The community had also developed another system of livestock mobility whereby it was only men who moved with livestock while women, children and the elderly were left behind for the children could go to school (Chebet, 2010).

2.9.2. **Conceptual framework**

Climate variability elicited environmental modifications that may result in droughts, floods and downward or upward temperature changes. The affected agro-pastoral communities devised adaptation strategies to the significant climate variability scenario by adoption of irrigation, livestock reduction or migration to more suitable areas. These adaptation strategies will affect food and fodder production as well as the health of livestock. The overall outcome determined sustainability and economic empowerment of the specific pastoral community. Adaptation strategies will influence sustainability and economic empowerment while also economic empowerment and sustainability will influence adaptation strategies. These are displayed in the conceptual framework in figure 1 below:

Figure 1**: Conceptual framework; Climate Variability and Economic Activities**



Source: Researcher, **2018**

Climate variability will elicit environmental modifications that may result in droughts, floods and downward or upward temperature changes. The affected pastoral communities will devise adaptation strategies to the significant climate variability scenario by adoption of irrigation, livestock reduction or migration to more suitable areas. These adaptation strategies will affect food and fodder production as well as the health of livestock. The overall outcome will determine sustainability and economic empowerment of the specific pastoral community. Adaptation strategies will influence sustainability and economic empowerment while also economic empowerment and sustainability will influence adaptation strategies.

CHAPTER THREE: STUDY AREA

3.1. **Introduction**

This study was undertaken in Marakwet East sub - county which is one of the sub - counties in the Rift Valley region. The sub county has been divided into three (3) agro-ecological zones: highlands in the west, escarpments in the central part and the valley floor on the east. The highlands (49%) comprise of Kapyego, Chesoi and Embobut / Embolot which are suitable for dairy cows, sheep for wool, potatoes, maize, peas and beans. The escarpment covers 11% of the sub – county area and is suitable for cultivation of maize, millet and sorghum.

The valley floor is flat, covering 40% of the county area and is the part with ASAL conditions. It is dry with sandy soils that supports growth of staple and drought resistant crops such as fodder, fruits, millet, sorghum, groundnuts and green grams. The farmers keep livestock such as zebu cattle, goats, sheep and poultry which graze freely in open areas. Many farmers are smallholders with an average of 1.36ha while the few large scale farmers have an average of 17.3ha (GoK, 2013). The areas on the valley include Mogil, Chesongoch and Tot (GoK, 2015). These areas experience low and unreliable rainfall which falls in April and August with intermittent dry spells within the months.

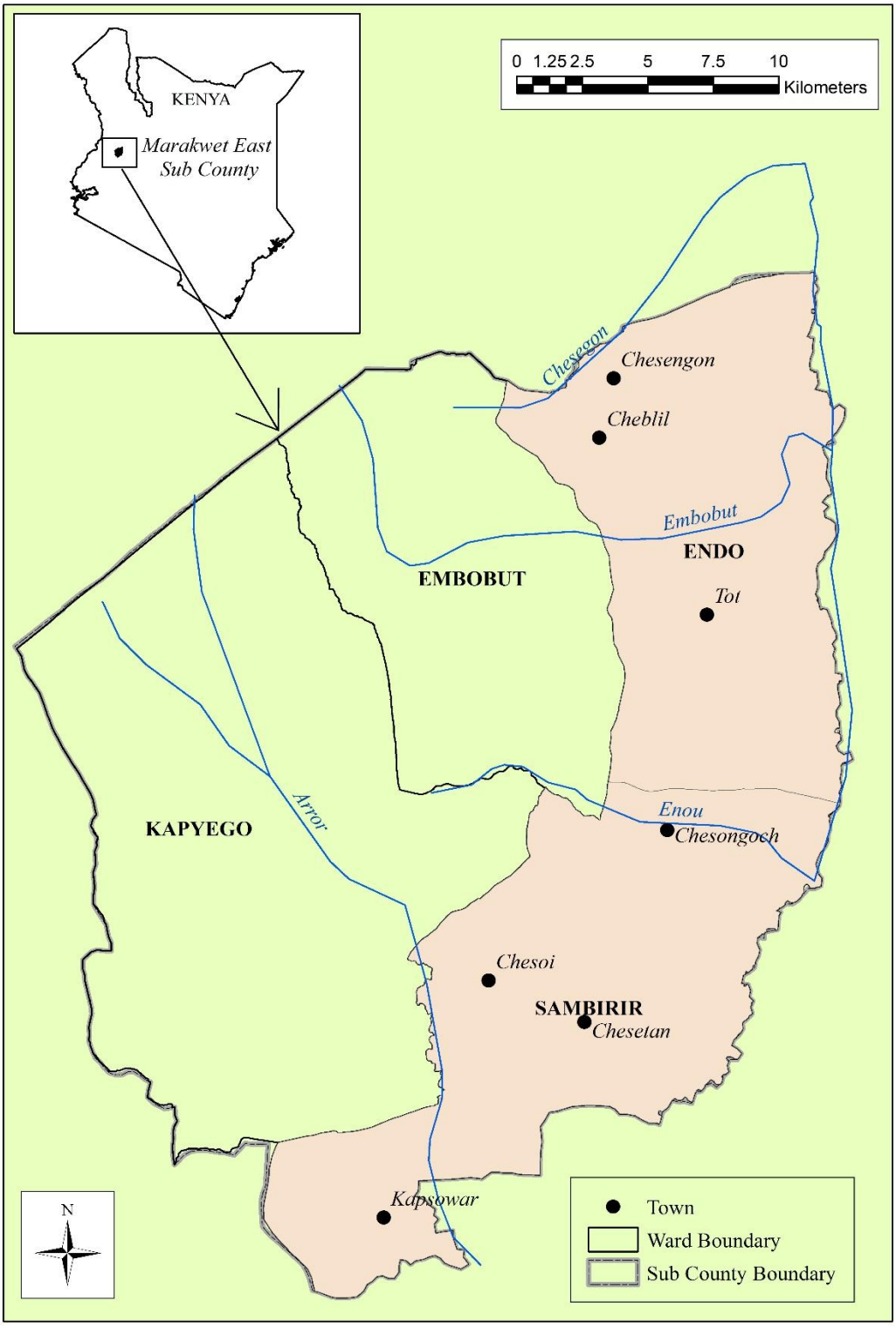


Figure 2: Map of Marakwet East sub - county

Source: Survey of Kenya, 2011

3.2. **Biophysical characteristics of Marakwet East Sub - County**

3.2.1.1. Climate of the study area

The rainfall is about 30% reliable ranging from 400 to 1000mm annually with high variability, receiving an average rainfall of 600mm per annum (Wasonga, et al., 2011). In normal circumstances, rainfall is bimodal with long rains starting in May to August while short rains at the end of September to early November with intermittent dry seasons in the months (Chebet, 2010). The average annual temperature ranged between 14ºC and 24ºC. The period between December and March is the hottest with extended droughts.

3.2.1.2. Physiology

The sub-county was located along the basin of Kerio River, Kenya. It lies between latitude 0° 59'N and longitude 35° 34' E and at an altitude ranging from 800 to 1200 metres above the Sea Level (GoK, 2005). The sub - county is characterised by three topographical features namely; river valleys, Cherangani hills and volcanic rocks. The floor of Rift Valley as a result of tectonic and volcanic disturbances was aligned towards River Kerio which is a tributary of Lake Turkana. Cherangani Hills forms an important source of seasonal rivers in the sub-county.

3.2.1.3. Vegetation and Water Resources

The vegetation is widely varied in the sub-county. This is because the county has both arid and semi-arid areas and highlands which receive favourable rainfall that support food production. The highlands have a large chunk of forest cover especially in Embobut / Embolot Ward and Kapyego Ward. The forest can be categorized into plantations, indigenous, grassland and bush land. The vegetation in ASAL varies from woody shrubs, herbaceous plants, patchy grassland and riverine woody trees species. Most parts of the sub-county have dwarf shrubs and bushy species. Plants such as *acacia* and *Milifera* are dominant in the area and have deep roots for accessing moisture which is limited (Kariuki et al., 2008). The shrub lands along Kerio Valley have silt loam to clay loam soil with low organic matter (Wasonga, et al., 2011).

The sub county has soils of varying textures and drainage conditions that have developed alluvial deposits. Water is mainly from rivers. The main rivers are Chesegon, Embobut, Embomon, Enou, Embolot (Kipkorir and Kareithi, 2013). These rivers provide water for livestock, humans and for small irrigation.

3.2.1.4. Ecological Conditions

The three agro-ecological zones of the sub – county include highlands, escarpment and lowlands (Kerio Valley), escarpment and highlands each with varied agricultural potential. The highlands are high potential areas suitable for food crops and cash crops which include vegetables (cabbages, kales, carrots, and peas), pyrethrum, potatoes, passion fruits, temperate fruits, maize, beans and Napier grass. The escarpment which is medium potential area is rocky with steep slopes and hills, but is a residential area. Crops such as mangoes, avocadoes, Napier and sugar cane are grown in the escarpment but not in all areas in the sub-county.

The lowland is semi-arid and arid land important for production of dry land cereals (millets, maize, pearl millet and sorghum), mangoes, tomatoes, pawpaw, groundnuts, watermelon and legumes (beans, pigeon peas, green grams and cowpeas.The lower regions along the valley are suitable for food production such as sweet potatoes, water melon, cassava, cow peas, green grams, millet, sorghum and mangoes (District Development Office, 2011). The agricultural produce is diminishing due to climate change that is increasing drought periods as rainfall becomes inadequate.

Agriculture generates revenue for more than seventy eight percent of the households in the sub county through engagement in crop and/or animal husbandry (GoK, 2014a). Livestock farming is an economic activity with 87% of the population in the sub-county engaged directly or indirectly in the activities (Little et al., 2008). Livestock reared in the county include poultry, dairy cattle, goats, rabbits, donkeys and sheep. Bee keeping is also thriving well as it has been practiced for a very long time in the area (Chebet, 2010).

3.3.**Socio – Economic Factors of Marakwet East Sub County**

3.3.1.1. Livelihood Systems of the study area

The main economic activity in the sub –county is agricultural production. The area is endowed with fertile soils suitable for the cultivation of crops such as sorghum, finger millet, cassava and maize. Cassava was introduced by the British colonialists as anti-famine food crop in the 1940s and since then, the crop has remained the reliable food in times of drought in the valley. The ministry of agriculture recognizes the contribution of the orphan crops such as sorghum, millet green grams, cow peas among other traditional crops in boosting food security especially in the arid and semi-arid lands (ASAL) like in Marakwet-sub-county (Government of Kenya: Ministry of Agriculture, 2009:5-7) and in the implementation of the national food and nutrition

policy (Government of Kenya: Ministry of Agriculture, 2011). Crops are grown between April and May, then harvested on August and /or September; and planted in September and harvested in December. There are two harvest seasons in August and December.

Land for cultivation is traditionally divided into that of men and women. Marakwet women acquired rights to land for cultivation by marriage. The lands were given by men and consisted of several plots in different places of the clan areas. Men owned lands and had full rights in use (Korir, and Kareithi, 2013). The amount of land held by households varied for land adjudication has not been undertaken in the ward. Adams, *et, al*., (1997) reported that plots per households in Endo Ward range from one to six acres and a majority had two and four acres spread in the valley and foothills of magnificent Marakwet East Escarpment. Families with insufficient land for cultivation leased more land mostly for three to four years from other clansmen with larger pieces. In return, the leaser is paid back in form of castrated male goats or old female goats. When a land is leased, the owner of the land was given crop harvests in exchange of labour and other production costs. The farmers practice shifting cultivation such that when the farm yields declined, the farmers left the fields to fallow and cultivated other virgin lands. Crop harvests were stored in two granaries at homestead, one for the man and the other for the wife.

3.3.1.2. Population Dynamics

Marakwet East sub-county had a total population of 78,749 people comprising of 38,808 male and 39,941 female according to Kenya Bureau of Statistics Report (2009). The ratio was almost 1:1. The total area of the sub- County is 299km^2 with a population density of 100.41 people per km^2 with 18,035 households (Kenya Bureau of Statistics Report, 2009). The settlement patterns are dictated by climatic factors, economic activities and security. The people who live in the sub-county is Marakwet who are part of the larger Kalenjin speaking people that include Tugen, Keiyo, Pokot, Sabaot, Kipsigis, Okiek, Nandi and Terik. The Marakwet people are traditionally agro-pastoralists in nature and balance between cultivation of drought resistant crops (sorghum, finger millet and cassava), some traditional irrigation and keeping livestock (goats, sheep and cattle) for their livelihoods. Land tenure is basically communal ownership with clans being the form of identity.

The settlement patterns are dictated by climatic factors, economic activities and security. There is high concentration of the population in high altitude areas that are close to the forest and markets.

Indigenous knowledge among the Marakwets of Kenya is stored in the memories and passed on from one generation to another either verbally or through education techniques exercised during rites of passage (circumcisions), during ceremonies and rituals in coded language structure and social interactions between group members.

3.3.1.3. Economic Activities

The economy of the county relies on crop farming and livestock production. Crops are grown on small scale that is used for home consumption only. The crops grown include common foods such as maize, beans, cassavas, sorghum, millet and fruits such as mangoes and passion fruit (Korir, 2013). Crop farming relies on rain fed and furrow irrigation that is practised along Kerio Valley. The main rivers that provide water for irrigation include Embomon, Enou, Embolot and Embobut. Livestock reared include cattle, sheep and goats (Korir, 2013). Livestock concentration is very high at Kipyebo, Kaptora, Murkutwo, Kabetwa, Tot, Soko Bora and Sangach. Livestock graze and browse freely in the extensive community land. It also relies on businesses which are conducted on markets such as Chesegon, Soko Bora, Chesongoch, Chesoi, Kapyego and Kapsowar (Chebet, 2010).

Dairy farming is also practiced by few farmers and institutions such as primary and secondary schools along the escarpment. The dairy animals include crosses of local breeds such as Zebu which are commonly known as cross by the local people. Other dairy cattle reared in the sub - county include Jersey, Guernsey and Freshian. These are commonly found in schools because they produce almost enough milk for students.

Marakwet East sub-county is not sufficient in both crop farming and milk production. This therefore makes business people import food stuff from neighbouring sub – counties such as Trans- Nzoia and Keiyo sub - counties.

CHAPTER FOUR: RESEARCH METHODOLOGY

4.1. Introduction

This chapter discusses the methodology used in this study. It begins by describing research design, collection of data, sampling procedure and data analysis. It further explains ethical considerations in the study area.

4.2. Research Design

The nature of the study was exploratory that used both quantitative and qualitative methods. The study site was Marakwet East sub-county, Elgeyo - Marakwet County. The sub – county comprises of four wards each with different climatic features. The targeted wards included Endo and Sambirir wards.

The study area was chosen because it is largely agro-pastoral area and is thought to give a good insight about climate variability adaptation using fodder crops. It also falls under ASALs of Kenya. The total number of households of the two wards was 10,928 according to KNBS census of 2009. Endo ward had 5,862 households while Sambirir ward had 5,066 households (KNBS, 2009). The target population for the study included farmers, traders, NGOs and households that were not producing fodder.

4.3. Sampling

4.3.1. Sampling methods

This study employed both random and non – random sampling techniques. Purposive sample of the two wards that traverse through the arid and semi - arid land were selected for study. Each of the wards was regarded as a stratum. These wards were Sambirir and Endo wards. Simple random sampling was then used to identify the farmers who later helped to fill the questionnaires. The household questionnaires were administered randomly applying simple random sampling.

The required sample size was determined by Nasuirma Model (2014) as shown below:

$$n = \frac{Ncv^2}{cv^2 + (N - 1)\, e^2}$$

Where,

N = Target population

n = Sample size

CV = coefficient of variation

e = Tolerance at desired level of confidence.

Using the above formula, the sample size is calculated as shown below:

$$n = \frac{10{,}928\ (0.5^2)}{0.5^2 + (10{,}928-1)\ 0.05^2}$$

$$= 99.1022$$

$$= 100 \text{ sample size.}$$

The size of sample was 100 households and included both men and women aged between fifteen (15) years to seventy five (75) years.

The data was collected in two wards of the sub – county that fall in rid and semi-arid region. Sambirir ward had a household of 5066 while Endo ward had 5862 according to (KNBS, 2009). The sample size was therefore divided into two as shown in the table below:

Table 1: Sample size

S/No.	WARDS	POPULATION SIZE	SAMPLE SIZE
1.	Endo	5862	54
2.	Sambirir	5066	46

Source: Researcher 2019

The sampling interval was determined as follows:

Sampling interval = n / N

Where: n – Sample size (100)

N – Population size (10928)

Sampling interval = 100 / 10928

25 / 2732

1: 109.28

1: 110 (1 in 110)

4.3.2. Data collection Methods

The data was collected from both primary and secondary sources to achieve predetermined objectives. The secondary sources included works of governmental and non – governmental institutions which were both published and un – published. Data was also collected from available literature of Marakwet community, climatic conditions such as droughts and rainfall, coping and adaptation strategies. The materials included reports, past researches, books and online publications.

Primary data were collected from farmers using questionnaires that were distributed randomly in the two wards selected. The questionnaires were distributed and collected by research assistants who understood the culture and language of the study area. The selection was done systematically and it ensured that every region was represented. Questionnaire was used as the main tool to get views of agro-pastoralist. The questions that the household heads were asked included drought frequencies in the area, rainfall distribution and temperature trends. Moreover, they were asked to give ways used to pass information on climate variability and to give the adverse effects caused by climate variability.

Key informant checklist was used to gather information from officials of Ministry of Livestock, Meteorological Department, Non - Governmental Organizations such as Child Fund and private organizations such as Kerio Valley Development Authority (KVDA) while a documentary review for climate variability parameters was also done.

Direct observation was another tool that was widely used. For example observing migration of households directly as they get out of their usual residence to go better places that they can get plenty of water and pasture. This was an advantage as the behaviour of households was directly watched. Types of houses, dress code, food eaten, species of livestock kept and activities the households engaged themselves in were also observed. The surrounding was also observed to get information on wild pasture and types that grow well in the area. Furrows and rivers were also observed to see the water flow and the riverine environment as whole.

4.4.**Data Analysis**

The study used both descriptive and inferential statistical techniques in data analysis. Quantitative data were coded, edited and analysed using Statistical Package for Social Sciences

(SPPS) software version 22. Regression and correlation analyses were used to establish linear relationship and strength between annual rainfall and livestock sales. The simple linear regression model is as shown below:-

$Y = a \pm bX$ ……..…… (i)

Where Y is the dependent variable (livestock sales) and X is the independent variable (annual rainfall). a and b are regression coefficients. These coefficients were obtained by the Method of Ordinary Least Squares (OLS). The measure of the strength and direction of linear association which was used is the Pearson Product-Moment Correlation (PPMC) or r.

The correlation coefficient squared (r^2) gives the Coefficient of Determination which explains the percentage of variability in the dependent variable that is explained by any change in the independent variable.

$$r = \frac{\sum xy - (\sum x)(\sum y)/n}{\sqrt{\sum x^2 - \frac{(\sum x)^2}{n} \cdot \sum x^2 - \frac{(\sum y)^2}{n})}} \quad \text{(ii)}$$

The significance of the relationship between rainfall variability and livestock sales was tested by use of Student's t test which is mathematically given as:-

$$t = \frac{r\sqrt{n-2}}{\sqrt{n-2}} \quad \text{(iii)}$$

with n - 2 degrees of freedom

The calculated t-statistic is then compared to the tabulated critical value at 0.05 significance level.

Descriptive statistics were applied to give frequencies and percentages which were presented using graphs and cross-tabulation tables.

4.5.Ethical considerations

Permission was sought from the key informants, NACOSTI and also from the county of Elgeyo – Marakwet before data collection process was commenced. Elaborations were given to the respondents before conducting any interview and were assured of the confidentiality of the information that they gave. This was done by not including their names in the project report.

CHAPTER FIVE: RESULTS AND DISCUSSIONS

5.1. Introduction

This chapter presents the findings from the field. It starts by describing influence of rainfall variability on livestock keeping and fodder production. It further goes ahead to discuss drought frequencies in Marakwet East sub – county, socio – economic factors affecting fodder production and finalizes by discussing results of hypothesis testing.

5.2. Influence of rainfall variability on livestock keeping and fodder production

Rainfall data was obtained from Kapsowar weather station which is former headquarters of Marakwet District. The annual rainfall data for the last fifteen years is as shown below.

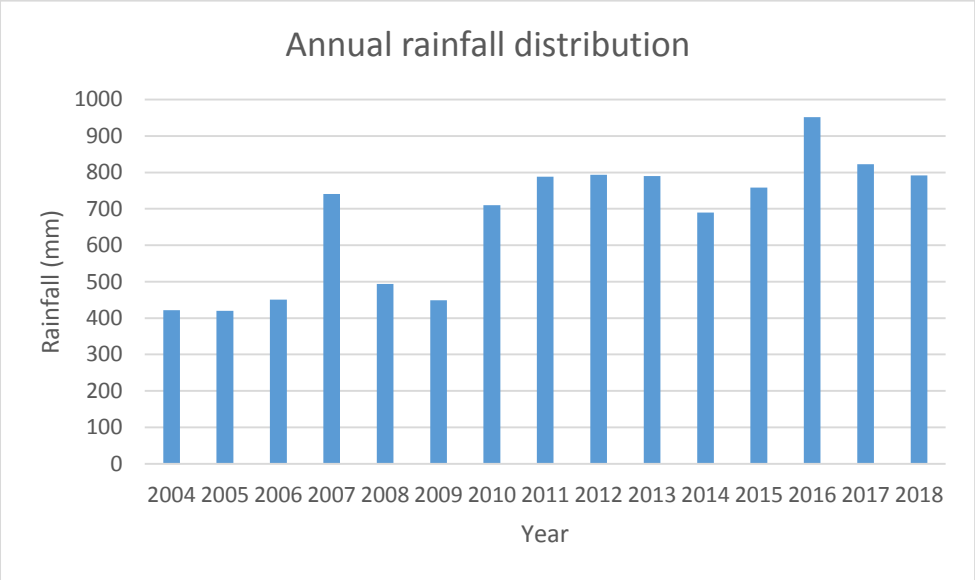


Figure 3: Annual rainfall distribution in Marakwet East Sub County

Source: Researcher 2019

From the findings, there are large differences in rainfall variability. For instance, annual rainfall increased from the year 2004 up to 2007. In the year 2008 and 2009, there was decrease in annual rainfall as compared to the year 2007. On the other hand, the annual rainfall from the year 2010 up to and including 2018 showed a lot of fluctuations which may be as a result of ENSO phenomenon.

Rainfall amounts and distribution are important for agriculture in Kenya. From the years 2004 up to 2009, rainfall received was not enough to sustain fodder production and livestock rearing.

There were poor crop harvests and rising livestock deaths which compelled the government to provide relief food for the people. Washington et al., (2006), stated that there was need for coming up with scientific and economic capacity that could help in understanding and coping up with existing climate variability.

Respondents confirmed that fodder production is one of the lasting solutions for climate variability adaptation. The main objective of producing fodder was for feeding livestock. This is illustrated by 65% that is the highest percentage. On the other hand, 35% of the respondents stated that they produce fodder for sale. Respondents stated that most of those who sold their fodder lost their livestock to cattle rustlers.

Table 4: Reasons for fodder production

Reasons for producing fodder	**Frequency**	**Percentages**
Livestock feed	65	65%
For sale	35	35%

Source: Researcher 2019

From the findings, napier grass (81%) is the dominant fodder crop that is grown in the sub county while maize crop is (4%) is rarely grown for as fodder crop. Other fodder grown are kikuyu grass (1%) and acacia trees (14%). In addition, the information from the key informant interviews confirmed that napier grass is the best fodder crop that does well in the sub county. It further concluded that napier is preferred by the livestock themselves and is adaptable to the surrounding. Advantages of growing napier include availability of seeds and can easily be produced. The grass is given to livestock when it is still fresh. Maize corps and stalks are dried and stored in traditional granaries for dry periods.

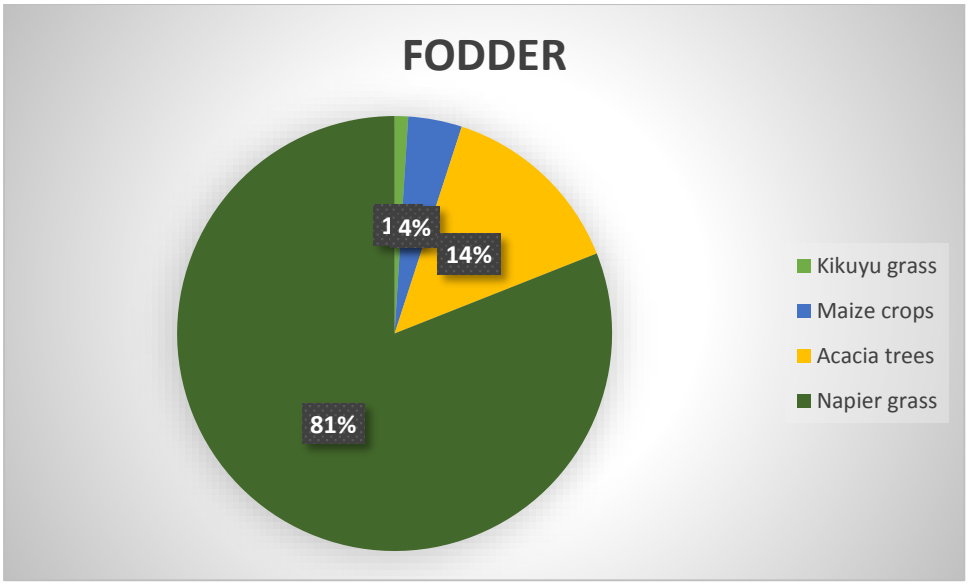


Figure 4: Fodder grown in Marakwet East Sub – County

Source: Researcher 2019

5.3. Drought frequencies in Marakwet East Sub – County

In ASALs of Kenya, drought is very common phenomenon and its intervals have changed today. From the findings, it was found that drought occurred at intervals of two or three years as indicated by the highest percentage that is 53%. This is echoed in the previous studies such as study which was done by Huho and Mugalavai (2010), which suggested that drought occurrences have increased particularly in the last three decades. The table below indicates their occurrences:

Table 5: Drought frequencies

Drought frequencies	Frequency	Percentages
3-6 months of rainfall	8	8%
Annually	2	2%
After 2 years of rainfall	53	53%
After 3 years of rainfall	37	37%
After 5 years of rainfall	0	0%

Source: Researcher 2019

Findings from the key informants indicated that for the past fifteen years, there has been variation in rainfall. For instance, the respondents stated that droughts occurred every after ten (10) years in the past two decades, but nowadays, droughts have become very rampant. Droughts now occur every 2-3 years and they are more severe compared to those that occurred in past many decades and they take more months compared to the past ones. The respondents too gave the trend of droughts for the last two decades. For instance in the years 1996/1997, 1999/2001, 2004/2006, 2008/2009 and 2010/2011, severe droughts were experienced in Marakwet East sub - county. It led to food insecurity which made the government to provide food for the households.

This drought information supported what Kaitho's and Gatarwa's (2006:2) said about drought frequency. They had indicated that drought occurrences had become more frequent than it used to be in the past few decades. They stated that drought occurs nowadays at intervals of three years and sometimes yearly as opposed to past which happened every after seven or ten years.

The warning of impending drought included drying up of trees and shedding leaves, clan elders observe intestines of slaughtered animals such as sheep, cows and goats, and patterns of stars. Marakwet people communicate climate variability information during *Barazas* and during traditional weddings.

Drought has significant effects in ASALs of Kenya. For instance rampant droughts were associated with changing livestock health, livestock deaths, and incidences of diseases and collapse of livestock markets (Speranza, 2010). Furthermore, explanations from the key informants showed that rising incidences of livestock diseases were associated with drought. Ruminants died as result of drought - related diseases. From the observation, it was concluded that conflicts occur as result of limited pasture and water resources along the borders of Tiaty and Marakwet East Sub – counties.

The people of Marakwet East sub - county practiced diversification as one of the other adaptation strategies. Reardon and Vosti (1995), stated that the importance of diversification was to create portfolio livelihoods with different risk attributes in that, risks associated with drought are managed properly in advance.

5.4. Socio-economic factors affecting fodder production

5.4.1. The ages of respondents

The ages of the respondents ranged from 15 to 66 years and above. 32% of them range from 26 to 35 years, 16% of them range from 36 to 45 and from 56-65, 14% of them range from 46 to 55, 12% range from 66 and above. The smallest percentage which is 10% falls between 15 to 25 years.

Table 6: Ages groups of household respondents

Age group	Frequency	Percentages
15-25	10	10%
26-35	32	32%
36-45	16	16%
46-55	14	14%
56-65	16	16%
66 and above	12	12%

Source: Researcher 2019

The ages of the respondents affects fodder production. Most household heads who were farmers in the study area were under forty five. They had economic effect particularly in fodder production and crop production that demands more labour. For instance, respondents between the ages 26-35, 36-45 and 46-55 are farmers who have energy that can be used in the farm. These people have energy to plough land, plant crops and harvest them. They are also able to look after livestock and provide necessary requirements for them to live and grow. Their age is economically active and was useful in efficient production and management of crop production.

5.4.2. Level of education of the respondents

The highest percentage that is 56% represents the respondents who ended their education in primary level. On the other hand, 7% represents those who never went to school in their entire life. Other percentage such as 34% represents those who completed secondary education and never continued with further education while 3% represents those who went to college to develop their careers. Those who never went to school claimed that education was not of any importance during their time. Those who never joined secondary school after completing primary education said that it was because of lack of school fees due to poverty level that was very high.

Others claimed that up to late 90s, girl child education was still not important since most parents preferred educating boys as boys were known to be heads of families and they said boy child would have many dependents. In addition, low education levels in the sub - county coupled with unemployment in the country made the household heads depend so much on livestock production that is highly affected by climate variability.

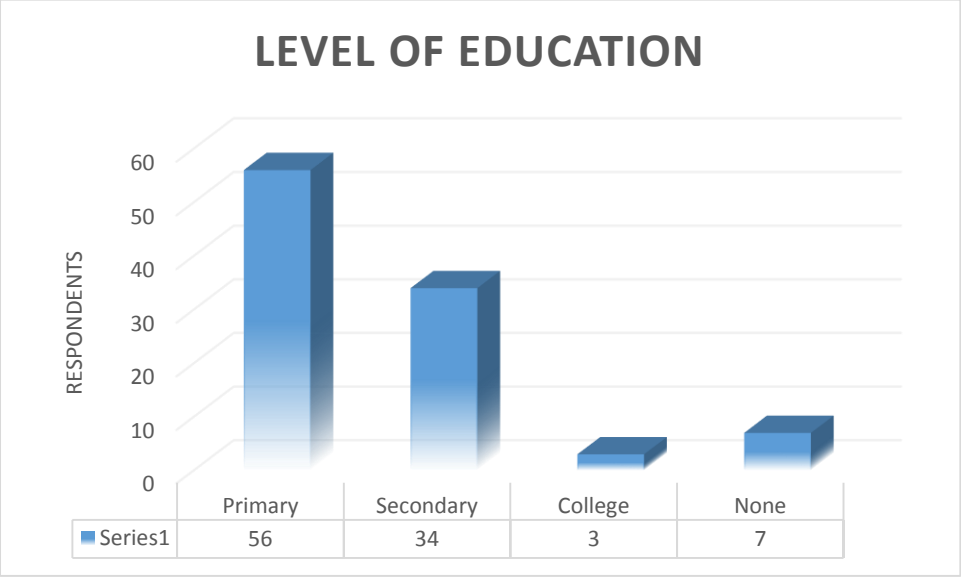


Figure 5: Level of education

Source: Researcher 2019

5.4.3. Marital status of the respondents

The findings show that 72% of the respondents were married while 5% were single. On the other hand, 7% separated and 16% were widowed. The widows and widowers purport to have

lost their spouses as a result of tropical diseases and insecurity which was experienced along Kerio Valley. There was a rampant cattle rustling along the border of Tiaty and Marakwet East Sub - counties. The single respondents were in the process of getting married.

There was no divorce rate in the sub – county because their customs and traditions value marriage so much and thus in case of any problem in a family, clan elders solve it immediately. The separated farmers claimed that it was due to poverty that led to separation as men could no longer provide for their wives which led to family wrangles hence separation. Dependency rate in families made household heads to produce fodder and rear livestock to earn income in order to provide for the families.

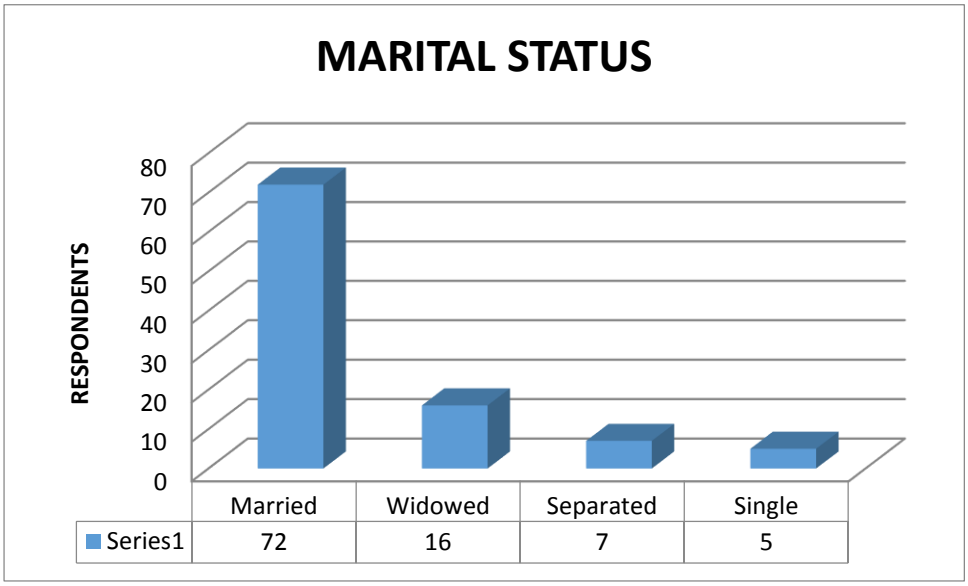


Figure 6: Marital Status

Source: Researcher 2019

5.4.4. Occupation of the respondents

From figure 4, more than half of the respondents (65%) were farmers, 20% were operating various businesses while 13% are working as casual labourers and others permanently employed by government. From the findings, most households practice farming as a source of food and income. I realized that even the employed respondents were engaging in farming because some of them have jobs but the standard of living was high that salary cannot meet personal needs. As a result of national economy, farming provided income that supplemented

salary from employment. 0% shows that nobody lives without doing anything in the sub – county. It shows that every individual is busy doing something in order to earn income.

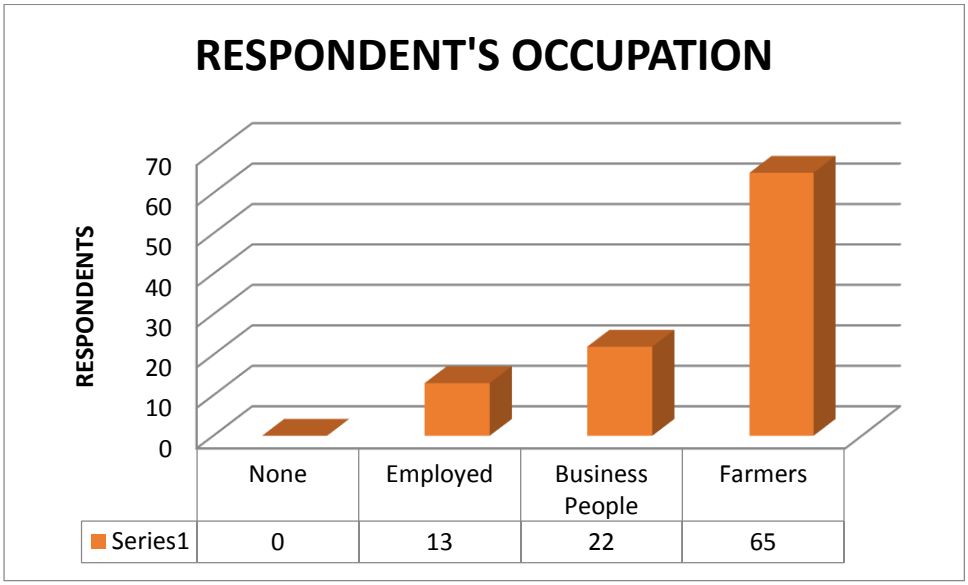


Figure 7: Occupation of the respondents

Source: Researcher 2019

5.4.5. Herd size

From the findings, many respondents who are farmers have large herd size (75%). This means that their livestock is more than one hundred (100) and it comprises of cattle, sheep and goats. The other farmers had herd size ranging from 51-100 which is represented by 11%, 21-50 which is 8% and 1-20 represented by 6%.

Herd size in the sub – county is high indicating that livestock keeping is the main economic activity. This confirms what KIPPRA (2015) stated that over sixty (60) percent of all livestock is found in the ASALs, where the sub sector employs roughly ninety (90) percent of the entire population.

Due to large herd size, the farmers grow fodder crops which can be used to supplement what the animals forage for themselves. This fodder is given to the livestock in the morning before

being released to grazing reserves and in the evening. The fodder have good nutritional value which is very important for the livestock growth and body development.

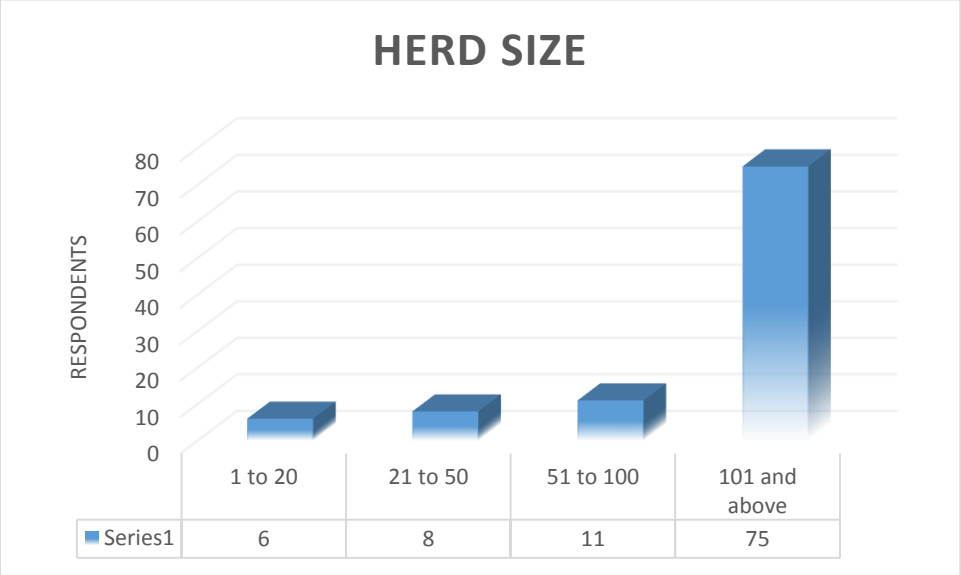


Figure 8: Herd size

Source: Researcher 2019

5.4.6. Environmental Conditions

Marakwet East is a medium potential sub – county with large numbers of livestock in mixed systems. The sub county is dry in most months of the year with average annual rainfall of 600mm. Annual rainfall variation affects moisture availability in the soil hence reduction in agricultural production. This is echoed by Mertz et al., (2010) who stated that both rainfall variability and its erratic distribution were the main factors that reduced crop and animal production hence income.

Livestock production depends so much on natural systems. This makes it highly sensitive to climate variability particularly changes in climatic factors (rainfall and temperature). Rainfall in the sub county is unpredictable hence resulting to frequent droughts, loss of livestock due to starvation, flooding, increased land encroachment and spread of livestock diseases. On the other hand, high temperatures degrades resources in the land hence causing starvation and rampant deaths of livestock. This conquers with what Mwiturubani and Van Wyk (2010), stated that decimation of animals has severe consequences for livestock farmers as their survival depends much on their livestock.

Due to climate variability, the pasture available is not enough for the livestock throughout the year. This therefore makes farmers to grow fodder as a supplement during dry seasons. The fodder grown in the sub county include napier grass, kikuyu grass, maize and acacia trees.

5.4.7. Reduction of communal grazing reserves

Population growth rate in Marakwet East sub – county is high (2.8%) and population density is one hundred and twenty two (122) people per kilometre square. Land in Marakwet East sub - county is communally owned. As a result, people encroached grazing reserves to get a space for settlement. As population increases, livestock numbers increase also because it is the main economic activity. As a result, a lot of land is lost to people which was initially a grazing reserve. This therefore forces farmers to grow fodder for livestock consumption during dry season.

5.5.Results from Correlation Analysis

Land in Marakwet East sub – county is communally owned. This means that resources such as water and pasture are also communally owned and every person belonging to the community is allowed to use them freely. These resources depend on rainfall for their growth and existence.

However, climate variability (temperature and rainfall) affected availability of water and pasture in the sub-county. It led to reduction in natural pasture and water availability. In turn, it resulted to competition of resources which eventually led to decline in livestock production and conflict with neighbouring communities. As a result of limited natural pasture, the community introduced fodder production to supplement natural pasture that the livestock forage for themselves.

From the findings, annual rainfall is an important factor in growing fodder for livestock consumption. Rainfall is also important as a source of water for livestock consumption.
Rainfall contributes to 58.4% of variability in sales of livestock. This indicated that there were other factors that contributed 41.6% of livestock sales. These other factors included community's culture, economic demands, disease outbreak and conflict.

The null hypothesis was rejected because the calculated value statistic was greater than the critical value. This led to adoption of alternative hypothesis which confirms that there is significant relationship between rainfall variability and livestock sales. This could be attributed to the fact that;

- Livestock is the main economic activity
- Farmers will find other sources of fodder for livestock
- As the rainfall increases, sale of livestock reduces gradually
- Storage of fodder for drought period

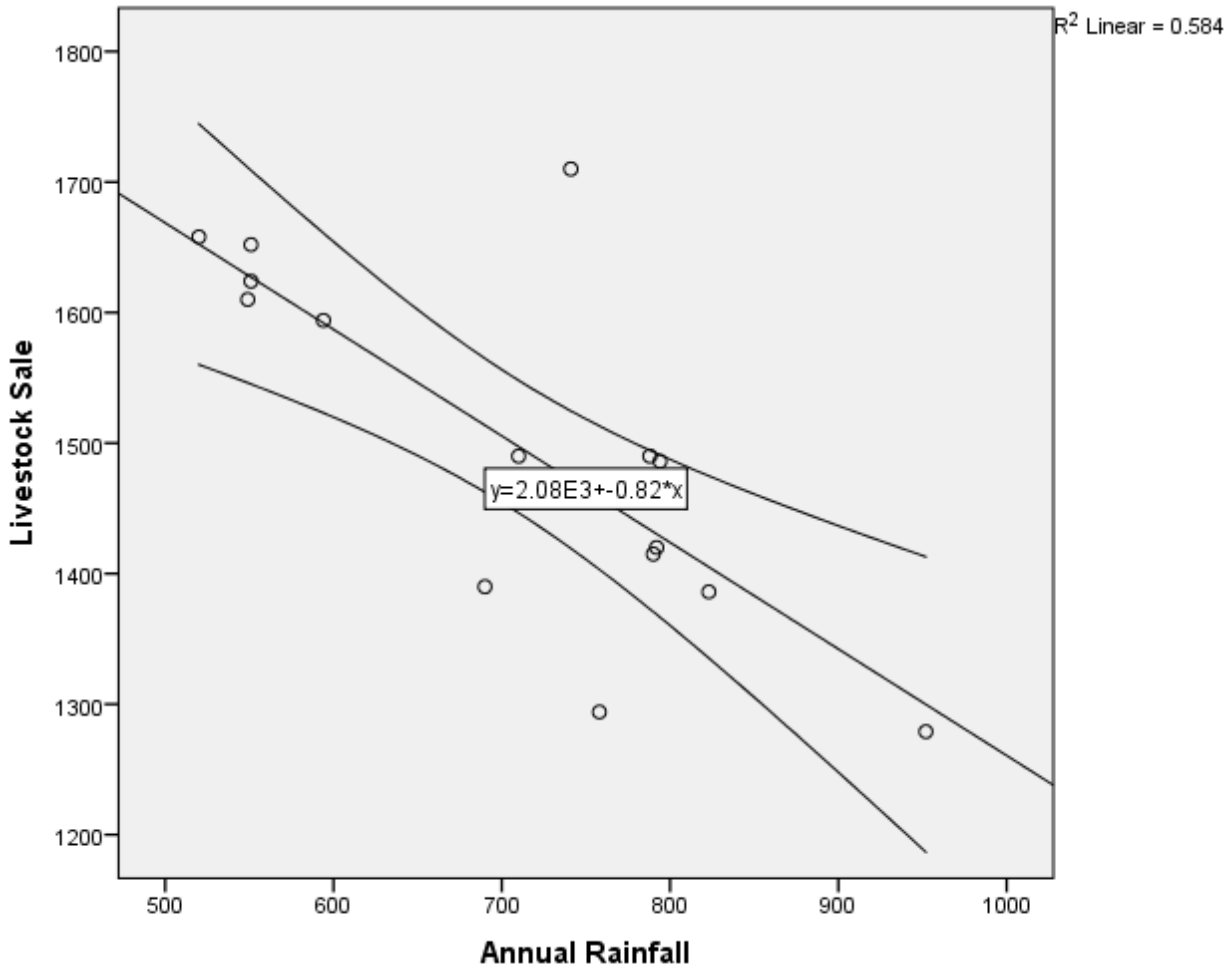


Figure 9: **Livestock sales and annual rainfall**

Source: Researcher 2019

This graph is simple linear regression where X (annual rainfall in mm) is independent variable while Y (annual livestock sales) is the dependent variable. Livestock sales depends on annual rainfall distribution. The relationship between the two variables is linear but negative meaning that as annual rainfall increases, sales of livestock are lower (figure 7). The coefficient of determination of 0.584 means that any change in annual rainfall will affect about 58% change in the sale of livestock in Marakwet East sub – county.

Data of livestock sales was used instead of fodder production data. This was because the farmers were not recording any information on fodder production. Also land over there is

communally owned which make it impossible to approximate land size and quantity of fodder produced in every season.

When rainfall is enough fodder is produced in large quantities and harvests become good. This means that livestock won't die and also cannot be sold in large numbers. This means that farmers may sell them only to get money for various uses such as school fees, to buy food and other personal uses. On the other hand, when there is limited rainfall and also during dry seasons in the sub county, fodder production becomes poor. This therefore, forces farmers to practice culling and sell many of their livestock in fear of starvation during drought.

CHAPTER SIX: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1.Introduction

This chapter provides summary of the findings from field. It also gives conclusions and recommendations of the study based on the objectives of the study. The study is aimed to give sustainability of fodder crops as an adaptation to climate variability.

6.2. Summary

Climate variability is a major threat facing humanity today. It has led to an increase in global temperatures, widespread melting of snow and ice caps, while rising global mean sea level. The effects of climate variability on societies are a result of extreme events, which vary from one region to another basing on the amount of energy from the sun and the circulation of the atmosphere and oceans which carry heat and moisture from one place to another. Poor households highly rely on economic activities that are more sensitive to climate variability. For instance, crop and livestock production are activities that rely on local weather and climatic conditions. This means that variations in temperature and rainfall could directly interfere with productivity levels, therefore diminishing livelihoods.

Marakwet East Sub – county households just like other arid and semi-arid households are farmers rearing livestock. Livestock production in the past few years was affected by climate variability that resulted in the reduction of wild pasture and water. This affected livestock production which is widely known as the mainstay of rural households in Kenya and contributes a lot to their livelihoods. However, adaptation strategy was sought by the locals to be a solution to climate change hence improving livestock production which is a backbone of the community.

6.3. Conclusions

This study sought to investigate climate variability adaptation using fodder crops in the dry lands of Marakwet East sub - county, Elgeyo - Marakwet County. Majority of the households understand climate variability as sunny days, inadequate and unpredictable rainfall in the area. They believe that climate variability occurs due to deforestation that took place in the whole sub-county. For instance the main gazetted forests such as Embobut and Tirap had their trees cut down and others drying up. These forests are believed that have been source of rainfall to the sub county which made rivers flowing down the valley to ever full. They also stated

population growth as the other factor which made some hills to be cleared to get space for settlement. The community have their own ways of communicating warning on impending disasters associated with climate variability.

The effects of climate variability in the sub - county included drought, heat stress, tropical diseases, conflicts and flood. Prolonged droughts and floods have led to deaths of livestock resulting to severe food insecurity and finally poverty. As a result, the households were given relief food for about five years by the government.

The findings of this study states that climate variability affects livestock production. Reduction of wild pastures and drying up of streams leads to death of livestock. Increase in temperature leads to reduction in grassland leading to decline in anima productivity as well as affecting their health. Drought forces the livestock keepers to sell most of their livestock and practice culling on the remaining in order to reduce losses associated with it.

Majority of the respondents believed in fodder production as an adaptation to climate variability. The reasons why they believed in it include increment in milk production as Napier grass acted as stimulant, improved livestock health and reduction in livestock deaths. Surplus can as well be sold to earn income. The entire adaptation process has helped the community to improve livestock production and reduced food insecurity.

Lastly, there is negative linear correlation in the hypothesis test. This is because when rainfall is adequate, livestock sales goes down, while when rainfall is insufficient, livestock sales increases. With good harvest from fodder production, farmers would have enough feed for their livestock that could sustain them throughout the year hence getting enough milk for consumption and sale.

6.4. Recommendations

The study suggests the following recommendations basing on the research findings:

6.4.1. Recommendations for policy makers

i. The study recommends that households should be educated on the risks of climate variability, its causes and effects so that they can minimize deforestation and stop charcoal burning. They also need to understand their environment and its carrying capacity.

ii. The study recommends that both national and county governments through NGOs and Private organizations should promote fodder production by providing seeds, training programmes and improving furrows to boost irrigation in order to get enough produce that could last throughout the entire drought season.

iii. The county government should support livestock production by strengthening their extension work in veterinary drug provision for both prevention and treatment, organized grazing and controlled breeding management.

6.4.2. Recommendations for further research

i. Further research be done on the importance of fodder crops on the environment and livestock keeping.

ii. There is need for research on the effects of conflicts in economic welfare by investigating the impact of migration on livestock keeping in the sub county.

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APPENDICES

Appendix i: Household questionnaire

The questionnaire is used to collect data for the degree of Master of Arts in Environmental Planning and Management, Department of Geography and Environmental Studies. An informational collected shall only be used for academic purposes and shall be treated with high level of confidentiality.

SECTION A: GENERAL INFORMATION

1. Name of respondent …….
2. Age: 15-25 [ ] 26-35 [ ] 36-45[ ] 46-55[ ] 56-65[ ] 66 and above [ ]
3. Education level: (a) Primary [ ]
   (b) Secondary [ ]
   (c) College [ ]
   (d) None [ ]
4. Marital status: Single [ ] Married [ ] Divorced [ ] Separated [ ] Widowed [ ]
5. Occupation: (a) Business [ ]
   (b) Farmer [ ]
   (c) Employed [ ]
   (e) Others (specify) [ ]

SECTION B: LIVESTOCK PRODUTION

6. How many livestock do you have?
   a) 1-20 [ ]
   b) 21-50 [ ]
   c) 51-100 [ ]
   d) 101 and above [ ]
7. Apart from livestock production, do you have other farm related activities? Yes [ ]No [ ]

SECTION C: PERCEPTION OF CLIMATE VARIABILITY AND ITS EFFECTS

8. Have you experienced any climate variability in this region for the last five years?
   Yes [ ] No [ ]
9. What could have caused climate variability?
   a) Deforestation [ ]
   b) Any other [ ]
10. What indicates climate variability in this region?
    a) Increased disease prevalence [ ]
    b) Reduced rainfall and high temperatures [ ]

c) Food insecurity [ ]

d) Death of livestock as a result of reduced pasture and water [ ]

11. After how long the indicator you have mentioned above occurs in the locality?

a) 3 months [ ]

b) 3-6 months [ ]

c) 6-12months [ ]

d) Yearly [ ]

e) Every 3 years [ ]

12. Which is the best way of passing information on climate variability in this region?

a) Radio [ ]

b) Television [ ]

c) Ceremonies [ ]

d) *Baraza* [ ]

13. Do you have any encounters with drought associated with climate variability? Yes [ ] No [ ]

14. How frequent is drought occurrence in your sub-county?

a) Monthly [ ]

b) Every three (3) months [ ]

c) Yearly [ ]

d) Every three (3) years [ ]

15. What is the adverse effect of drought associated with climate variability?

a) Increased deaths of livestock and people [ ]

b) Increased poverty rate of households [ ]

16. Is there any difference between the droughts experienced in the past decades and the ones occurring in this decade? Yes [ ] No [ ]

SECTION D: EFFECTS OF CLIMATE VARIABILITY ON LIVELIHOODS

17. What is the social effect of climate variability in your community?

a) Separation of families [ ]

b) Increased school drop outs [ ]

c) Increased food insecurity [ ]

d) Conflict [ ]

18. Have you been sharing resources with other communities? Yes [ ] No [ ]

19. Which resource have you been sharing with neighbouring communities?

a) Water and pasture [ ]

b) Salt licks [ ]

c) None [ ]

20. Has the sharing of resources been affected by climate variability? Yes [ ] No [ ]

SECTION E: FODDER PRODUCTION

21. Do you produce fodder? Yes [ ] No [ ]

22. What is the main objective of producing fodder?

a) Feeding my livestock [ ]

b) For sale [ ]

c) Leasing out for income [ ]

23. What is the socio-economic factor affecting fodder production?

a) Livelihood options [ ]

b) Past experience with drought [ ]

c) Herd size [ ]

d) Age of household head [ ]

e) Reduction of communal grazing reserves [ ]

24. Where did you learn about fodder production?

a) KALRO [ ]

b) Neighbouring farmers [ ]

c) Farmer groups [ ]

d) Others (specify)……..

25. Which fodder species do you grow?

a) Napier grass [ ]

b) Maize [ ]

c) Kikuyu grass [ ]

d) Others (specify)……..

26. Which fodder species do you get from the wild?

a) Acacia trees [ ]

b) Lantana [ ]

c) Star grass [ ]

d) Others (specify)……..

27. Which factor (s) influenced the choice of fodder that you grow?

a) Preference by livestock [ ]

b) Availability of seeds [ ]

c) Cost of production [ ]

d) Adaptability to the area [ ]

e) Other (specify)……..

28. What major constraint do you face in fodder production?

a) Inadequate water supply [ ]

b) Fodder crop diseases [ ]

c) Poor market prices [ ]

d) Other (specify)……..

29. Do you sell fodder? Yes [ ] No [ ]

30. If yes, whom do you sell your fodder to?

a) Local consumers [ ]

b) Traders [ ]

c) None [ ]

d) Others (specify)……

31. What are the selling arrangements?

a) Contract [ ]

b) Freelance [ ]

c) Both [ ]

d) None [ ]

32. Is the adaptation of climate variability sustainable in your community? Yes [ ] No [ ]

33. Have you attended any agronomic training on fodder production? Yes [ ] No [ ]

THANK YOU FOR YOUR TIME.

Appendix ii: Observation checklist

1. Topography of the study area.
2. Type of vegetation in the study area.
3. Forage available in the study area.
4. Types of houses lived and food eaten by residents.
5. Activities undertaken by the people in the area.

Appendix iii: Total Annual Rainfall

Year	Average annual rainfall
2004	422mm
2005	420mm
2006	451mm
2007	741mm
2008	494mm
2009	449mm
2010	710mm
2011	788mm
2012	794mm
2013	790mm
2014	690mm
2015	758mm
2016	952mm
2017	823mm
2018	792mm

Appendix iv: NUMBER LIVESTOCK SOLD FROM THE YEAR 2004 T0 THE YEAR 2018 IN THE ENDO AND SAMBIRIR WARDS

S.NO.	YEAR	LIVESTOCK SOLD
1.	2004	1658
2.	2005	1652
3.	2006	1710
4.	2007	1594
5.	2008	1610
6.	2009	1624
7.	2010	1490
8.	2011	1490
9.	2012	1486
10.	2013	1415
11.	2014	1390
12.	2015	1294
13.	2016	1279
14.	2017	1386
15.	2018	1420