FACTORS INFLUENCING FARMERS' RESPONSE TO CLIMATE VARIABILITY IN NAROK EAST SUB-COUNTY, KENYA

KELVIN JOHN KINUTHIA

A thesis submitted to the Graduate School in partial fulfillment for the requirements of the Master of Science Degree in Natural Resource Management of Egerton University

EGERTON UNIVERSITY

OCTOBER 2018

DECLARATION AND RECOMMENDATION

DECLARATION

I hereby declare that this thesis is my original work and has not, wholly or in part, been presented or submitted for examination for an award of a degree in any other University.

Sign: ___________________

Kelvin John Kinuthia (NM11/51506/14) Date: _____________

RECOMMENDATION

This thesis has been submitted with our approval as University supervisors

Sign:____________________

Dr. Shadrack Kinyua Inoti, PhD

Department of Natural Resources

Egerton University Date:______________

Sign:____________________

Prof. Lenah Nakhone, PhD

Department of Crops, Horticulture and Soils

Egerton University Date:______________

COPYRIGHT

DEDICATION

I dedicate this thesis to my mother, Ms. Joyce Wanjira Kinuthia for her emotional, spiritual and financial support during the course of my studies.

ACKNOWLEDGEMENT

I am grateful the Almighty to God for seeing me through my study period, for blessing me with good health and all the necessary means to complete this course. I also acknowledge Egerton University for providing me with the opportunity and the means to pursue this Degree in a conducive environment, especially the teaching and non-teaching staff at the Department of Natural Resources. I am also grateful to my supervisors, Dr. Shadrack Kinyua Inoti and Prof. Lenah Nakhone for their guidance, corrections and time invested in my work. Finally, I would like to appreciate my family and friends for their encouragement and support.

ABSTRACT

There is sufficient evidence to show that climatic conditions are changing all over the world. The agricultural sector, especially in developing countries, is one of the hardest hit by the impacts of climate change and variability. Within these countries, the arid and semi-arid areas are the most vulnerable to the impacts of climate change and variability. Farmers in these regions have to cope and adapt to changes in climatic conditions so as to reduce losses. There are many response strategies to climate change and variability that farmers can use, but some strategies are adopted at a higher rate than others. This study was carried out in Narok East Sub-county, an area that represents one of the semi-arid regions in Kenya. The objective of the study was to find out the main changes in climatic patterns that the farmers of Narok East Sub-county have perceived, how they are responding to the threat of climate variability and the factors that influence their choice of response strategies. A cross-sectional research design was used for the study whereby a household survey was carried out to collect data, with a questionnaire being the main data collection tool. Multi-stage sampling technique was used with a total of 223 household heads being interviewed. Key informant interviews and one focus group discussion with 16 participants was also used to supplement data from the household survey. Descriptive statistics were used to summarise and analyse the data. Principal Component Analysis in conjunction with multivariate probit model was used to determine the factors that influence farmers' choice of response strategies. Results showed that farmers had perceived changes in climatic patterns especially in regards to increase in temperatures and reduction in rainfall. The results also showed that farmers had taken up various crop production strategies, with early planting, use of organic and inorganic fertilizers, terracing and planting short season crops being the most preferred. Among the livestock production strategies identified, herd reduction, transhumance, fencing farms and buying new breeds of animals were the most preferred response strategies. The Principal Component Analysis grouped the response strategies into four components, both for the crop production and livestock production strategies. Results of the multivariate probit analysis show that household head characteristics, household size, noticing changes in mean annual rainfall and onset of rains, receiving weather information and the land tenure system were all significant factors that influence choice of response strategy either positively or negatively. This study therefore recommends for more awareness creation and training of farmers of Narok East on how to identify and deal with changing climatic conditions.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

ASALs	Arid and Semi-Arid Lands
CBD	Convention on Biological Diversity
ENSO	El Nino Southern Oscillation
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
GDP	Gross Domestic Product
ITCZ	Inter Tropical Convergence Zone
IPCC	Intergovernmental Panel on Climate Change
GHGs	Green House Gases
GoK	Government of Kenya
KNBS	Kenya National Bureau of Statistics
MCA	Member of County Assembly
NACOSTI	National Commission for Science, Technology and Innovation
NGO	Non-governmental Organisation
OECD	Organisation for Economic Co-operation and Development
PCA	Principal Component Analysis
SDGs	Sustainable Development Goals
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

CHAPTER ONE

INTRODUCTION

1.1 Background information

Climate change is considered one of the most serious threats to sustainable development in the world (Kalungu, Filho, and Harris, 2013). Although climate change is a normal phenomenon which has been happening naturally in the past, it is now happening at a faster rate, with research showing that anthropogenic activities are responsible for the increased rate. For example, the current rate of atmospheric temperature increase is the highest seen in the last 800000 years (Dinse, 2010). Burning of fossil fuels, cement production and deforestation are the anthropogenic activities that contribute the most to climate change and variability (Almassy, 2014). Climate variability can be explained as the way climate fluctuates yearly above or below a long-term average value of a variable such as temperature or rainfall (Dinse, 2010).

Recent studies have shown that global climatic patterns have been changing, for example, the land and ocean surface temperatures have risen by 0.65 to 1.06 °C between 1880 and 2012, the number of warm days and nights has increased, the average Artic ice volume has decreased and sea level has risen (Stocker *et al*., 2013). Extreme weather events such as droughts, storms and floods have also been on the increase (UNDP, 2015). Such changes have led to some observed impacts such as changes in snow, ice, frozen ground, terrestrial and marine ecosystems and ocean acidification (UNFCCC, 2014). Of all the economic sectors that support livelihoods, agriculture is probably the one that is most dependent on climate (Antle, 2008).

Depending on the region and type of agriculture, climate change is expected to lead to changes in crop and livestock productivity (Antle, 2008). A warmer climate will increase food insecurity especially in Africa (Ngaira, 2007). A temperature increase of 1-3° C will cause a decrease in major crop yields in developing countries that are not properly equipped to adapt (Rosegrant *et al*., 2008). Climate change and variability is also increasing water scarcity, pollution and soil degradation (OECD, 2015). As the global surface temperature rises, agriculture will be more productive near the poles, deserts and grasslands are expected to increase, marginal agriculture will be threatened, there will be coastal flooding and ocean ecology will be altered (Ngaira, 2007). The change in rainfall patterns and mean temperature will also lead to increased incidents of pests and diseases (Rosegrant *et al*., 2008). Droughts and storms are also expected to become more frequent and therefore contribute to lower productivity which may lead to conflicts over scarce resources (Kabubo-mariara and Kabara, 2015). Furthermore, extreme weather events have already caused significant increases in food prices all over the world, causing both political and economic crises (Mazhirov, 2011).

The Government of Kenya acknowledges that climate change and variability and its effects are a common concern of all humankind (GoK, 2010). Climate change and variability in regards to agriculture is a major concern in Kenya since agriculture is the biggest employer (about 82% of the population), the largest contributor to the GDP (30%) and the largest export sector with 70% of export earnings (Kabubo-Mariara and Karanja, 2006). Despite this great importance of agriculture, only 12% of the country is considered high potential, with the remaining 80% being considered as arid and semi-arid (Ojwang, Agatsiva, and Situma, 2010). This therefore means that the arid and semi-arid areas of Kenya are not only under pressure from climate change and variability, but also from increased conversion to agricultural farms (Ojwang *et al*., 2010).

Some of the extreme climatic events that have been experienced in Kenya such as the severe drought in January 1997, El Niño rains of 1997/98, severe drought in the year 2000 and the devastating floods in the year 2004 can be attributed to climate change and variability (Kandji and Verchot, 2006). The Government of Kenya (2010), noted that climate change and variability has already caused some adverse impacts including; increase in the extent of arid and semi-arid land, loss or decline of important and indigenous species, loss of rangelands, reduction in fresh water availability, loss of coastal land as a result of sea level rise, increase in food insecurity, increased prevalence of livestock and human diseases, increase in human wildlife conflicts, migrations and displacement, loss of fish biomass and hampered energy production. All over the country, droughts continue to interrupt rainfall patterns leading to harvest failures, deteriorating pastures, water scarcity and livestock loss (Kabubo-mariara and Kabara, 2015). Such impacts of climate change are expected to get worse this century (GoK, 2013).

Although many places in Kenya are vulnerable to the effects of climate change and variability, the arid and semi-arid areas including Narok County are the most vulnerable especially in relation to food and livelihood security (Kandji and Verchot, 2006). According to Ngaira (2007), Kenya's ASALs have been experiencing droughts and unpredictable rainfall patterns since 1960. Kenya's dry lands are experiencing higher frequency and severity of droughts and floods, which are expected to increase in the coming years (Ojwang *et al*., 2010). In the period between 1950 and 2007, Narok County experienced an overall decline in rainfall amounts and a steady increase in mean temperature (Ojwang *et al*., 2010). The region has also experienced an increase in the frequency and intensity of extreme weather events, especially droughts, and a delayed onset of rains, the rivers and streams in the County have also seen receding water levels (Mulenkei, 2015).

A farmer's ability to perceive such changes in climatic patterns has been linked to their ability to adapt (Komba and Muchapondwa, 2012). Perceiving climate change and variability is, however, also influenced by certain socio-economic factors (Debela, Mohammed, Bridle, Corkrey, and Mcneil, 2015; Mamba, 2016). According to Mamba (2016), a more educated was farmer, an older farmer, a female farmer and a farmer with access to weather data and extension services was found to be more likely to perceive climate change and variability more accurately than a less educated farmer, a younger farmer, a male farmer and a farmer without access to weather data and extension services respectively.

When farmers and pastoralists in the affected areas notice changes in climatic patterns, they normally respond by adopting various coping mechanisms (Rakgase and Norris, 2014). These adaption mechanisms do not aim to prevent all adverse impacts of climate variability or clean-up after a disaster, but to create long-term resilience within concerned communities (Obayelu, Adepoju, and Idowu, 2014). In Africa and other developing countries, those farmers take up both traditional and modern adaptation strategies (Nti, 2012). Most communities in African countries affected normally resort to irrigation, crop diversification, agroforestry practices and changing planting dates (Komba and Muchapondwa, 2012). In Narok, 91 % of farmers reported to having changed their farming practices so as to adapt to climate change (Mulenkei, 2015).

Many factors have been hypothesized as influencing farmers' choice of response strategies to changing climate. These mostly include; socio-economic factors of entire communities or individual households, or institutional factors at play in the regions affected by climate variability or change. The most common factors identified as influencing farmers' choice of climate change and variability adaptation include; farmer's age, education, gender, size of the household, annual family income, access to credit, access to extension services, farm size, access to information on climate change and observing climate variability (Komba and Muchapondwa, 2012; Nti, 2012; Obayelu *et al*., 2014; Uddin, Bokelmann, and Entsminger, 2014) The significant factors change from region to region.

With the knowledge that Narok East Sub-county is already experiencing climate change and variability and its impacts, this study aimed at investigating certain critical questions in order to improve adaptation to climate variability. This was done in order to fill the critical knowledge gaps in regards to those questions and also to help the farmers, the local government and local NGOs come up with a better climate change and variability adaptation strategy. An improved strategy would contribute to better food security and improved livelihoods.

1.2 Statement of the problem

The phenomenon of climate change and variability has been receiving a lot of global attention. This is because it has wide implications on natural biodiversity and also the socio-economic aspects of human existence. In most developing countries, the agricultural sector and crop farming is largely rain-fed and decline or variability in rainfall has implications on productivity. Kenya, as one of the developing countries in question, usually experience losses of both crops and livestock due to unreliable rainfall patterns and the occurrence of extreme weather events. Since agriculture is the mainstay of Kenya's economy, failure to adapt effectively to climate change and variability will lead to increased food insecurity, rising food prices and massive unemployment. Narok East, being a semi-arid region, is more vulnerable to the impacts of climate change and variability. The ever increasing population and conversion of land for agricultural purposes only serves to make the region more vulnerable. The national and county governments have put in place measures to help farmers and pastoralists adapt to changing climate. The farmers and pastoralists in Narok East Sub-county have also tried to adapt to the changing climatic conditions, using both traditional and modern adaptation strategies. Despite these efforts, the farmers still experience low productivity and heavy losses due to unreliable rainfall and extreme weather events such as drought. While it is clear that some adaptation strategies are more effective than others, the farmers and pastoralists of Narok East have not taken them up at the same rate. Currently, it is not well understood why farmers choose certain response strategies over others, a factor that may be influencing their ability to cope effectively. This study sought to investigate which factors influence farmers' choice of response mechanisms to climate variability in Narok East Sub-county.

1.3 Objectives

1.3.1 Broad objective:

The broad objective of the study is to contribute towards achievement of food security in Kenya's Arid and Semi-Arid Lands through improved community based adaptation strategies to climate variability.

1.3.2 Specific objectives

i. To document the changes in climatic patterns as perceived by farmers in Narok East Sub-County in the years between 1996 and 2016
ii. To assess the adaptation and coping strategies to climate variability by farmers in Narok East Sub-county
iii. To determine the factors that influence adaptation and coping strategies to climate variability for farmers in Narok East Sub-county

1.4 Research questions

i. What are the main changes in climatic patterns that farmers in Narok East Sub-county have perceived between the year 1996 and 2016?
ii. What are the adaptation and coping strategies to climate variability adopted by the farmers in Narok East Sub-county?
iii. Which factors influence farmers' choice of response strategies to climate variability in Narok East Sub-county?

1.5 Justification of the study

There is a general agreement that the whole world needs to find a way to mitigate climate change and variability and also deal with its impacts. This agreement is well summarized in the UN's Sustainable Development Goal 13 which aims to 'take urgent action to combat climate change and its impacts (UNDP, 2015). If climate change is left unmitigated, it can make it difficult to achieve the other SDGs especially the ones that seek to end hunger, achieve food security and promote sustainable agriculture (Reeves and Huq, 2015). Kenya on her part also recognizes the importance of integrating climate change information in its development policies such as the Vision 2030 and also in its National Climate Change Response Strategy (GoK, 2010).

Research in climate change and variability, its impacts and how Kenyan communities are adapting to it is therefore paramount if the country is to achieve its development goals. Narok East Sub-county as one of the arid and semi-arid areas of Kenya is vulnerable to the impacts and effects of climate change and variability. Research has shown that climatic patterns in the region are already changing (Ojwang *et al*., 2010). Erratic rainfall patterns and extreme weather events usually contribute to losses for both crops and livestock. Understanding the current situation will facilitate better coping and adaptation to changing climate. Farmers in this Sub-county have to deal with the impacts of climate change and variability, in order to safeguard their agricultural livelihoods.

There is limited information on how farmers are responding to climate variability. This study is designed to study the perception of farmers to climate variability and how they respond to the phenomenon. Information gathered during this study will be shared with the farmers and also used to recommend better and more effective ways of dealing with the impacts of climate variability on their livelihoods. Both the county government and the national government through the ministry of agriculture may use the information generated by this study to help improve the existing policies on climate change and agriculture. NGOs operating in Narok County may also use the information to advise the farmers on suitable coping and adaptation strategies to climate variability.

1.6 Scope and limitations of the study

The study was conducted within Narok East Sub-county, which was used as a representative of the arid and semi-arid areas of Kenya and also because the region is already experiencing the impacts of climate change and variability. Only farmers with at least 20 years of experience farming or keeping livestock in the Sub-county were interviewed. This is because they were in a better position to have noticed climate variability and extreme weather events over a period of time. In terms of the independent variables, this study limited its investigation to household characteristics, land tenure and access to weather information and did not include institutional factors, distance to a market and government policies as outlined in other similar studies.

1.7 Assumptions of the study

Considering that a questionnaire was the main data collection tool, the assumption was that the respondents would give truthful and accurate information to all the questions. The study also assumed that climate change and variability has been significant enough for the farmers in Narok East sub-county to notice and respond to questions appropriately. Further, the study assumed that farmers would be able to recall significant details about climate variability over a period of 20 years. The last assumption was that the household head would be available for the survey when their household was visited.

1.8 Operational definition of terms

Adaptation strategies encompasses all activities undertaken to adjust human systems in response to actual or expected climatic stimuli or their effects which reduces the impact of the stimuli or brings about certain benefits. Such activities are usually undertaken with a long term vision

Climate change statistically significant variation in the mean state of the climate persisting for an extended period of time (decades or longer) whether due to natural variability or as a result of human activity or a combination of both factors

Climate variability refers to variations in the mean state and other statistics (such as standard deviation, statistic of extremes) of the climate on all temporal and spatial scales beyond that of individual weather events

Coping Strategies activities that are undertaken after certain climatic conditions have already occurred with the goal to minimize loss. They are usually short-term in nature

Drought the phenomenon that occurs when precipitation is significantly below normal recorded levels causing serious hydrological imbalances that often affect land resources and agricultural production systems

Extreme weather event a climatic event that is rare within its statistical reference distribution at a particular place, and it normally encompasses droughts and floods

Food Security **t**he situation whereby people have access to sufficient amounts of safe and nutritious food for normal growth, development and an active and healthy life

Response strategies refers to all actions taken by members of a community either before or after a certain climatic or extreme weather event that are meant to minimize loss associated with that event

Vulnerability the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change and variability and extremes

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter is an in-depth review of available literature on the topic of climate change and variability in regards to its causes and trends and its impact on agriculture and livelihoods. Literature on adaptation strategies taken up by farmers and the factors that influence their choice of adaptation strategies is reviewed. The critical knowledge gaps that this study aimed to fill are highlighted. The theoretical framework that guided this study and the conceptual framework as visualized by the author are also discussed.

2.2 Climate change and climate variability: causes and trends

In simple terms, climate can be described as the average weather conditions in an area over a period of time (IPCC, 2007). Global climate conditions are the result of the atmosphere, glaciers and ice sheets, living organisms, oceans, soil, rocks, sediments and their interaction with each other. It therefore changes continuously over time (Devkota, Paudel, Bhuju, and Kubota, 2012). UNFCCC (1992) defined climate change as 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.'

Climate variability is however defined as the way climate fluctuates yearly above or below a long-term average value of a variable such as temperature or rainfall (Dinse, 2010). Since climate naturally fluctuates year to year, climatic trends are calculated over a period of 30 years, referred to as a climatological normal, so as to get a figure not influenced by yearly variability (Dinse, 2010). Other than the difference in meaning, the two concepts can also be separated by the fact that climate change is that change in climatic conditions that can be attributed directly or indirectly to anthropogenic activities (GoK, 2013).

Climate change and variability is partly attributed to emission of greenhouse gases (GHGs), which is currently on the rise due to increasing world population and industrial development (Amedie, 2013). Ironically, even the agricultural sector is a major contributor of greenhouse gases emission, which contributes to climate change and variability (OECD, 2015). Human induced actions such as large scale deforestation, widespread use of land and increased consumption of fossil fuels can also exacerbate climate change (Obayelu *et al*., 2014).

On the other hand, there are natural forces that also contribute to climate variability, chief of which is the El Nino- Southern Oscillation (ENSO) (Dore, 2005). The ENSO phenomenon constitutes two parts; one is the exceptionally warm sea temperatures of the tropical Pacific and second is the Southern Oscillation which together are linked to big changes in the atmosphere (Trenberth, 2013). As a whole, the phenomenon leads to major variations in precipitation and temperature over the tropics and sub-tropics, and also some mid-latitude areas (Dore, 2005; Trenberth, 2013). Different parts of the world are affected differently by ENSO, with the mid and high latitude areas receiving more precipitation while some parts of Africa, for example, East Africa having suffered more severe droughts in recent decades (Dore, 2005). The rate and frequency of climate change and variability has increased over the years due to anthropogenic activities.

There is sufficient evidence to show that climate has been changing in the 20th Century, including, global sea level rise by 10-20 mm, the volume of glaciers in Switzerland decreased by two-thirds, Mt Kenya has lost 92% of its ice mass and Mt Kilimanjaro has lost 82% of its ice mass, 70% of sandy shorelines have retreated (CBD, 2007). In terms of precipitation, there is increased variance all over the world, with research showing that the wet areas have become wetter, with arid areas becoming drier (Dore, 2005). Annual temperature extremes have become more prevalent in the past decade than in any other period in the last century (McElroy and Baker, 2012).

In East Africa, large water bodies such as; the Indian Ocean, Lake Tanganyika, Lake Victoria, varied topography including mountains and plateaus interact to give a range of climatic conditions (Herrero, Ringler, Steeg, Koo, and Notenbaert, 2010). The region has been experiencing a warming trend, with Mount Kilimanjaro, Mount Kenya and Ruwenzori peaks losing their snow caps and the southern parts of Uganda experiencing warming temperatures (Kandji and Verchot, 2006). Further, as noted by Few *et al*. (2015), the 1-3°C temperature increase over the past five decades (1965-2015) in East Africa is strong evidence of climate change.

In the Kenyan case, rainfall is variable, but more variability is experienced during the short rains rather than the long rains (Few *et al*., 2015). Kenya's mean annual temperature is also on the increase, projected to increase between 0.8 and 1.5 degrees Celsius by the 2030s (GoK, 2015). In terms of extreme weather events, Kenya as a whole also experiences drought on a regular basis, with a major one occurring every 10 years and minor ones every 3-4 years

(Herrero *et al*., 2010). The frequency and severity of floods has also increased in the past two decades, with more people being affected, though droughts still affect more people than floods (Herrero *et al*., 2010).

2.3. Impacts of climate change and variability on agriculture

Climate change and variability is adding to the challenges already facing the global agricultural sector, having negative impacts on both crop and livestock production (OECD, 2015). For example, climate change is already contributing to the decline in food production despite the fact that increasing human population has more than doubled the demand for food (Nti, 2012). Every year, tsunamis, tropical cyclones, flooding and even earthquakes cause losses amounting to hundreds of billions of dollars globally (UNDP, 2015).

The main climatic parameters that have a huge impact on the agricultural sector are temperature and precipitation (Kurukulasuriya and Rosenthal, 2003; Keane, Page, and Kennan, 2009). This is because these two parameters cause changes in soil moisture content, the onset and duration of growing periods and the distribution of agro-ecological zones, thereby affecting agricultural production (Kurukulasuriya and Rosenthal, 2003). Other climatic changes that adversely affect agricultural production are extreme weather events such as droughts, heat waves and floods, changes in atmospheric CO_2 and seal level rise (Keane *et al*., 2009). According to McElroy and Baker (2012), extreme weather events have a direct impact on the hydrological cycle and fresh water availability, with fresh water becoming more scarce and inaccessible.

On top of significantly decreasing crop yields, climate change and variability is also expected to increase pest outbreaks, increase soil erosion , increase waterlogging and increase livestock losses due to lack of forage (Ojwang *et al*., 2010). Research has shown that climate change is already altering the distribution, incidence and intensity of plant and animal diseases (FAO, 2008). In Europe, the spread of bluetongue disease will be strongly influenced by climate change, while in East Africa, the Rift Valley fever and other tick borne diseases will also be influenced by changing climate (FAO, 2008).

Climate change and variability is projected to affect different regions of the world in different ways (Antle, 2008; Rosegrant *et al*., 2008). Developing countries and especially those in sub-Saharan Africa are expected to be more adversely affected by climate change and variability due to overreliance on natural weather for agricultural production, lack of resources to adapt effectively, poor infrastructure and poor planning and policies (Kurukulasuriya and Rosenthal, 2003; Ngaira, 2007; Kabubo-mariara and Kabara, 2015). According to the IPCC (2007), within some African countries, yields from rain-fed crops could have halved by 2020 and the income from such crops falling by 90%. Furthermore, the semi-arid areas within those countries are more vulnerable, as increasing temperatures, reduced rainfall and increased rainfall variability is likely to impact agriculture negatively (Antle, 2008). It is also projected that, with increasing global temperatures, coastal farmlands will be flooded, thereby reducing arable land and increasing aridity in the tropics (Ngaira, 2007; Antle, 2008).

In most of sub-Saharan Africa, agriculture is non-mechanised, meaning that climate and weather heavily influences the onset of cultivation, planting, harvesting operations and also the crop varieties to plant (Obayelu *et al*., 2014). With most African countries still battling with low agricultural productivity, poverty and other environmental issues, climate change is making the situation worse and negatively affecting economic growth (Obayelu *et al*., 2014). Climate change and variability will continue to be a thorny issue for African governments as they aim to grow economically while still feeding their growing populations (Nti, 2012).

Within the past decade, global food prices have risen, mainly due to severe droughts in important agricultural regions, increased demand for food and diversion of certain grains for biofuel production (McElroy and Baker, 2012). In the period between 2006 and 2008, the global average price for rice rose by 217 %, wheat by 136%, maize by 125% and 107% for soybeans (Mazhirov, 2011). Floods and droughts are directly attributed to such price rises and related conflicts, like the floods in Pakistan that inundated farmland and the heat wave and drought in Russia that caused a grain embargo in 2010 (Mazhirov, 2011).

On the other hand, as global CO_2 levels rise, some type of plants could see increased productivity under the right conditions, a phenomenon known as 'carbon fertilization effect' (Antle, 2008; Rosegrant *et al*., 2008). Some of the crops to benefit from this effect are C_3 crops such as soybean, peanut and rice which have accelerated growth and earlier flowering which ultimately leads to higher grain yield (Amedie, 2013). C_4 plants such as maize and wheat however suffer decreased yields in elevated CO_2 levels due to a shorter growing period (Amedie, 2013).

In Kenya, the shrinkage of Lake Baringo by 20km^2 from 1990 to 2000 is seen as a prime example of the impact of climate change, which was attributed to prolonged droughts (Ngaira, 2007). In that period, the annual fish catch also dropped from 380 metric tons to 7 metric tons

(Ngaira, 2007). In 2013, Narok County was hit by raging floods which led to 15 fatalities and the displacement of 350 people. Livestock deaths were also reported, and more than 80 ha of food crops were damaged by the floods (Mulenkei, 2015).

2.4. Vulnerability and adaptive capacity to climate change and variability

Vulnerability has been defined as "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes (IPCC, 2007). Africa as a continent is vulnerable to the effects of climate change and variability due to widespread poverty, limited capacity to cope and highly variable climate (Brown *et al*., 2012; Mulenkei, 2015).

The arid and semi-arid areas of Africa are especially more vulnerable to climate change because: small changes in temperature and rainfall patterns can have serious impacts on their biodiversity. Furthermore, dry lands are already under stress from various activities including conversion to agriculture, the introduction of invasive species, alterations to fire regimes and pollution (CBD, 2007). Among the rural households in the developing countries, there is an inverse relationship between adaptive capacity and vulnerability, meaning that there is need to enhance their adaptive capacity if they are to reduce their vulnerability (Valdivia, Gilles, Jette, Quiroz, and Espejo, 2003).

The pastoralists in Narok County have become more vulnerable to the impacts of climate change and variability due to changing land tenure systems from communal to individually owned which restricts the movement of livestock (Mulenkei, 2015).

2.5. Climate change and variability adaptation strategies

Climate change and variability can severely affect developing countries which are highly dependent on agricultural livelihoods, resulting in food shortages and other similar consequences (Uddin, Bokelmann, and Entsminger, 2014). In order to reduce the negative impacts of climate change and variability, farmers, government institutions and private players will have to take up various adaptation and coping strategies (Antle, 2008).

Many farmers in areas that have been studied acknowledge that they have perceived changes in climatic conditions and have come up with strategies to respond to those changes (Deressa, Ringler, and Hassan, 2010; Komba and Muchapondwa, 2012; Nti, 2012; Obayelu *et al*., 2014; Rakgase and Norris, 2014; Oo, Huylenbroeck, and Speelman, 2015). Farmers in Magwe

District of the Dry Region of Myanmar practice both indigenous adaptation strategies such as adjustment of planting dates, crop diversification, cultural practices and soil related practices and modern adaptation strategies such as use of improved crop varieties, use of fertilizers and pest control, crop diversification and rotation and recommended agricultural practices (Oo *et al*., 2015). Of these, adjusting crop planting dates, incorporating soil and plant health practices and crop rotation and diversification strategies were the most popular in that order (Oo *et al*., 2015).

In Bangladesh, it was noted that neither implementation of sound technological protocols nor use of local techniques were effective on their own for helping farmers overcome climate related challenges and risks. It was therefore recommended that the two approaches be integrated so as to get better results (Uddin *et al*., 2014). Still in Bangladesh, irrigation, crop diversification and use of integrated farming systems were identified as the three most important adaptation strategies (Uddin *et al*., 2014).

The most common response mechanisms within African countries are tree planting, planting improved crop varieties, adjusting planting dates and irrigation (Komba and Muchapondwa, 2012; Phiri, 2012). A study conducted in Ethiopian Nile Basin reported that the common risk-mitigation strategies at household levels include; mixed farming, crop diversification, livestock production that incorporates different species and joining credit groups. The same study also identified various coping strategies by Ethiopian farmers at household level including; temporal or permanent migration, selling assets, employing child labor, selling farm produce and livestock, leasing land, and reducing consumption (Deressa *et al*., 2010). Farmers in Northern Ghana have resorted to planting drought tolerant and early maturing crops such as sorghum, cowpeas and cassava, water harvesting and use of organic fertilisers so as to minimize the effects of climate variability (Asante, Boakye, Egyir, and Jatoe, 2012).

The smallholder farmers in Kenya's dry lands mainly result to diversifying crops and livestock, diversifying livelihoods, food and animal feed storage, fallowing, irrigation, reforestation and agroforestry practices in order to cope with the impacts of climate change (Ojwang *et al*., 2010). Pastoralists on the other hand adapt to climate change by migrating their livestock to better pastures, increasing the number of livestock, livelihood diversification, livestock species diversification, using supplementary livestock feed, intensifying livestock disease management efforts, using borehole water for livestock and saving up in the banks or use of credits mechanisms (Ojwang *et al*., 2010).

Pastoralists in Baringo County have opted to relocating their livestock to suitable grazing areas depending on the climate, diversifying crops and livestock, changing livestock herd sizes (through selling and herd splitting) using specialized food storage methods, planting local crop seeds and rationing food during periods of low food availability (Kimani, Ogendi, and Makenzi, 2014). In Kajiado County, farmers have turned to drought tolerant crops, harvesting rain water, irrigation, use of organic manure, changing the planting time, vaccinating livestock, migrating with livestock and preserving pastures (Naanyu, 2013). African countries that have agriculture as their main economic activity will continue to suffer as long as the capacity to adapt to those changes continues to be lacking. Ghana, for example, a country that depends on agriculture, forestry and hydroelectricity is likely to experience serious economic consequences as a result of climate change (Nti, 2012).

2.6. Factors influencing farmers' response strategies to climate change and variability

In Bangladesh, the most significant factors that influence farmer's choice of adaptation strategies to climate change were identified to be; farmer's age, education, annual family income, farm size and cooperative involvement. On the other hand, access to credit, access to extension training and market access were not significant (Uddin *et al*., 2014). In studies conducted in both Ghana and Nigeria's Ekiti State, it was discovered that factors such as literacy level of household head, size of household, access to credit, age of household head, gender of household head, years of farming experience, extension services, access to information on climate change and household income were some of the factors that influence the choice of the coping mechanism adopted (Nti, 2012; Obayelu *et al*., 2014). Komba and Muchapondwa (2012) reported that observing climate change, the level of drought frequency experienced, education level of household head, the major crop grown and the agro-ecological zone all influenced Tanzanian farmers' adaptation strategies to climate change.

Contrary to the above findings, some authors have reported different results on the factors that influence farmer's choice of response strategies. For example, in Limpopo South Africa, it was reported that most socio-economic characteristics of farmers for example gender, age, farm size and location, access to extension and farm income had no influence on farmers' choice of drought coping strategies. In this study, farm type and farmers' literacy levels were reported to be the main predictors of choice of drought coping strategies (Rakgase and Norris, 2014). Phiri (2012), expanded the scope of factors under investigation and found that on top of household characteristics such as gender and education level of household head, extreme weather events such as drought and floods also influence household choice of adaptation strategies.

2.7. Knowledge gaps

This study aims to build on work done on two previous studies. One of the studies conducted in Narok County focused on climate trends and adaptation strategies to climate change and variability (Ojwang *et al*., 2010) and the other focused on some of the impacts of climate change and variability and extreme weather events (Mulenkei, 2015). However, they did not assess the farmers' perception of climate change and variability, neither did they study the factors that influence farmers' choice of response strategies (Table 1). In addition, there was no ranking of the adaptation strategies specifically in Narok East Sub-county.

This study addresses this gap in research in order to obtain a comprehensive understanding of the farmer's perception of climate change and variability and also understand the underlying factors that influence their choice of coping strategies. With this information, it is possible to recommend the strategies that can be used that are farmer friendly and more effective.

Table 1: Knowledge Gaps

Author(s)	**Title of Research**	**Objectives Covered**	**Areas not covered**
Gordon O. Ojwang', Jaspat Agatsiva and Charles Situma (2010)	Analysis of Climate Change and Variability Risks in the Smallholder Sector: Case studies of the Laikipia and Narok Districts representing major agro-ecological zones in Kenya	Assessment of climatic trends in Narok County using rainfall and temperature data from 1950-2007 Documented some of the adaptation strategies used by farmers in Narok County Land use and land cover changes	Farmers' own perception of climate change and variability Did not rank the adaptation strategies in order of the most widely adopted Did not look into the factors that influence farmers' choice of response strategies
Lucy Mulenkei (2015)	Promoting Climate change adaptation for natural resource dependent communities in Narok on Best practices in Energy and livestock Indigenous Information Network	Documented some of the impacts of climate change and variability and extreme weather events on Narok County Documented the indigenous knowledge on the identification of various weather patterns	Did not rank the adaptation strategies in order of their popularity Did not look into factors that influence farmers response strategies

2.8 Theoretical framework

According to Eisenack and Stecker 2010, an adaptation theory to climate change has certain core concepts including; stimulus, exposure unit, receptor, operator and the means (Figure 1). The stimulus is described as the change in biophysical variable as influenced by climate change. These include changes in average values of precipitation and temperature and the occurrence of extreme weather events. It is this stimulus that leads to certain quantifiable impacts on the exposure unit. Second is the exposure unit; this refers to all those actors who depend on climatic conditions and are therefore exposed to the stimuli. More specifically, the actor who exercises the actual response is referred to as the operator. This operator has to be a social entity such as households or governments, meaning machines and natural systems are not part of it. The receptor is the actor or system that is the recipient of the adaptation. This can be biophysical entities or social systems. The receptor may not necessarily be an exposure unit but sometimes it can be. For adaptation to be successful, the operator needs resources which are called means. The resources include; finances and materials, legal power, social networks, knowledge and availability of information.

For this study, the stimulus remains the same. The exposure unit represents the players in the agricultural sector in Narok East Sub-county, including both farmers and pastoralists. The receptor of adaptation includes; the farms, pastures, animals and crops. The operator in this case are the households composed of farmers and pastoralists who adopt various response strategies to the impacts of climate change. The means represent the factors that influence the how the farmers respond to climate variability, including both independent and intervening variables.

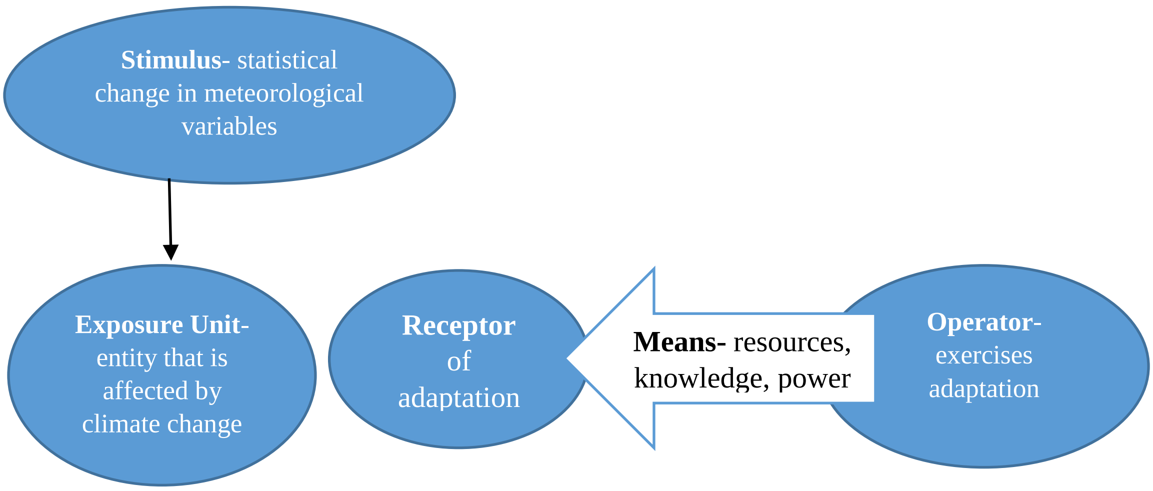

Figure 1: Figure 1: Theoretical framework for climate change adaptation-adopted from (Eisenack and Stecker, 2010)

2.9 Conceptual framework

This study was primarily investigating the factors that influence farmers' choice of response strategies to climate variability. The farmers' response mechanism was therefore the dependent variable. From literature reviewed, there are many factors that are hypothesized to influence farmers' response mechanisms to climate change and variability. These include; perceiving climate change and variability, characteristics of the household head (age, education level and gender), household size, access to weather information, land size, land tenure policies, access to agricultural extension among many others. All these factors can be the independent variables for a study but for this study, the investigation was limited to; characteristics of the household head (age, gender and level of education), household size, perceiving changes in climatic patterns, access to weather information and land tenure. In addition to the above independent variables, four intervening variables were also identified; level of infrastructural development in an area, the land policies in Narok County, indigenous technical knowledge and the cultural characteristics of the community that a household head belongs.

The culture of a household head's community influences their level of education and household size. The level of infrastructural development influences a farmer's ability to access weather information and also their choice of response strategy. The land policies influence the type of land tenure a farmer will use while indigenous technical knowledge influences their ability to perceive climate variability. The way the independent variables, intervening variables and dependent variable interact with one another is clearly demonstrated in Figure 2.

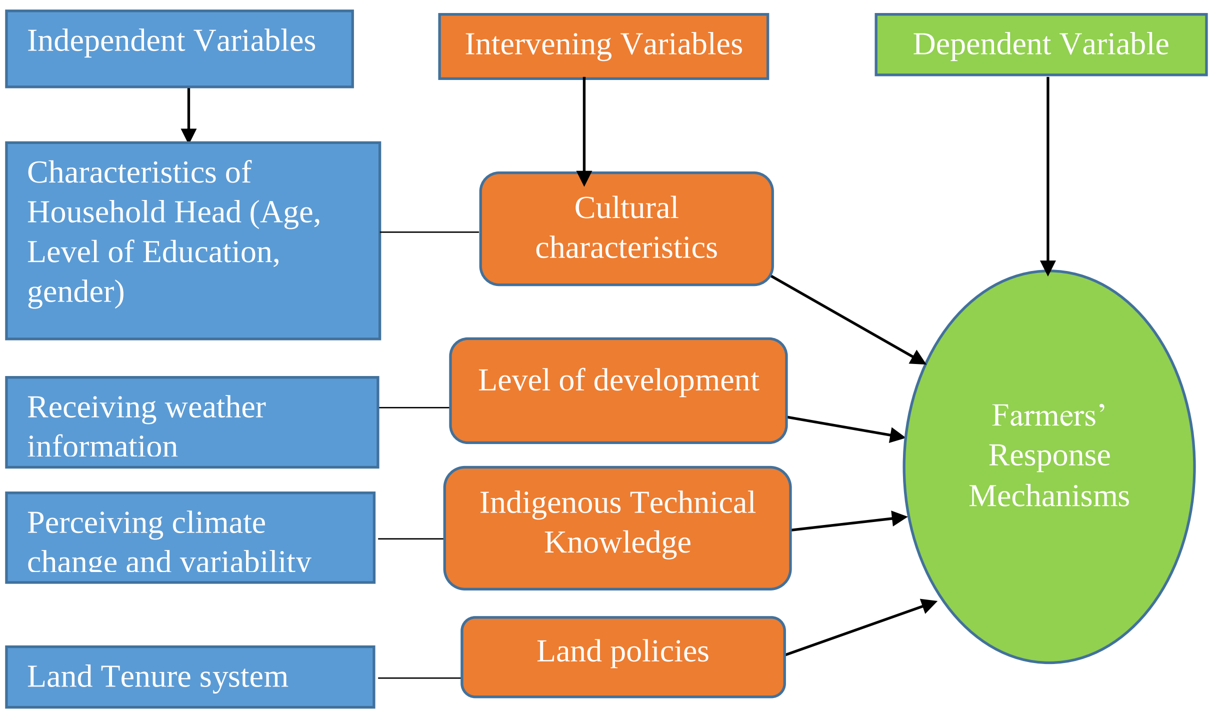

Figure 2: Conceptual Framework

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter looks into the characteristics of the study site, including the location, climate, soils, hydrology and drainage and population and economic activities. Next, the research design used for the study is explained, including the sampling technique, how the sample was calculated, how data was collected and the ethical considerations for the study. Finally, how the data analysis was carried out is highlighted.

3.2 Study Area

3.2.1 Location and size

Narok East Sub-county is one of the six Sub-counties of Narok County, which is located in the southwest of Kenya, in the Great Rift Valley between Latitude 1°00' to 1°200'S and Longitude 36°00' to 36°150' E. It comprises four wards namely; Mosiro, Keekonyokie, Ildamat and Suswa as shown in Figure 3 (Kenya National Bureau of Statistics {KNBS}, 2013). Narok Town serves as the Sub-county's main town and headquarters for the entire County. The town is 109 km from Nairobi in the North-west direction.

3.2.2 Climate

Within the Narok County as a whole, the rainfall is partly related to the Inter Tropical Convergence Zone (ITCZ), with local variations in topography playing a major role in the distribution patterns (Brown and Cocheme, 1973). Rainfall increases along a gradient from the dry southwest plains (500 mm/year) to wet northern highlands (2000 mm/year), with higher rainfall amounts being realized in higher altitude areas including the hills and escarpments. The region has two rainy seasons, with the first occurring between March and May and the second between November and December. The driest months are June and July while the annual temperature range is 12-28^{0} C (Ojwang *et al.*, 2010).

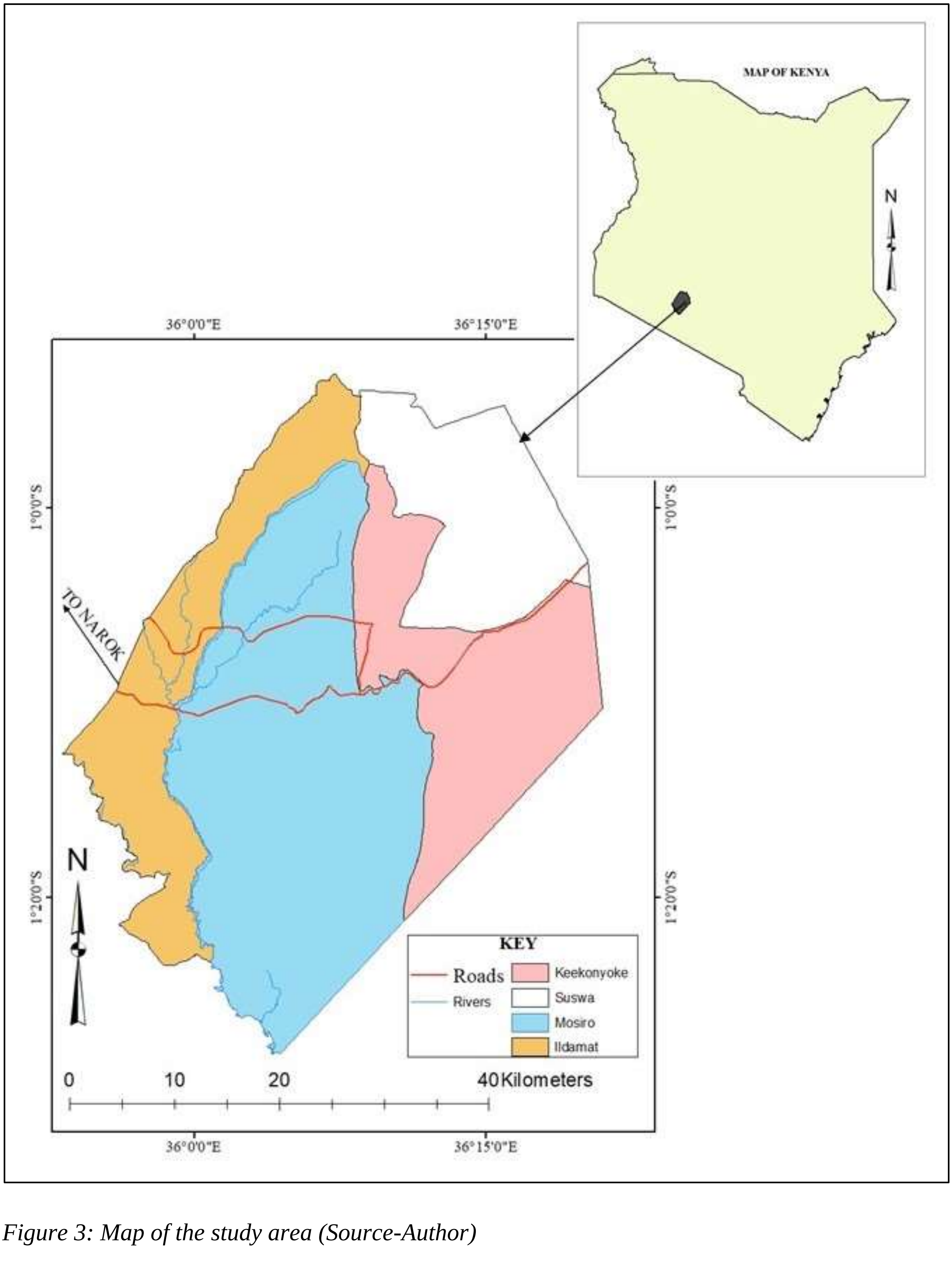

Figure 3: Map of the study area (Source-Author)

3.2.3 Soils

Soil types within the Sub-county are quite varied. At the high altitude areas of the sub-county, the soils are categorized as shallow sandy and well drained. Within the plains areas the soils are deep, silt and poorly drained. The soil in the plains is classified as black cotton soil which is poorly drained and susceptible to seasonal waterlogging. Suswa has volcanic ash soils that are vulnerable to erosion due to loss of grass cover from overgrazing (Mulenkei, 2015).

3.2.4 Hydrology and drainage

Narok County as a whole is served by one main river; the Mara River, which is 290 km and drains into Lake Victoria through Tanzania. Although the river does not pass through Narok East Sub-county, there are various tributaries in the region that drain into the river. There are seasonal streams and ponds that local communities use for their domestic use and their livestock (Mulenkei, 2015). Water harvesting is an uncommon practice especially among the pastoral communities and piped water is non-existent in a majority of the Sub-county (Ojwang *et al*., 2010).

3.2.5 Population and economic activities

Narok East has a human population of 82,956 (KNBS, 2013). It has a population density of 47 people per km^2, which is lower than the national density of 401.1 people per km^2. Within the Sub-county, high human population density is found in the humid, sub-humid and semi-humid zones (Ojwang *et al*., 2010). These are also the areas associated with high agricultural activities, while the remaining portion of the county is occupied by pastoral activities. The dominant ethnic group is the Maasai with significant population of Abagusii, Kikuyu and Kalenjin (SMART STAT Consultants Ltd., 2013). The main economic activities are livestock farming (cattle, goats, sheep and donkeys), subsistence and commercial crop farming (wheat, barley, maize, beans, Irish potatoes, and horticultural crops) and tourism and mining. Narok County's gross national income per capita was $2780 in 2014 (KNBS, 2013).

3.3 Research design

A cross-sectional research design was used for this study, whereby a household survey was conducted to collect the data. Narok East Sub-county was selected for the study so as to represent the semi-arid areas of Kenya. The Sub-county was also selected since it has farmers who practice both crop farming and livestock keeping, unlike other Sub-counties that are dominated by pastoralists. The Sub-county has four wards, (Suswa, Mosiro, Ildamat and

Keekonyokie) from which a representative sample was taken (Figure 3). The wards were purposively selected so as to ensure that the whole sub-county was well represented in the survey.

3.3.1 Sample size calculation

The following formula was used to calculate the sample size (Cochran, 1977):

$$\boldsymbol{Sample\ size} = \frac{\frac{\boldsymbol{z^2 * p(1-p)}}{\boldsymbol{e^2}}}{\boldsymbol{1 + (z^2 * p(1-p)\big|e^2\, N)}}$$

Where: *z is the z-score; the number of standard deviations a given proportion is away from the mean, e is the margin of error, N is the population size, p is 50% distribution*

Population data for the Sub-county was obtained from the Kenya National Bureau of Statistics and the breakdown of the household numbers is as shown below in table 2.

Table 2: Population data of Narok East Sub-county (KNBS, 2013)

Ward	Population (2009 census)	Total Number of Households	No. of Households practicing agriculture
Mosiro	27463	5493	3845
Ildamat	15,643	3129	2190
Keekonyokie	20,613	4123	2886
Suswa	19,237	3848	2694
Total	**82956**	**16593**	**11615**

A confidence level of 95% and a margin of error of 6.5% (0.065) was used for this study. The z-score for a 95% confidence level is 1.96. The population size for the study as shown in Table 2 was 11,615 households. P is 0.5. The sample size was then calculated as follows;

$$\boldsymbol{Sample\ size} = \frac{\frac{1.96^2 * 0.5(1-0.5)}{0.065^2}}{1+\left(\boldsymbol{1.96^2 * 0.5(1-0.5)\big|0.065^2\ 11615}\right)} = \mathbf{223}$$

Sample size for whole survey was **223 households**. Each ward contributed a sample proportionate to its population size as shown in Table 3 using the following formula:

$\boldsymbol{WS} = \frac{S}{TH} * {}^{WH}$ *Where WS is Ward sample size, S is Total sample size, TH is Total number of agricultural households in the Sub-county* and *WH is the total number of households practicing agriculture in a ward.* For example, (Mosiro Ward)

$\boldsymbol{WS} = \frac{223}{11615} * {}^{3845} = \boldsymbol{74}$

Table 3: Households sampled in each ward

Ward	Sample Size
Mosiro	74
Ildamat	42
Keekonyokie	55
Suswa	52
Total	223

3.3.2 Sampling technique

The study utilised three main data collection tools; key informant interviews, focus group discussions (FGDs) and a questionnaire for the household survey. Participants for the key informant interviews were purposively selected. The people targeted for these interviews were the local Members of County Assembly (MCAs) and a few experienced farmers. Officers from the County Government of Narok East assisted with the identification and contact of potential participants.

The participants of the FGD were also purposively selected. The FGD had 16 participants excluding the researchers. Each ward was represented by 4 household heads who had at least 20 years of experience farming in the Sub-county. Given that only one FGD was held, it was important to get the maximum number of participants possible, hence the reason for having 4 participants from each ward. The participants of the FGD were identified with the help of County Government officials and also the key informants.

For the household survey, a multi-stage sampling technique was used. This was done so as to ensure that all the wards were represented as they have different topographies and different communities living within their borders. First, with the help of key informants, a shortlist of all farmers with at least 20 years' experience was drawn up. This therefore means that purposive sampling technique was used for the first stage. Next, the 223 households were randomly selected from a list of all eligible household heads. Some extra names were taken to act as replacements whenever a household head was unavailable.

3.3.3 Pilot survey

A pilot study was used to test the appropriateness of the questionnaire. Laikipia West sub-county was identified as a region with similar conditions and characteristics as Narok East and was used as the location for the pilot survey. A total of 30 household heads were interviewed. The pilot study was conducted for three days. Corrections on the questionnaire were made after the survey, with some questions being removed, others being added and the wording on some changed to be clearer for the enumerator and respondent.

3.3.4 Data collection

The first part of data collection involved key informant interviews and a focus group discussion. The persons for the key informant interviews were purposively selected and included four MCAs for the respective wards and two experienced farmers. An interview schedule was used (see appendix 2), with the interviewer taking notes as the respondent answers. Key informant interviews took place in 2 days. Each interviewee was interviewed individually. For the FGD, the researcher acted as the moderator and the research enumerators took the notes. The FGD took place in one day.

For the household survey, data was collected one ward at a time. For the sake of convenience, Ildamat Ward was selected as the first ward since it was the closest to Narok town. Data was then collected in Mosiro Ward, followed by Keekonyokie Ward and finally Suswa Ward. Transport was provided to the enumerators, whereby the selected household heads were interviewed from their homesteads. A local contact person who also served as an interpreter where necessary travelled with the researcher to help identify where the households were located. During the survey, the researcher/ enumerator used the questionnaire to ask the respondent the questions and fill in the answers. Where a household head was unavailable, another adult household member with enough farming experience, for example a spouse, took their place as the respondent. In cases where a suitable respondent could not be found for a particular household, another household that met the criteria for the study was selected as a replacement.

3.3.5 Reliability and validity

A questionnaire was the main data collection tool for this study. Its reliability and validity was tested during the pilot survey. Any questions that were found to be ambiguous or unclear were rectified based on the results of the pilot survey. More questions were also added so as to incorporate information that was left out in the original questionnaire.

3.3.6 Ethical considerations

The first thing that the enumerator did after the necessary introductions was to ensure they had the consent of the respondent before they interviewed them. The information provided by respondents was treated with utmost confidentiality and was only used for education purposes. An interpreter was provided for respondents who could not speak either English or Kiswahili, so as to make communication easier. All the enumerators were also trained before taking part in the survey on the cultural and social expectations that the local communities expect from them. A research permit was also obtained to authorize the survey, one from the Board of Post Graduate Studies of Egerton University and the other from National Commission for Science, Technology and Innovation (NACOSTI).

3.4 Data analysis

For the first two objectives, descriptive statistics were used for the analysis. Results are presented in tables and charts format. A multivariate probit model was used to determine the factors that influence farmers' choice of response strategies to climate change and variability. The multivariate probit model was chosen because of its ability to show the relationship among various adaptation strategies, because it takes into account the unobserved and unmeasured factors. The model can make interpretations for the simultaneous influences of the independent variables on the dependent variables (Feleke, Berhe, Gebru, and Hoag, 2016). Principal Component Analysis (PCA) was used on the dependent variables (response strategies) before the Probit model was applied. PCA is important for compressing the size of the data by extracting the most important information, simplifying the description of the data set and analysing the structure of observations and variables (Abdi and Williams, 2010). The model is as specified below;

$$Y_{im}^{*} = \beta_m X_{im} + \varepsilon_{im}$$

Where Y_{im}^{*} (m = 1,….,k) represent the unobserved latent variable of adaptation strategies adopted by the ith farmer (i = 1,…,n), k is the strategies adopted by the farmer. X_{im} is a 1 × k vector of observed variables that affect the strategy adoption decision, the variables include the characteristics of the household head, awareness of climate change and variability, receiving weather information and the land tenure system. A summary of data analysis is given in Table 4.

Table 4: Summary of data analysis

Objective	Data collection tools	Data Analysis
To document the changes in climatic patterns as perceived by farmers in Narok East Sub-County in the years between 1996 and 2016	FGD, Key informant interviews and questionnaire	Descriptive statistics; frequency tables
To assess the adaptation and coping strategies to climate variability by farmers in Narok East Sub-county	Questionnaire and FGD	Descriptive statistics; frequency tables and charts
To assess the factors that influence adaptation and coping strategies to climate variability for farmers in Narok East Sub-county	Questionnaire	PCA and Multivariate probit model

CHAPTER FOUR

RESULTS

4.1 Introduction

This chapter is an in-depth look at the results of the study based on the specific objectives. The first part is a highlight of the household characteristics of the respondents of the survey. The other parts are a look into how farmers perceive climate variability, the response strategies they use in response to varying climate divided up into crop production strategies and livestock production strategies and the factors that influence their choice of those strategies.

4.2 Household characteristics

Household data was collected from a total of 223 household heads from the four wards of Narok East Sub-county (Table 5).

Table 5: Summary of the household characteristics

Household characteristic	Frequency	Percentage
Gender of HH: Male	211	94.6
Female	12	5.4
Level of Education: Informal	117	52.5
Primary	41	18.4
Secondary	43	19.3
Tertiary	22	9.9
Land Tenure: With title	143	64.1
Without Title	66	29.6
Communal	13	5.8
Family	11	4.9

From data, 94.6% of household heads were male, with only 5.4% being female. The average age for all the household heads was 47.2 years. The average household size was 11.54, accounting for family members both under and over 18 years of age. More than half of the household heads (52.5%) had no formal education, with another 18.4% having gone up to primary level. Household heads who had gone up to college or university accounted for 9.9%.

In terms of land tenure, a majority of households had a title deed for their land (64.1%). Another group did not possess a title deed for their land although they were using it as their private land

(29.6%). Some households who did not have a title deed for their land considered it as their family land (4.9%) and another 5.8% used communal land especially for their livestock. A majority of farmers (83%) reported that they do receive weather information, with radio being the most common means of receiving this information with 67.3% of farmers using it. Another 26% of farmers reported that they get their weather information from television while word of mouth from fellow farmers accounted for 28.7%.

4.3. Farmers' perception of climate variability

Participants of the FGD reported that they had observed changes in climatic patterns, with most reporting increasing temperatures, lower rainfall and changes in rain onset. A majority of household heads had observed climate variability in the Sub-county (Table 6). Temperature change was the most observed phenomenon, with 100% of respondents reporting to having observed changes in mean temperatures.

Table 6: Farmers' perception of climate variability

Question	Frequency		Percentage	
	Yes	No	Yes	No
Perceived changes in mean temperature over the last 20 years?	223	0	100	0
Perceived changes in mean annual rainfall over the last 20 years?	215	8	96.4	3.6
Perceived changes in the onset of rains in the last 20 years?	210	13	94.2	5.8

A majority of farmers (96.4%) had also noticed changes in mean annual rainfall and another 94.2% had perceived changes in the onset of rains. Despite this general agreement among the respondents that they had perceived changes in key climatic parameters over the last 20 years, there were some differences on the direction of those changes (Table 7). The majority of respondents (91.9%) reported having noticed an increase in mean temperature and the number of hot days. Another majority of respondents (95.5%) also reported that they perceived the weather to have become drier over the last 20 years, with those who reported a decline in the number of rainy days being 94.6%. There was, however, a group of respondents who observed the opposite trend, with 8.1 % observing a decline in mean temperatures and a decline in the number of hot days, and a further 0.9% reporting the weather to have become wetter.

Table 7: Farmers' perception of change in key climatic parameters

Climatic Parameter	Observation	Frequency	Percentage
Change in mean temperature and number of hot days	Increased	205	91.9
	Decreased	18	8.1
	Stayed the same	0	0
Changes in mean annual rainfall	Drier	213	95.5
	Wetter	2	0.9
	No change	8	3.6
Changes in the number of rainy days	Increased	4	1.8
	Decreased	211	94.6
	Stayed the same	8	3.6

Respondents had also experienced a number of extreme weather events over the last 20 years. As shown in Table 8, 97.3% of respondents said they had experienced drought, followed by 88.3% of respondent who said they had experienced El Nino rains.

Table 8: Extreme weather events experienced by farmers

Extreme weather event experienced	Frequency		Percentage	
	Yes	No	Yes	No
Drought	217	6	97.3	2.7
El Nino rains	197	26	88.3	11.7
Floods	90	133	40.4	59.6
Strong winds	13	210	5.8	94.2

Less than half of the respondents reported to have observed floods in the last 20 years, with the smallest group of 5.8% reporting having observed strong winds over the last 20 years. The FGD also confirmed these findings, with participants reporting an increase in the incidence of drought and flooding.

During the FGD, excessive cutting down of trees, overgrazing, burning of farm wastes and factory emissions were seen as the major contributing factors to changes in climatic patterns and the occurrence of extreme weather events. These observations were also confirmed by the household survey, with 100% of respondents identifying cutting down of tress as the main driver of climate change and variability.

4.4. Farmers' response strategies to climate variability

Participants of the FGD acknowledged that with the changing climatic patterns most farmers were engaging in a variety of response strategies to improve their crop and animal production. From the household survey, all the coping and adaptation strategies being used by farmers of Narok East Sub-county were documented. For better analysis and interpretation of results, the response strategies were categorized into two groups. One included all strategies meant to improve crop production or shield against poor crop yields and were named 'crop production strategies'. The other group included all response strategies meant to improve livestock production or protect against loss and was named 'livestock production strategies'. Descriptive statistics were then used to determine which of those strategies are the most widely adopted and charts used to represent the findings.

A total of 12 crop production response strategies were identified, including; use of water harvest structures, increased use of manure, increased use of fertilisers, using terraces, planting drought tolerant crops, crop diversification, early planting, replanting, staggering planting dates, planting agroforestry trees, irrigation and planting short season crops. Five of the crop production response strategies were found to be used by more than 50% of the respondents. These were, in descending order; early planting, increased use of manure, use of terraces, increased use of inorganic fertilizer, and planting short season crops. The least adopted crop production strategies were found to be; planting agroforestry trees, crop diversification and irrigation in that order (Figure 4).

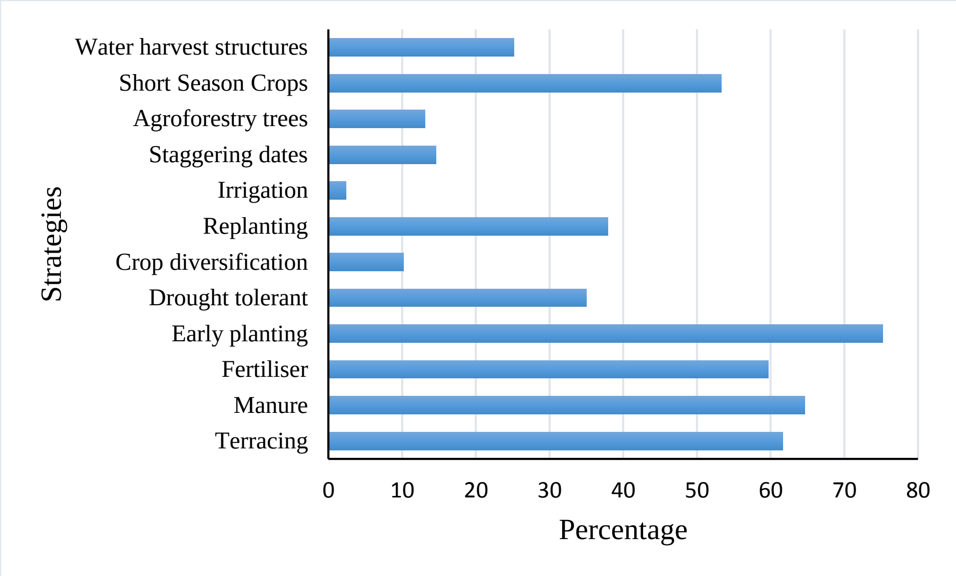

Figure 4: The percentage of farmers using each crop production strategy

A total of 10 livestock production strategies were also identified, including; herd reduction, rearing new animals, zero grazing, using new breeds of animals, fencing off one's farm, using improved fodder, getting into alternative livelihoods, abandoning livestock keeping herd increase and engaging in transhumance. Herd reduction, transhumance, fencing farms and getting new breeds of animals were the most preferred response strategies in that order (Figure 5). Increasing the herd size was the least adopted response strategy.

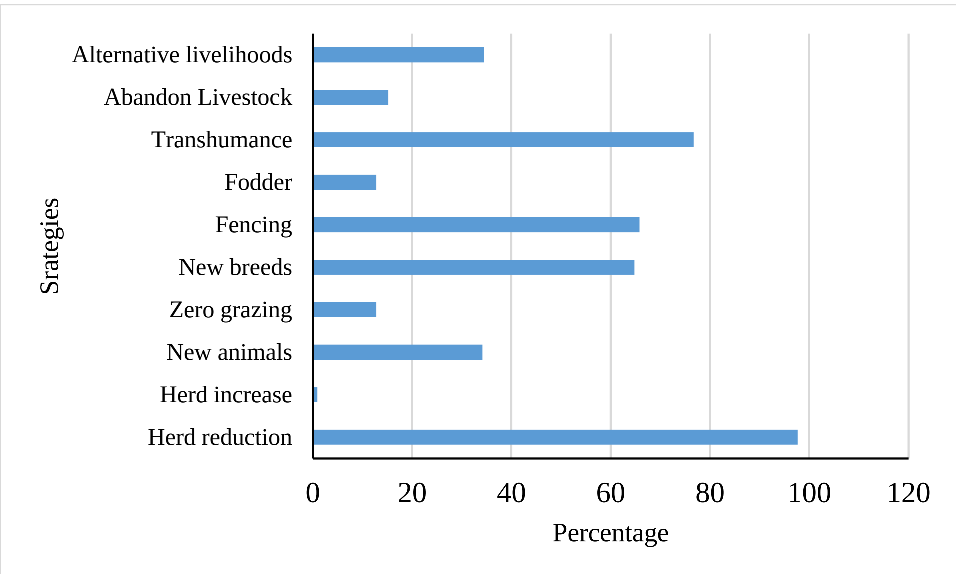

Figure 5: The percentage of farmers using each livestock production strategy

4.5. Factors affecting farmers' choice of crop production response strategies

For this study, the following factors were hypothesized to be affecting a farmer's choice of response strategies; gender of household head, age of household head, household size, level of education of household head, perceiving changes in mean annual temperature, perceiving change in mean annual rainfall, perceiving change in onset of rains, receiving weather information and land tenure system.

For level of education, most farmers belonged in the 'informal' category. It was taken as the base category, with the three remaining levels were then compared to it. The same procedure was applied for the land tenure system, with 'with title' being the base category and the others being compared to it. 'Perceiving changes in mean temperature' was removed from the analysis since 100% farmers had perceived those changes, meaning that the variable became a constant.

Before the multivariate probit model was run, the strategies had to be condensed into fewer components of related strategies. Principal Component Analysis was used to find the correlated strategies and put them in one group. Using Kaiser's criterion, all the components with an eigenvalue of >1 were retained for analysis (Constantin, 2014), and therefore a total of four components for crop production strategies were identified (Table 9).

Table 9: Eigenvalues of PCA for crop production components

Principal components/correlation			Number of obs =	223
			Number of comp. =	12
			Trace =	12
			Rho =	1.0000
Rotation: (unrotated = principal)				
Component	**Eigenvalue**	**Difference**	**Proportion**	**Cumulative**
Comp1	**2.32765**	**.202768**	**0.1940**	**0.1940**
Comp2	**2.12489**	**.445147**	**0.1771**	**0.3710**
Comp3	**1.67974**	**.434226**	**0.1400**	**0.5110**
Comp4	**1.24551**	**.263127**	**0.1038**	**0.6148**
Comp5	.982386	.153519	0.0819	0.6967
Comp6	.828867	.125608	0.0691	0.7658

To determine the component where each individual response strategy lies, their eigenvalues were used (Table 10). Each strategy was considered to belong to the component under which it had the highest eigenvalue, irrespective of the sign on the value (Constantin, 2014).

Table 10: Eigenvalues of individual crop production response strategies

Variable	**Comp1**	**Comp2**	**Comp3**	**Comp4**
COPCROPS0	0.1284	0.3594	**0.4556**	0.0108
COPCROPS1	**0.2380**	0.1550	-0.1178	-0.1301
COPCROPS2	0.3385	**0.3434**	-0.1761	-0.1251
COPCROPS3	0.2648	**0.4140**	-0.1104	0.1660
COPCROPS4	0.3084	-0.0150	-0.2709	**-0.5218**
COPCROPS5	0.3621	**-0.4505**	0.0500	0.1704
COPCROPS6	0.0986	-0.0927	**0.5247**	-0.2167
COPCROPS7	0.3040	0.3295	0.2315	**0.4172**
COPCROPS8	-0.2361	-0.0882	0.0924	**0.4712**
COPCROPS9	**0.4393**	-0.1801	-0.2297	0.3815
COPCROPS10	0.1656	-0.0669	**0.5074**	-0.2232
RSTRRD2	0.3710	**-0.4388**	0.1089	0.0062

Each component was then given a name that represents the strategies under it (Table 11). Out of the four components, Soil fertilization and drought avoidance strategies were the most widely adopted by the farmers (70.9%) followed by adjusting planting dates and irrigation with 68.6% of adopters. Loss reduction strategies and crop diversification strategies were the least adopted with 48.9% and 38.1% of adopter respectively.

Table 11: Variables under each component

Component	Variables in component	Adopters (%)	Non-adopters (%)
Comp1-Loss reduction	• Terraces • Staggering planting dates	48.9	51.1
Comp2- Soil fertilization and drought avoidance	• Increased use of manure • Increased use of organic fertilizer • Planting drought tolerant crops • Planting short season crops	70.9	29.1
Comp3-Crop diversification	• Water harvesting structures • Crop diversification • Planting agroforestry trees	38.1	61.9
Comp4-Adjusting planting dates and irrigation	• Early planting • Replanting • Irrigation	68.6	31.4

Results of the multivariate probit analysis show that the model was suitable for the data, wald $\chi 2$=163.55 probability > $\chi 2$=0.0000. A test of correlation between the different adaptation strategies shows there is interdependence between them, Chi^2 (6)=144.757, probability >chi^2=0.0000. The following factors were found to significantly influence a farmer's decision of crop production strategies; age of household head, household size, perceiving changes climate patterns, receiving weather information, level of education of household head and land tenure system (Table 12). Gender of the household head was not a significant factor.

Table 12: Factors affecting farmers' choice of crop production response strategies

	Loss reduction		Soil fertilization and drought avoidance		Crop diversification		Adjusting planting dates and irrigation	
Independent Variable	**Coef.**	**Std. Err**	**Coef.**	**Std. Err**	**Coef.**	**Std. Err**	**Coef.**	**Std. Err**
Gender	0.561	0.428	-0.324	0.582	-0.130	0.529	-0.509	0.535
Age	0.009	0.009	-0.008	0.01	-0.034	0.01***	0.003	0.009
Household size	-0.075	0.019***	0.002	0.015	0.031	0.015*	0.008	0.014
Mean annual rain change	-0.656	0.664	0.005	.597	0.241	0.665	1.490	0.519***
Rain onset change	2.086	0.545***	1.537	0.411***	-0.549	0.411	1.179	0.372***
Weather info	0.772	0.273***	0.521	0.248**	-0.130	0.339	0.408	0.236*
Primary education	-0.060	0.278	0.575	0.276**	-0.251	0.314	0.460	0.266*
Secondary education	0.173	0.270	0.668	0.3**	1.463	0.293***	0.838	0.285***
Tertiary education	-0.044	0.318	1.148	0.389**	2.319	0.439***	0.624	0.315*
No title deed	0.552	0.218**	0.117	0.224	1.202	0.242***	0.290	0.223
Family land	-0.533	0.489	1.941	4.454	-0.349	0.503	0.440	0.627
Communal land	-4.688	109.469	-0.828	0.385**	-0.946	0.654	-.674	0.340*
_cons	-2.284	0.995**	-0.959	1.009	0.622	-1.010	-2.413	0.999**

Observations	223
Log Likelihood	-349.694
Wald χ 2	163.55
Prob > χ 2	0.0000

Likelihood ratio test of rho21 = rho31 = rho41 = rho32 = rho42 = rho43 = 0: chi^2 (6) = 144.757 Prob > chi2 = 0.0000 *, **, ***= significant at 10%, 5% and 1% significance level respectively.

4.5.1. Household characteristics

The age of the household head was found to be a significant factor that influenced a farmer's decision to take up crop diversification strategies. The older the farmer was, the less likely they were to take up water harvesting, crop diversification or to plant agroforestry trees at 1% significance level. The age of the household head was not significant for the other three components.

Household size was also found to be a significant explanatory variable for two of the components. The relationship was however positive for one of the components but negative for the other one. Households with more household members were less likely to take up loss reduction strategies (terraces and staggering planting dates) at 1% significance level. On the other hand, a household with more members was found to be more likely to engage in crop diversification, planting agroforestry trees and having water harvest structures at 10% level.

The level of education was found to be a significant explanatory variable for three of the dependent variable components. The only component for which the level of education was not found to be significant was loss reduction component (terraces and staggering planting dates). Household heads who had gone up to either primary school, secondary school or to tertiary institutions of learning were more likely to use soil and drought avoidance strategies at 5% level each compared to those who had no formal education. Farmers who had attained secondary and tertiary education were more likely to do water harvesting, diversify crops and plant agroforestry trees at 1% significance level compared to those who had informal education. Farmers who had gone up to primary school were more likely to adjust planting dates and do irrigation compared to illiterate farmers at 10% significance level, those who had gone up to secondary school were more likely to use the same strategies at 1% significance level while those who attained tertiary education were more likely to use those strategies at 10% level compared to illiterate farmers.

4.5.2 Perceiving changes in climatic patterns

Farmers who perceived changes in mean annual rainfall were more likely to engage in early planting, replanting and irrigation at 1% significance level. Noticing changes in mean annual rainfall was however not a significant factor for the three other components. Those who perceived changes in the onset of rainfall were also more likely to engage in three out of four of the components (loss reduction, soil and drought avoidance and adjust planting dates) at 1% significance level.

4.5.3 Receiving weather information

Receiving weather information is another factor that was found to be significant in influencing farmers' choice of three of the components. Farmers who received weather information were more likely to stagger planting dates and use terraces at 1% level. They were also more likely to use soil and drought avoidance strategies at 1% significance level. At 10% significance level, the same farmers were more likely to adjust planting dates and do some irrigation. Key informants and participants of the FGD noted that most farmers still relied on indigenous methods of predicting climatic patterns rather than on weather focus given by the Kenya Meteorological Department.

4.5.4 Land tenure system

Key informants revealed that land tenure was still a sensitive issue in the region, with the move to privatize previously communal land complicating matters and causing conflicts. Despite this, many households had secured title deeds for their land, another significant portion was yet to secure their title deeds, and some were still using communal land. This study found that farmers who were using land without having the title deed were more likely to use terraces or stagger planting dates at 5% significance level compared to those who had title deeds. At 1% significance level, farmers who did not have title deeds were also more likely to do crop diversification and water harvesting compared to those who had title deeds. On the other hand, farmers who still used communal land were less likely to use soil and drought avoidance strategies at 5% significance level compared to those who had title deeds. The same farmers were also less likely to engage in irrigation or adjust planting dates at 1% level compared to those who had title deeds.

4.6. Factors influencing farmers' choice of livestock production strategies

The same process that was done for the crop production strategies was repeated for the livestock production strategies. The results of the principal component analysis for livestock production strategies are shown in Appendix 3. Four components were also identified and named (Table 13). They were designated as non-traditional strategies, herd management strategies, lifestyle change and traditional strategies. Herd management strategies were found to be the most widely adopted, with 96.9% of respondents, followed by traditional strategies 74.9%, and then lifestyle change strategies with 67.7% of adopters and finally the non-traditional strategies were the least adopted with 40.4% of adopters.

Table 13: Livestock strategies under each component and their rate of adoption

Component	Variables in component	Adopters (%)	Non-adopters (%)
Comp1- Non-traditional	• New farm animals • Zero grazing • Improved fodder	40.4	59.6
Comp2- Herd management	• Reduce herd size • Increase herd size	96.9	3.1
Comp3-Lifestyle change	• Abandon livestock keeping • Seeking alternative livelihoods • Fencing farms	67.7	32.2
Comp4- traditional strategies	• Transhumance • New breeds	74.9	25.1

Results of the multivariate probit model shows that the explanatory power of the model has a strong effect, wald $\chi 2$=118.56, probability> $\chi 2$=0.0000. The correlation coefficient of the error terms shows that there are complementarities between the response strategies, Probability> chi^2 (6) = 13.233, probability>chi^2=0.0395. Fewer independent variables were found to be influencing choice of livestock production strategies; gender of household head, age of household head, household size, receiving weather information, level of education of household head and land tenure system (Table 14). Perceiving changes in climate patterns was found not to be significantly influencing the decision to take up any livestock production strategy.

4.6.1 Household characteristics

Unlike the crop production strategies, gender of household head was found to be a significant explanatory variable for one of the components. The results show that a household with a male household head was more likely to engage in transhumance or to get new breeds of animals at 5% significance level. The age of the household head was found to be a significant variable for two of the components. A household with an older household head was less likely to adopt herd management practices at 5% significance level. A household with an older household head was also found to be less likely to engage in lifestyle change strategies at 1% significance level.

Table 14: Factors affecting farmers' choice of livestock production strategies

	Non-traditional		**Herd management**		**Lifestyle change**		**Traditional**	
Independent Variable	**Coef.**	**Std. Err**	**Coef.**	**Std. Err**	**Coef.**	**Std. Err**	**Coef.**	**Std. Err**
Gender	0.190	0.428	0.844	0.758	-0.347	0.486	0.871	0.404**
Age	-0.019	0.014	-0.1	0.043**	-0.043	0.014***	-0.009	0.012
Household size	0.005	0.0.014	-0.01	0.035	0.012	0.018	-0.026	0.013**
Mean annual rain change	0.552	0.531	0.680	0.787	-0.411	0.656	-0.713	0.7
Rain onset change	0.130	0.403	1.135	0.744	0.203	0.451	-0.032	0.457
Weather info	1.123	0.340***	-1.584	0.1.208	0.847	0.28***	0.302	0.273
Primary education	0.102	0.264	-0.728	0.618	0.49	0.281*	-0.181	0.27
Secondary education	0.483	0.246*	0.325	0.795	1.033	0.331***	0.185	0.279
Tertiary education	2.217	0.582***	0.59	1.133	6.139	184.764	0.872	0.532
No title deed	0.211	0.220	4.189	346.906	0.303	0.246	0.24	0.236
Family land	-0228	0.452	-0.678	0.796	-0.574	0.532	-0.516	0.425
Communal land	-2.128	0.957**	4.3	587.685	-0.817	0.599	-0.519	0.418
_cons	-1.510	1.079	6.045	3.125	1.9	1.194	1.084	1.143

Observations	223
Log Likelihood	-324.19771
Wald χ 2	118.56
Prob > χ 2	0.0000

Likelihood ratio test of rho21 = rho31 = rho41 = rho32 = rho42 = rho43 = 0: chi^2 (6) = 13.233 Prob > chi^2 = 0.0395 *, **, ***= significant at 10%, 5% and 1% significance level respectively.

The household size was another independent variable that was significant for one of the components. The study found that households with a larger household size were less likely to engage in transhumance or to buy new breeds of animals at 5% level.

The level of education of the household head was found to be a significant explanatory variable for two of the components. Household heads who had attained secondary education were more likely to engage in non-traditional strategies than those who had informal education at 10% level. Those who had attained tertiary education were more likely to use non-traditional strategies compared to those who had no formal education at 1% significance level. Household heads who had gone up to primary school were more likely to engage in lifestyle change strategies compared to those with informal education. Furthermore, those who had gone up to secondary school were more likely to use lifestyle change strategies than those who had no formal education at 1% significance level. Interestingly, attaining tertiary education was found not to be a significant variable when it came to the same lifestyle change strategies.

4.6.2 Receiving weather information

Receiving weather information was a significant variable for two of the components. Farmers who receive weather information were found to be more likely adopt the non-traditional coping strategies at 1% significance level. Those farmers who received weather information were also found to be more likely to choose lifestyle change strategies at 1% significance level.

4.6.3 Land tenure system

When it came to the issue of land tenure system, only one of the categories was significant for only one of the components. Farmers who used communal land for their livestock were found to be less likely to engage in non-traditional strategies compared to those who had title deeds for their farms at 5% significance level.

CHAPTER FIVE

DISCUSSION

5.1 Introduction

This chapter is a discussion of the results whereby the results of this study are compared with the results of similar studies conducted in other parts of the world. Explanations are offered based on available literature and the author's own thinking on the subjects in question.

5.2 Farmers' perception of climate variability

Farmers in this study reported experiencing increasing temperatures, more variable rainfall, changing onset of rainfall, drought and floods. These observations about climate change and variability in Narok East are consistent with the observations by Herrero *et al*. (2010) and Ojwang *et al*. (2010). In these studies, it was noted that there has been an overall long-term decline in rainfall amounts in Narok County, while the temperature has been rising gradually (Ojwang *et al*., 2010). Herrero *et al*. (2010) also reported that droughts and floods have been increasing in frequency and severity, with even the semi-arid areas of Kenya being prone to floods despite receiving low rainfall. Other studies that support these findings include the one by Few *et al*. (2015) who reported that the rainfall in Kenya is highly variable, with more variability experienced in the short rains.

5.3 Farmers' response strategies to climate variability

For this study, 12 crop production response strategies were identified. These strategies are similar to those that have been reported in other parts of the world. For example, farmers in the Punjab province of Pakistan were also found to be engaging in changing crop varieties, changing planting dates, planting shade trees, irrigation, soil conservation, crop diversification and changing fertilizers (Abid, Scheffran, Schneider, and Ashfaq, 2015). Also, in the arid Chiredzi District of Zimbabwe, farmers also engage in planting short season crops and crop diversification (Muzamhindo, Mtabheni, Jiri, Mwakiwa, and Hanyani-mlambo, 2015). However, the difference between Narok East and these other study areas is the rate of adoption of each strategy.

Farmers in Narok East Sub-county engage more in early planting, use of manure and fertilizer, terracing and planting short season crops. This is similar to the findings of Abid *et al.* (2015) who also reported that changing planting dates and changing fertilisers were among the most adopted strategies in Pakistan. The reason why these strategies are more preferred is because not only are they effective, but they also require little or no extra financial investment. Terraces are preferred because they are inexpensive, and they perform many functions such as helping to retain soil moisture and minimizing damage from rain runoff. Short season crops such as vegetables are also gaining popularity because they can provide sustenance for the families in the short term even as they wait for the main harvests. The study by Abid *et al.* (2015) also associated the higher rate of adoption of those strategies with low cost and ease of accessing them.

In the study site, planting agroforestry trees, crop diversification and irrigation were among the least utilised strategies. This is an agreement with the findings of Abid *et al.* (2015) who reported that irrigation, soil conservation, crop diversification and migration to urban areas were among the least utilised strategies. Irrigation as a response strategy has been noted to be among the least utilised strategies despite its potential for alleviating the impacts of climate change and variability in most areas especially the semi-arid areas (Abdi and Williams, 2010; Mulinya, 2017). Since Narok East is a semi-arid area with limited access to piped water, the limited use of irrigation as a response strategy is to be expected. Buying and setting up irrigation infrastructure is also capital intensive and many farmers cannot afford it. Farmers, however, have started using water harvest structures on their farms such as retention ditches and planting pits in an attempt to retain soil moisture.

The low rate of agroforestry adoption may be associated with the fact that its benefits take a longer time to be realized while farmers prefer the short term coping strategies. Crop diversification is adopted at a lower rate because the farmers lack exposure or knowledge of other crops that can do well in the region, preferring to stick with the tried and tested crops. As noted by Mwase *et al.* (2015) farmers in developing countries are less likely to choose response strategies that have high input expenses or strategies that they lack the knowledge and skills to properly implement.

The livestock production strategies adopted by farmers in Narok East were found to be similar to those adopted in Kajiado and Baringo Counties in Kenya (Kimani *et al* 2014; Bobadoye, Ogara, Ouma and Onono 2016). In Kajiado County, the Maasai pastoralists also practice migration, destocking, buying hay, diversifying herds, diversifying livelihoods, and adopting paddock grazing as the most utilised strategies (Bobadoye *et al.*, 2016). In Baringo County, farmers also make use of livestock relocation, herd splitting, livestock diversification and destocking as major coping and adaptation strategies to climate change and variability (Kimani *et al*., 2014).

In Narok East, herd reduction is normally done by way of selling off some livestock during the times of drought or low rainfall. This is an effective response as it is easier to get enough pasture and water for fewer animals. In this study, transhumance was reported to be one of the most popular response strategies by livestock owners. This is to be expected, as the dominant Maasai community in Narok East still practices transhumance as they move their livestock to places with greener pastures, water and market for their livestock (Bobadoye *et al*., 2016).

As reported by Bodadoye *et al.* (2016), herd diversification in the way of getting better breeds of animals and new animals all together such as the Sahiwal cattle and dairy goats is becoming more prevalent among the Maasai as they react differently to droughts and diseases. This study also reported similar results whereby getting better breeds of animals was one of the most adopted strategies. The reason for this is that the new breeds are more adapted to survive changing climate and are more productive than traditional breeds. Dairy goats for example, produce nutritious milk while consuming less forage than cattle (Bobadoye *et al*., 2016). Farmers who have larger farms where they do open grazing have also resorted to fencing off their farms. This is so as to discourage trespassing by other farmers who sometimes disregard land tenure rules and graze their livestock even in private land.

As the farmers of Narok East become more educated and land use in the region changes, more farmers are turning to more modern methods of livestock production as a response to changing climate. These include the use of improved fodder and practicing zero grazing. These strategies are however not as common since most of the community still follows traditional strategies. In extreme cases of drought, some farmers reported to having stopped livestock keeping altogether although they got back to it when conditions became more conducive. Considering that most extreme weather events normally lead to loss of livestock, the least preferred response strategy is increasing the herd size.

5.4 Factors affecting farmers' choice of crop production strategies

5.4.1 Household characteristics

Although gender was found not to be a significant factor for crop production strategies, other studies have reported it to be a significant factor (Mabe, Sienso, and Donkoh, 2014). In Northern Ghana, it was observed that female led households were more likely to change crop varieties than male led households since female farmers readily accept new innovations (Mabe *et al*., 2014).

There are however some studies that have also found gender of a household head to be insignificant in influencing farmers' choice of climate change adaptation strategies. For example, in Swaziland it was reported that gender of household head had no significant influence on farmers' choice of adaptation strategies (Shongwe, Masuku, and Manyatsi, 2014). Another study conducted in Ethiopia also reported that there was no significant difference in the response strategies adopted by male and female headed households (Karanja, Wijk, Rufino, and Giller, 2016).

The most possible explanation for this situation in the study site is that the Maasai are traditionally nomadic pastoralists who did little to no crop farming. Nowadays, however, more and more of them are turning to crop farming. The reason why gender might not influence their decision is that both the male and female farmers are equally inexperienced and ignorant in crop farming and therefore simply copy what others in the community and neighbouring areas are practicing.

This study found that the age of a household head was a significant factor that influenced their decision to take up various crop production strategies, with older farmers being less likely to take up certain strategies. This is in agreement with studies conducted in other parts of the world who also found age of household head to be a significant factor with a negative influence on decision to use certain strategies (Mabe *et al*., 2014; Obayelu *et al*., 2014; Uddin *et al*., 2014; Muzamhindo *et al*., 2015; Mwase *et al*., 2015; Atinkut and Mebrat, 2016; Mulinya, 2017).

More specifically, this study found that older farmers are less likely to engage in crop diversification, water harvesting or plant agroforestry trees. This is further echoed by Obayelu *et al.* (2014), who found that with increasing age, farmers where less likely to use improved varieties, engage in mixed farming, adjust planting period and diversify into non-farm activities. Similarly, in Ethiopia, Atinkut and Mebrat (2016) found that an older farmer was less likely to use soil and water conservation. A study conducted in several Southern African countries on factors affecting adoption of agroforestry practices found that farmers between the ages of 20-40 years contributed the largest group of adopters of agroforestry (Mwase *et al*., 2015). Younger farmers in Northern Ghana were found to be more likely to use improved crop varieties (Mabe *et al*., 2014).

This situation is to be expected, as older farmers are more conservative when following traditions and may be unwilling to experiment with new crops or new farming techniques (Uddin *et al*., 2014; Muzamhindo *et al*., 2015; Mulinya, 2017). Younger farmers are also more likely to take up various adaption strategies because they are more risk takers compared to older farmers and can also use the more labour intensive strategies (Mwase *et al*., 2015). In Narok East, older farmers are usually less educated compared to younger farmers and therefore lack the knowledge or skills to adopt and use new technologies and techniques.

Some studies, however, have found a positive correlation between age of household head and climate change and variability adaptation (Atinkut and Mebrat, 2016). The reason for this is that increasing age means more experience which enables older farmers to better anticipate climatic changes and plan for them (Atinkut and Mebrat, 2016).

For this study, household size was found to a significant factor, although it had a positive influence on one components (crop diversification, planting agroforestry trees and use of water harvesting structures) but a negative influence on another (loss reduction strategies). Similar to these findings, other studies have reported that with increasing household size, farmers are more likely to take up certain adaptation and coping strategies (Nti, 2012; Abid *et al*., 2015; Muzamhindo *et al*., 2015; Atinkut and Mebrat, 2016). More specifically, Nti (2012) found that larger families were more likely to use trees and cover crops as a response to drought. In Narok East, availability of cheap family labour means that farmers can comfortably construct water harvest structures and plant agroforestry trees. The need to provide food for a larger family may also necessitate households to look into more crops that provide both quality and quantity harvests thereby explaining why more family members means a higher probability to diversify crops.

On the other hand, however, other studies have reported a negative relationship between increasing household size and adapting to climate change (Zizinga *et al*., 2009; Mabe *et al*., 2014; Uddin *et al*., 2014; Mulinya, 2017). According to Mabe *et al*. (2014) families with large household sizes had low probability of shifting the cropping calendar. Ironically, availability of cheap family labour can also be used to explain why households with more family members in Narok East are less likely to stagger planting dates or use terraces. With more family members, farmers can use planting pits instead of terraces, and they can all finish the planting in one or two days rather than doing it in phases.

Other studies have also reported this scenario whereby household size affects two different strategies in opposite directions (Obayelu *et al*., 2014; Adimassu and Kessler, 2016). According to Obayelu *et al.* (2014), with increasing household size, households can increase the use of soil and water conservation strategies but reduce the probability of farmers adjusting their planting period or diversifying into non-farm activities.

The results of this study on the influence of level of education on climate change adaptation are echoed by many other studies that found the level of education (literacy level) to be positively related to adaptation to climate change and variability (Deressa *et al*., 2010; Nti, 2012; Mabe *et al*., 2014; Obayelu *et al*., 2014; Rakgase and Norris, 2014; Uddin *et al*., 2014; Abid *et al*., 2015; Fadina and Barjolle, 2018). This is because more educated farmers are more knowledgeable on climate change and on better agricultural production methods which they adopt to minimize loss and improve productivity in the face of changing climate and weather extremes.

5.4.2 Perceiving changes in climatic patterns

It is expected that a farmer cannot consciously adopt response strategies for a phenomenon they have not perceived. It therefore holds that perceiving climate change and variability is one of the most important factors that influence adaptation. In this study perceiving changes in mean annual rainfall and onset of rains positively influences the decision to take up most of the crop production response strategies. This result is consistent with the finding of Komba and Muchapondwa (2012) who reported that observing climate change and experiencing drought influenced farmers' coping strategies to climate change in Tanzania. In Ethiopia, farmers who had perceived increasing temperature were found to be more likely to adapt to climate change and variability compared to those who had not (Atinkut and Mebrat, 2016). In Northern Ghana, farmers who had perceived changes in temperature were more likely to plant trees on their farm (Mabe *et al*., 2014). When farmers in Swaziland perceive a change in climate, they are more likely to adapt to it by planting drought tolerant crops and changing planting time (Shongwe *et al*., 2014).

5.4.3 Receiving weather information

The results of this study indicated that farmers who received weather information were more likely to use most of the strategies. This is in agreement with the findings of Mwase *et al.* (2015) who reported that a better understanding of the relationship between climate change and land degradation is one of the factors that can enhance adoption of agroforestry technologies. Also, Abid *et al*. (2015) in a study conducted in Pakistan, reported that receiving weather forecast information positively influenced a farmer's decision to change crop types, change planting dates, plant shade trees, engage in soil conservation, change fertilizer, irrigate and diversify crops. Another study that had similar findings reported that farmers who had received climate change information were more likely to use improved varieties, adjust planting dates, and diversify into non-farm activities (Obayelu *et al*., 2014). Also, access to weather information also positively affects farmers' decision to fertilise and plant trees in their farms in Northern Ghana (Mabe *et al*., 2014). It is therefore agreeable that farmers who have a better understanding of what climate change and variability is, its causes and impacts are more likely to adapt better to it (Obayelu *et al*., 2014; Mwase *et al*., 2015).

5.4.4 Land tenure system

Land tenure systems and policies have a major influence on the nature of agriculture conducted on a farm, and indeed other land use practices (Wanjala, 2000). Land ownership is a sensitive in the study area, with a lot of previously communal land being privatized (Ojwang *et al*., 2010). Before undertaking the study, it was expected that people with title deeds would be more likely to use various strategies compared to those who had no title deeds. This was however not the case.

Similar findings were reported in Punjab Province of Pakistan, whereby tenant farmers were more likely take up various adaptation strategies compared to owner farmers (Abid *et al*., 2015). More specifically, they reported that farmers who owned their land were less likely to change crop type, change planting dates or change fertilisers, and these findings were similar to the ones of the current study. They associated this finding with the fact that a tenant farmer had more expenses including the rent of the land and therefore did more to be more profitable (Abid *et al*., 2015).

Part of this argument can be applied to Narok East, as farmers who don't have title deeds would want to get maximum benefits from the land. An even better explanation can be deduced from what Wanjala (2000) noted, that increased privatization of land in the pastoral areas had led to an increase in absentee landlords, those who hold onto land for accumulation and speculation purpose. This observation can therefore mean that farmers who have title deeds may be doing the bare minimum on their land as they wait for it to appreciate in value. Those without title deeds on the other hand may be maximizing use of their land since it may be their only source of livelihood.

The finding that farmers who use communal land are less likely to use soil and drought avoidance strategies and are also less likely to use irrigation or adjust planting dates is to be expected. This is because without complete freedom of how to use the land, farmers are restricted to using practices that would be acceptable to other community members.

5.5 Factors affecting farmers' choice of livestock production strategies

5.5.1 Household characteristics

This study reported that male headed households were more likely to engage in transhumance or get new breeds of animals. This finding is collaborated with the findings of Ndamani and Watanabe, (2016) who also found that male farmers are more likely to engage in certain adaptation practices compared to female farmers. In Ethiopia's Gondar region, it was reported that male headed households were more likely to engage in seasonal migration as an adaptation strategy compared to female headed households (Atinkut and Mebrat, 2016).

The findings of this study are as expected, since traditionally, female household heads are expected to stay at home and be care-givers, as the men go out to find pasture for the livestock. Furthermore, as noted by Bobadoye *et al.* (2016), the Maasai community is patriarchal in nature, which means that female household heads may not have the same opportunity as male household heads to access information on climate change and variability thereby hindering them from choosing certain strategies. This may explain their failure to get new breeds.

Just like the case with crop production strategies, age of household head was a significant but negative factor affecting climate change adaptation. Other studies have found similar results whereby older farmers were less likely to use certain adaptation practices (Atinkut and Mebrat, 2016; Ndamani and Watanabe, 2016). According to Atinkut and Mebrat (2016), older farmers were less likely to take up the more labour intensive livestock production strategy of seasonal migration.

Contrary to this observation however, older farmer's in Northern Ghana were found to be more likely to engage in destocking, which was attributed to them being less energetic to maintain a larger herd (Mabe *et al.*, 2014). This difference in findings can be explained by considering the differences in farming practices between Northern Ghana and Narok East. In Northern Ghana, the principal activity is crop farming with livestock keeping being restricted to zero grazing which is more labour intensive. Zero grazing is not a common practice in Narok East and owning more cattle is considered prestigious hence the unwillingness of older farmers to reduce their herd sizes. With older farmers also being less educated and more traditional, they are less likely to change their lifestyles.

The results of this study show that households with more family members are less likely to engage in transhumance or get new breeds of animals. This finding can be explained using some economic principles. Both of the strategies require significant financial investments. A family with more members would therefore rather spend the money on more basic needs such as food and education rather than on improving their animal breeds. In the same line, a family with more members might divert their resources to crop production rather than transhumance and buying new breeds of livestock, since crops can provide a family with food more readily than livestock. Some authors have had contradictory observations, for example, Ndamani and Watanabe (2016) reported that households with more family members were more likely to adapt to climate change in general. This ability of larger households to adapt is normally associated with the availability of cheap labor for those households. In the case of Narok East, having access to cheap labour may not give a household comparative advantage for transhumance or buying new breeds of livestock.

The level of education of household head was found to be positive and significantly related to farmers' choice of adaptation strategies with more educated farmers being more likely to use certain strategies, findings collaborated by many other studies (Deressa *et al*., 2010; Mabe *et al*., 2014; Uddin *et al*., 2014; Abid *et al*., 2015; Ndamani and Watanabe, 2016). On the other hand, at least one study reported a negative influence of education on adaptation. Educated farmers in Northern Ghana were found to be less likely to destock their livestock compared to illiterate farmers and this was associated with them having more knowledge and skills to manage greater number of stock (Mabe *et al*., 2014).

5.5.2 Perceiving climate variability

Unlike the case with crop production strategies, noticing climate change and variability in the way of noticing changes in mean annual rainfall or changes in the onset of rains was not a significant explanatory variable for the livestock production strategies. Farmers in Narok East Sub-county were originally and traditionally nomadic pastoralists. This means that they engaged in some of the response strategies such as transhumance and herd management as a way of life, long before climate change and variability became a global issue. This would in turn mean that engaging in such activities is not as response noticing changing climate, but rather continuing with their way of life.

5.5.3 Receiving weather information

Other studies have found similar results whereby access to climate information had a positive and significant impact on adaptation. One of the studies conducted in Ethiopia among sheep and goat farmers found that farmers who received climate information were more likely to use crossbred animals, engage in home feeding and do marketing during extreme weather events (Feleke *et al*., 2016). The Maasai pastoralists in Kajiado County also reported that receiving reliable and timely climatic information would enable them choose the appropriate response strategy (Bobadoye *et al*., 2016). In Nothern Ghana, farmers who received weather information were more likely to engage in destocking (Mabe *et al*., 2014). It is therefore to be expected that farmers who are more informed about climate change and variability are more likely to adopt zero grazing, use improved fodder, use new farm animals, fence their farms and look for alternative livelihoods.

5.5.4 Land tenure system

Farmers who use communal land for their livestock were found to be less likely to engage in zero grazing, use improved fodder or get new farm animals. This is to be expected as communal land tenure does not give the farmers the freedom to use the land as per their individual preferences but they instead have to follow the already agreed resolutions. Also, as reported by Mwase *et al* (2015), some climate change adaption strategies are difficult to adopt under communal land ownership, since farmers are more willing to invest in land whose security is guaranteed.

CHAPTER SIX
CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter presents the summary of this study's findings in the conclusion, and articulates the recommendations from the author on what can be done to improve farmers' adaptation to climate variability. Areas for further research are also highlighted at the end.

6.2 Conclusion

Farmers of Narok East have perceived changes in climatic patterns, especially the increase in temperatures, changing onset of rainfall, low rainfall and the increase of extreme weather events such as droughts and floods. Due to these changing conditions, they have responded by adopting various coping and adaptation strategies both for crop production and livestock production. The responses are not taken up at the same rate, with the traditional strategies and those that require less financial investment being more preferred. Of the twelve crop production strategies reported, early planting, use of manure and fertilisers, terracing and planting short season crops were the most widely adopted. Of the ten livestock production strategies, herd reduction, transhumance, fencing farms and getting new breeds of animals were the most widely adopted.

The age of a household head, level of education of household head, household size, noticing changes in mean annual rainfall and onset of rains, receiving weather information, and the land tenure system were all significant factors that influence a farmer's choice of both crop and livestock production response strategies. Older farmers were found to be less likely to use crop diversification strategies, herd management strategies and lifestyle change strategies compared to younger farmers. More educated farmers were more likely to use drought avoidance strategies, crop diversification strategies, adjust planting dates, use non-traditional strategies and engage in lifestyle change compared to less educated farmers. Households with more family members were found to be more likely to engage in crop diversification strategies, while at the same time being less likely to use loss reduction and lifestyle change strategies. Farmers who perceived changes in mean annual rainfall or the onset of rainfall were more likely to engage in adjusting planting dates, loss reduction and soil and drought avoidance strategies. Farmers who received weather information were more likely use loss reduction strategies, soil fertilization and drought avoidance strategies, adjust plating dates, use non-traditional strategies and engage in lifestyle changes. Farmers who use communal land were more likely to use loss reduction strategies, but less likely to use soil and drought avoidance strategies or non-traditional strategies.

The gender of the household head was not a significant factor for crop production response strategies. For the livestock production response strategies, female-headed households were found to be less likely to engage in transhumance or buy new breeds of animals.

6.3. Recommendations

The recommendations made are based on the objectives of the study. As regards to farmers observing or perceiving changing climate, the study recommends that farmers be provided with accurate and timely weather forecasts at the household level. This information can be sourced for the Kenya Meteorological Department by the Ministry of Agriculture of Narok County and then disseminated to the farmers. This information will help them plan better for their crop and livestock production, by giving them sufficient time to shield themselves from predicted impacts of climate variability. This study also recommends that more climate change education and climate variability awareness sensitization be carried out among the farmers of Narok East Sub-county.

As regards to the response strategies taken up by the farmers, this study recommends for the farmers to be trained and educated on the more effective response strategies. This role can be taken up by the NGOs working in the Sub-county, by the National government through the Ministry of Agriculture and the Narok County Government. Agricultural extension officers can be used to ensure that individual households are equipped with the knowledge and skills to use the more effective response strategies.

For crop production, farmers should be provided with better quality seeds that can thrive despite varying climate. For livestock production, farmers should be given incentives to access better breeds of animals that can produce more milk or more meat. As a long-term strategy, the County Government of Narok should invest in a large scale irrigation scheme, or in a scheme that provides irrigation water to households. They should also look into alternative response strategies such as the use of green houses, which shield crops against varying climate. All these actions would go a long way in ensuring that Narok County is food and livelihood secure.

Finally, as regards to the factors influencing a farmer’s choice of response strategies, this study recommends that all efforts be more concentrated on the more vulnerable groups of farmers.

This is to say that more emphasis should be placed on capacity building and educating older farmers, less educated farmers, female household heads and households with more family members. The Ministry of Lands in conjunction with the County Government of Narok should also expedite the process of issuing title deeds to farmers who use communal land so as to give them more freedom to adapt to varying climate. Finally, farmers without access to weather information should be assisted to get the information more conveniently and promptly.

6.4 Areas for further research

To improve community or household adaptation to climate change and variability, there is need to conduct research into which of the identified response strategies are more effective. This would involve doing a quantitative study into which strategies help farmers get more yields or minimize their loss. Further efforts can then be made to help farmers adopt those strategies and avoid the less effective ones.

Another area that needs further research is the issue of the challenges that farmers face while trying to adapt to changing climate. Although this study alluded to finances being one of those challenges, there is a need to identify and quantify the rest so as to help farmers overcome them.

REFERENCES

Abdi, H., & Williams, L. J. (2010). Principal Component Analysis. *WIREs Computational Statistics*, *2*(August), 434–459. https://doi.org/10.1002/wics.101

Abid, M., Scheffran, J., Schneider, U. A., & Ashfaq, M. (2015). Farmers ' Perceptions of and Adaptation Strategies to Climate Change and their Determinants : The Case of Punjab Province , Pakistan. *Earth System Dynamics*, *6*, 225–243. https://doi.org/10.5194/esd-6-225-2015

Adimassu, Z., & Kessler, A. (2016). Factors Affecting Farmers ' Coping and Adaptation Strategies to Perceived Trends of Declining Rainfall and Crop Productivity in the Central Rift valley of Ethiopia. *Environmental Systems Research*, *5*(13), 1–14. https://doi.org/10.1186/s40068-016-0065-2

Almassy, D. (2014). *Handbook for Asean Member States' Government Officials on Climate Change and the United Nations Sustainable Development Goals*. Hanoi: Hanns Seidel Foundation Viet Nam.

Amedie, F. A. (2013). *Impacts of Climate Change on Plant Growth, Ecosystem Services , Biodiversity , and Potential Adaptation Measure*. University of Gothenburg.

Antle, J. M. (2008). Climate Change and Agriculture: Economic Impacts. *Choices*, *23*(1), 9–11.

Asante, F. A., Boakye, A. A., Egyir, I. S., & Jatoe, J. B. D. (2012). Climate Change and Farmers' Adaptive Capacity to Strategic Innovations : The Case of Northern Ghana. *International Journal of Development and Sustainability*, *1*(3), 766–784.

Atinkut, B., & Mebrat, A. (2016). Determinants of Farmers Choice of Adaptation to Climate Variability in Dera Woreda , South Gondar Zone , Ethiopia. *Environmental Systems Research*, *5*(6), 1–8. https://doi.org/10.1186/s40068-015-0046-x

Bobadoye, A. O., Ogara, W. O., Ouma, G. O., & Onono, J. O. (2016). Assessing Climate Change Adaptation Strategies among Rural Maasai Pastoralist in Kenya. *American Journal of Rural Development*, *4*(6), 120–128. https://doi.org/10.12691/ajrd-4-6-1

Brown, D., Chanakira, R. R., Chatiza, K., Dhliwayo, M., Dodman, D., & Masiiwa, M. (2012). *Climate Change Impacts, Vulnerability and Adaptation in Zimbabwe* (The IIED Climate Change Working Paper Series No. 3). London.

Constantin, C. (2014). Principal Component Analysis - A Powerful Tool in Computing

Marketing Information. *Economic Sciences*, *7*(2), 25–30.

Convention on Biological Diversity. (2007). *Biodiversity and Climate Change*. Accessed on February 3, 2016

Debela, N., Mohammed, C., Bridle, K., Corkrey, R., & Mcneil, D. (2015). Perception of Climate Change and its Impact by Smallholders in Pastoral / Agropastoral Systems of Borana, South Ethiopia. *Springerplus*, *4*, 236–240. https://doi.org/10.1186/s40064-015-1012-9

Deressa, T. T., Ringler, C., & Hassan, R. M. (2010). *Factors Affecting the Choices of Coping Strategies for Climate Extremes: The Case of Farmers in The Nile Basin of Ethiopia* (No. 1032). Washington D.C.

Devkota, B. D., Paudel, P. P., Bhuju, D. R., & Kubota, T. (2012). Climatic Variability and Impacts on Biodiversity at Local Level : A case Study from Kanchanjanga Conservation Area , Nepal. *Journal of Faculty of Agriculture, Kyushu University*, *57*(2), 453–459.

Dinse, K. (2010). Climate Variability and Climate Change: What is the Difference? Accessed November 13, 2015, from www.miseagrant.umich.edu/climate

Dore, M. H. I. (2005). Climate Change and Changes in Global Precipitation Patterns : What do We know ? *Environment International*, *31*, 1167–1181. https://doi.org/10.1016/j.envint.2005.03.004

Eisenack, K., & Stecker, R. (2010). An Action Theory of Adaptation to Climate Change. In *Berlin Conference on the Human Dimensions on Global Environmental Change* (pp. 2–13). Berlin: Carl von Ossietzky Universitat Oldenburg.

Fadina, R., & Barjolle, D. (2018). Farmers ' Adaptation Strategies to Climate Change and their Implications in The Zou Department of South Benin. *Environments*, *5*(15), 1–17. https://doi.org/10.3390/environments5010015

Feleke, F. B., Berhe, M., Gebru, G., & Hoag, D. (2016). Determinants of Adaptation Choices to Climate Change by Sheep and Goat Farmers in Nothern Ethiopia: The Case of Southern and Central Tigray, Ethiopia. *Springerplus*, *5*(1), 1692.

Few, R., Satyal, P., McGahey, D., Leavy, J., Budds, J., Assen, M., … Bewket, W. (2015). *Vulnerability and Adaptation to Climate Change in The Semi-Arid Regions Of East*

Africa. Ottawa.

Food and Agriculture Organisation of the United Nations [FAO]. (2008). Climate-Related Transboundary Pests and Diseases. In *Climate Change, Energy And Food*. Rome: FAO.

Government of Kenya [GoK]. (2010). *National Climate Change Response Strategy*. Nairobi: Government Press.

Government of Kenya [GoK]. (2013). *National Climate Change Action Plan 2013 -2017*. Nairobi: Government Press.

Government of Kenya [GoK]. (2015). *Kenya National Adaptation Plan*. Nairobi.

Herrero, M., Ringler, C., Steeg, J. Van De, Koo, J., & Notenbaert, A. (2010). *Climate Variability and Climate Change and their Impacts on Kenya's Agricultural Sector*. Nairobi.

Intergovernmental Panel on Climate Change [IPCC]. (2007). *Climate change 2007: Impacts, Adaptation and Vulnerability*. New York.

Kabubo-mariara, J., & Kabara, M. (2015). *Climate Change and Food Security in Kenya* (5 No. 15). Nairobi.

Kabubo-mariara, J., & Karanja, F. K. (2006). *The Economic Impact of Climate Change on Kenyan Crop Agriculture : A Ricardian Approach*. Nairobi.

Kalungu, J. W., Filho, W. L., & Harris, D. (2013). Smallholder Farmers ' Perception of the Impacts of Climate Change and Variability on Rain-Fed Agricultural Practices in Semi-Arid and Sub-Humid Regions of Kenya. *Journal of Environment and Earth Science, 3*(7), 129–141.

Kandji, S. T., & Verchot, L. V. (2006). *Impacts of and Adaptation to Climate Variability and Climate Change in the East African Community; A Focus on the Agricultural Sector*. Nairobi.

Karanja, S., Wijk, M. T. Van, Rufino, M. C., & Giller, K. E. (2016). Adaptation Of Agriculture to Climate Change in Semi-Arid Borena , Ethiopia. *Regional Environmental Change*, *16*(8), 2317–2330. https://doi.org/10.1007/s10113-016-0940-4

Keane, B. J., Page, S., & Kennan, J. (2009). *Climate Change and Developing Country Agriculture : An Overview of Expected Impacts , Adaptation and Mitigation Challenges, and Funding Requirements* (Global Platform on Climate Change, Trade and Sustainable Development No. 2). Geneva.

Kenya National Bureau of Statistics {KNBS}. (2013). *Exploring Kenya's Inequality: Pulling*

Apart or Pooling Together? Nairobi.

Kimani, E. W., Ogendi, G. M., & Makenzi, P. M. (2014). An Evaluation of Climate Change Indigenous Coping and Adaptation Strategies for Sustainable Agro-Pastoral Based Livelihoods in Baringo County, Kenya. *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*, *8*(8), 38–58.

Komba, C., & Muchapondwa, E. (2012). *Adaptation to Climate Change by Smallholder Farmers in Tanzania* (No. 299).

Kurukulasuriya, P., & Rosenthal, S. (2003). *Climate Change and Agriculture; A Review of Impacts and Adaptations* (Climate Change No. 91). Washington D.C.

Mabe, F. N., Sienso, G., & Donkoh, S. (2014). Determinants of Choice of Climate Change Adaptation Strategies in Northern Ghana. *Research in Applied Economics*, *6*(4). https://doi.org/10.5296/rae.v6i4.6121

Mamba, S. F. (2016). Factors Influencing Perception of Climate Variability and Change among Smallholder Farmers in Swaziland. *Indian Journal of Nutrition*, *3*(2), 138–142.

Mazhirov, A. (2011). Climate Change to Exacerbate Rising Food Prices. Accessed September 12, 2016

McElroy, M., & Baker, D. J. (2012). *Climate Extremes: Recent Trends with Implications for National Security*. Washington D.C.

Mulenkei, L. (2015). *Promoting Climate Change Adaptation for Natural Resource Dependent Communities In Narok on Best Practices in Energy and Livestock Indigenous Information Network*. Nairobi.

Mulinya, C. (2017). Factors Affecting Small Scale Farmers Coping Strategies to Climate Change in Kakamega County in Kenya. *Journal of Humanities and Social Science*, *22*(2), 100–109. https://doi.org/10.9790/0837-220202100109

Muzamhindo, N., Mtabheni, S., Jiri, O., Mwakiwa, E., & Hanyani-mlambo, B. (2015). Factors Influencing Smallholder Farmers ' Adaptation to Climate Change and Variability in Chiredzi District of Zimbabwe. *Journal of Economics and Sustainable Development*, *6*(9), 1–6.

Mwase, W., Sefasi, A., Njoloma, J., Nyoka, B. I., Manduwa, D., & Nyaika, J. (2015). Factors Affecting Adoption of Agroforestry and Evergreen Agriculture in Southern Africa. *Environment and Natural Resources Research*, *5*(2), 148–157. https://doi.org/10.5539/enrr.v5n2p148

Naanyu, M. (2013). *Integration of Indigenous Knowledge With Information and*

Communication Technologies in Coping With the Effects of Climate Change and Variability on Agriculture in Kajiado County, Kenya. University of Nairobi.

Ndamani, F., & Watanabe, T. (2016). Determinants of Farmers' Adaptation to Climate Change: A Micro Level Analysis in Ghana. *Scientia Agricola*, *73*(3), 1–7.

Ngaira, J. K. W. (2007). Impact of Climate Change on Agriculture in Africa by 2030. *Scientific Research and Essays*, *2*(7), 238–243.

Nti, F. K. (2012). *Climate Change Vulnerability and Coping Mechanisms among Farming Communities in Nothern Ghana*. Kansas State University.

Obayelu, O. A., Adepoju, A. O., & Idowu, T. (2014). Factors Influencing Farmers ' Choices of Adaptation to Climate Change in Ekiti State , Nigeria. *Journal of Agriculture and Environment for International Development - JAEID*, *108*(1), 3–16. https://doi.org/10.12895/jaeid.20141.140

Ojwang, G. O., Agatsiva, J., & Situma, C. (2010). *Analysis of Climate Change and Variability Risks in The Smallholder Sector: Case Studies of the Laikipia and Narok Districts Representing Major Agro-ecological Zones in Kenya* (No. 41). Rome.

Oo, A. T., Huylenbroeck, G. Van, & Speelman, S. (2015). Conference on International Research on Food Security, Natural Resource Management and Rural Development. In *Determining Factors for the Application of Climate Change Adaptation Strategies Among Farmers in the Magwe District in the Dry Zone Region Of Myanmar* (pp. 8–11). Berlin.

Organisation for Economic Co-operation and Development [OECD]. (2015). Agriculture And Climate Change.

Phiri, I. P. (2012). *Modelling Farmers ' Choice of Adaptation Strategies Towards Climatic and Weather Variability : Empirical Evidence from Chikhwawa District , Southern Malawi Authored by*. Bunda College of Agriculture.

Rakgase, M., & Norris, D. (2014). Factors that Influence Choice of Drought Coping Strategies in Limpopo Province , South Africa. *Journal of Human Ecology*, *47*(2), 111–116.

Reeves, J., & Huq, S. (2015). Impacts of Climate Change on Least Developed Countries: Are the SDGs Possible? https://doi.org/10.13140/RG.2.1.2817.0649

Rosegrant, M. W., Ewing, M., Yohe, G., Burton, I., Huq, S., & Valmonte-santos, R. (2008). *Climate Change and Agriculture: Threats and Opportunities*. Eschborn.

Shongwe, P., Masuku, M. B., & Manyatsi, A. M. (2014). Factors Influencing the Choice of Climate Change Adaptation Strategies by Households : A case of Mpolonjeni Area Development Programme (ADP) in Swaziland. *Journal of Agricultural Studies*, *2*(1), 86–98. https://doi.org/10.5296/jas.v2i1.4890

SMART STAT Consultants Ltd. (2013). *Report of SMART Nutrition Survey Narok County, Kenya*. Nairobi.

Stocker, T. F., Qin, D., Plattner, G., Tignor, M. M. B., Allen, S. K., Boschung, J., … Midgley, P. M. (2013). *Climate Change 2013: The Physical Science Basis: Summary for Policymakers*. Cambridge.

Trenberth, K. E. (2013). *El Nino southern oscillation (ENSO)*. Boulder. https://doi.org/10.1016/B978-0-12-409548-9.04082-3

Uddin, M., Bokelmann, W., & Entsminger, J. (2014). Factors Affecting Farmers' Adaptation Strategies to Environmental Degradation and Climate Change Effects: A Farm Level Study in Bangladesh. *Climate*, *2*(4), 223–241. https://doi.org/10.3390/cli2040223

United Nations Development Programme [UNDP]. (2015). Sustainable Development Goals. Accessed March 26, 2016

United Nations Framework Convention on Climate Change [UNFCCC]. (2014). Climate Change Science- The Status of Climate Change Today.

Valdivia, C., Gilles, J. L., Jette, C., Quiroz, R., & Espejo, R. (2003). *Coping and Adaptation to Climate Variability: The Role of Assets, Networks, Knowledge and Institutions* (Vol. 2003). Columbia.

Wanjala, S. (2000). *Essays on Land Law: The Reform Debate in Kenya*. University of Nairobi.

Zizinga, A., Kangalawe, R. Y. M., Ainslie, A., Tenywa, M. M., Majaliwa, J., Saronga, N. J., & Amoako, E. E. (2009). Analysis of Farmer ' S Choices for Climate Change Adaptation Practices in South-Western Uganda, 1980-2009. *Climate*, *5*(89), 1–15. https://doi.org/10.3390/cli5040089

Code _ _ _ _

APPENDICES

Appendix 1: Questionnaire for the Household Survey

I am Kelvin Kinuthia a Masters student at Egerton University's Natural Resources Department conducting a research on climate variability and how farmers in Narok East are adapting to the phenomenon. All information you give out will be strictly confidential and will only be used for academic purposes. Your time and honesty is highly appreciated.

Questionnaire No: ______________________
Sub-County ___________________________
Ward ________________________________
Village _______________________________
Date: ________________________________
Enumerator: ___________________________

SECTION A: RESPONDENT INFORMATION

A.1 Information of the household head

1. Occupation of household head and other livelihood sources

____

2. Household information:

Gender of household head	**Age in Yrs.**	**Marital status**	**Level of education**	**Household size** (People living in the homestead over the last one year)	**Source of water** (Can tick more than one)
1=Male 2=Female		1=Married 2=Single 3=Divorced 4=Widowed	1=Primary 2=Secondary 3=Tertiary 4=University	1.Over 18 years 2. Under 18 years	1=River 2=Bore–hole 3=Tap water 4= Rain water 5=Roof catchment 6=Water pan 7=Spring 8=Other (Specify)

A2. Land tenure system

Tenure	Tick
1. Freehold with certificate/title	
2. Freehold without certificate	
3. Communal	
4. Family	
5. Lease	
6. Others (specify)	

A3. Livestock Information

List down all animals kept in the farm in order of importance

S/No	Current	Animals with declining numbers	Animals with increasing numbers	Animals that farmers stopped rearing	New animals farmers started keeping in last 20yrs
1					
2					
3					
4					
5					

B. CROPPING ENTERPRISES AND CROPPING SYTEMS

B.1 List down all crops grown now and state any changes in crop enterprises and cropping systems over the last 20 years:

S/No	Current	Crops with increasing acreage	Crops with declining acreage	Crops that you stopped planting	New crops that you started planting in last 20yrs
1					
2					
3					
4					
5					

SECTION C: IMPACT OF CLIMATE VARIABILITY IN PREVALENT FARMING PRACTICES

Awareness

C1) Have you noticed any changes in mean temperatures over the last 20 years?

Yes [ ] No [ ]

If Yes explain i.e. has the number of hot days stayed the same, increased or declined**?**

1. Stayed the same [ ] 2. Increased [ ] 3. Declined [ ]

C 8) What changes in the rainfall patterns have you noticed in the last 20 years ?

1. Drier [ ] 2. Wetter [ ] 3. No change [ ]

C2) Have you noticed any long term changes in mean annual rainfall over the last 20 years?

Yes [ ] No[ ]

If yes Explain i.e. has the number of rain days stayed the same, increased or declined?

1. Stayed the same [ ] 2. Increased [ ] 3. Declined [ ]

C3) Have you noticed any changes in the onset of long rains in the last 20 years?

Yes [ ] No [ ]

If yes, how has this affected planting times?

1. Stayed the same [ ] 2. Earlier [ ] 3. Later [ ]

C4) What changes in climatic patterns have you noticed/perceived in the last 20 years?

Indicators	
1. Extended dry spells	
2. Windstorms	
3. Increase in growing period	
4. Decrease in growing periods	
5. Increase in rainfall amounts	
6. Decrease in rainfall amounts	
7. Change in rainfall distribution	
8. Increased frequency of floods	
9. Decreased frequency of floods	
10. Occurrence of pests and diseases	
11. Frequent drought	
12. others (specify	

C5) What in your opinion are the causes of climate change?

Causes	
1. Excessive cutting down of trees	
2. Overgrazing	
3. Burning of farm wastes	
4. Others (*specify)*	

C6) What extreme events have you experienced in your area in the last 20 years?

Event	**Year of occurrence**	**Impacts**
1.Strong winds		
2.Elnino rains		
3.Severe drought		
4.Floods		
5.Livestock loss		
6.Others (specify)		

- *If event occurred more than once, indicate all the years*

C7) Do you receive weather information?

Yes [ ] No [ ]

If yes, through what means do you receive weather information?

Means of information	Tick
1. Radio	
2. Television	
3. Friends	
4. Fellow farmer	
5. Internet	
6. Mobile SMS	
7. Extension officer	
8. NGOs	
9. Others (specify)	

C9) In your opinion, has the yield of your crops improved/ declined since you started farming?

1. Improved [ ] 2. Remained the same [ ] 3. Declined [ ]

C10) What do you think caused the above changes?

1. Soil Fertility [ ] 2. Rainfall [ ] 3. Drought [ ] 4. Pests and Diseases [ ]

C11) What coping strategies have you used in crop and animal production on your farm?.

Coping strategies			
Crops	Tick	**Animals**	Tick
Water harvesting		Reduction of herd size,	
Terraces		Increase of herd size	
Increased use of manure		New farm animals	
Increased use of fertilizer		Zero grazing	
Early planting		New breeds of animals	
Drought tolerant crops		Fencing	
Crop diversification		Improved fodder	
Replanting		Others (specify)	
Irrigation			
Staggering planting dates			
Planting agroforestry trees			
Others (Specify)			

C12) Which water harvesting structures do you have on your farm for crop production and state how long you have continuously used each structure

Water harvesting Structures	***Length of time in use continuously***					
	Tick (if in use)	One season	2 seasons	3 seasons	4 seasons	More than 2 years
1. Planting pits						
2. Water pans						
3. Furrows						

4. Retention ditch						
5. Terraces						
6. Road run off						
7. Roof catchment						
8. Trenches						
9. Others (specify)						

SECTION D: HOUSEHOLD ADAPTATION PRACTICES AND LIVELIHOOD STRATEGIES AS INFLUENCED BY CLIMATE VARIABILITY AND CHANGES

D1. What are the farmer's response strategies to climate variability?

	Livelihood Strategy CROPPING	**Response Strategies**	
	Low yields/Crop failure		Tick
		Diversification of crops grown	
		Drought tolerant varieties	
		Local varieties	
		Adaptable species	
		Application of fertilizers/ manure	
		Use of pesticides	
		Use of herbicides	
	Low rainfall		
		Irrigation	
		Livestock production	
		Migration	
		Open up larger fields	
		Use of greenhouses	
		Water management practices	
	Late onset of rains		
		Change crop variety	
		Harvest and store water	
	Few number of rain days		
		Water management practices	
		Short season crops	
	Increased Droughts	Transhumance	
		Nomadism	
		Abandon livestock keeping	
		Alternative livelihoods	
		Keep browsers e,g goats/ sheep	

Appendix 2: Interview Schedule for Key Informant Interview

Name:……………………….

Occupation:………………….

Ward:………………………..

1. How long have you been a resident of Narok East?
2. How long have you been an active farmer/pastoralist in the area?
3. What are the indicators of climate change and variability in your community?
4. Have you noticed any changes in the climatic conditions? Mention some of the changes you have noticed
5. Would you say other farmers and pastoralists have noticed these changes as well?
6. What are the major impacts of such changes in Narok East Sub-county?
7. How do the farmers/ pastoralists of Narok East prepare to deal with any predicted changes in climatic patterns?
8. How do the farmers/pastoralists of Narok East react to the climatic changes after they have happened?
9. Have you received any training on the meaning of climate change/variability and how you can better adapt to the changes? If yes, which ones?
10. What kind of support has the local and national governments and other NGOs offered to help the resident of Narok East deal with the impacts of climate change/variability?
11. What are the main challenges that farmers/pastoralists facing while trying to adapt to climate change and variability?

Appendix 3: PCA results for livestock production strategies

Principal components/correlation		Number of obs	=	223

Number of comp. = 10

Trace = 10

Rotation: (unrotated = principal) Rho = 1.000

Component	**Eigenvalue**	**Difference**	**Proportion**	**Cumulative**
Comp1	**2.11287**	**.462683**	**0.2113**	**0.2113**
Comp2	**1.65019**	**.335065**	**0.1650**	**0.3763**
Comp3	**1.31512**	**.173839**	**0.1315**	**0.5078**
Comp4	**1.14129**	**.256397**	**0.1141**	**0.6219**
Comp5	.884889	.106139	0.0885	0.7104
Comp6	.77875	.0466052	0.0779	0.7883
Comp7	.732145	.16042	0.0732	0.8615
Comp8	.571725	.0799602	0.0572	0.9187
Comp9	.491765	.170509	0.0492	0.9679
Comp10	.321255	.	0.0321	1.0000

Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Comp4
COPANIMALS0	0.1227	**-0.6775**	-0.1010	0.0467
COPANIMALS1	-0.0772	**0.6921**	0.0678	-0.0305
COPANIMALS2	**0.4444**	0.0411	0.2963	0.0294
COPANIMALS3	**0.4344**	0.0346	-0.2133	-0.1793
COPANIMALS4	0.3805	0.0336	-0.1579	**0.4677**
COPANIMALS5	0.2746	0.0721	**0.4091**	0.1804
COPANIMALS6	**0.5044**	0.1623	-0.1520	-0.2053
RSRTID1	-0.1943	0.0936	-0.1750	**0.7590**
RSRTID3	0.1487	-0.0982	**0.5993**	0.2503
RSRTID4	0.2417	0.0895	**-0.4967**	0.1783