IMPACT OF CLIMATE VARIABILITY ON HOUSEHOLDS' ADAPTIVE CAPACITY AND ADAPTIVE STRATEGIES IN MAASAI PASTORALIST COMMUNITIES IN MAGADI DIVISION OF KAJIADO COUNTY, KENYA

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A Thesis Submitted in Partial Fulfilment of the Requirements for the Award of the Degree of Masters of Science in Environment and Natural Resources Management in the Department of Environment and Natural Resource Management and the School of Science and Technology of Africa Nazarene University

May 2025

DECLARATION AND RECOMMENDATION

Declaration

I hereby declare that this proposal is my original work and has not been presented for the award of a degree or diploma in this or any other University.

Phiah Wanjiru Muya

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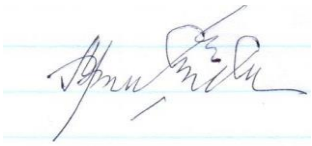
4th May, 2025

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Recommendation

The research proposal has been submitted with our approval as university supervisors.

Dr. Mark Ndunda Mutinda



_ _4th May, 2025_____

Dr. Sharon Jones



_____ _____ ___4th May, 2025_____

AFRICA NAZARENE UNIVERSITY

NAIROBI, KENYA

DEDICATION

This thesis is fondly dedicated to my parents Wamuyu and Muya for their encouragement and prayers during the course of my studies

ACKNOWLEDGEMENTS

I wish to register my heartfelt thanks to God for giving me life and good health throughout my studies and the success in finalizing this work.

I am greatly indebted to my supervisors Dr. Mark Ndunda Mutinda and Dr. Sharon Jones for their honest guidance and constructive criticism during the course of this research work. They have left an indelible impression on my mind which will continue to influence my work in future.

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Finally, I congratulate my research team for work well done and pass my sincere appreciation to the three hundred and sixty-six (366) pastoral households, thirty-four (34) Key Informants and forty (40) members of Focus Group Discussions who willingly provided the data used in this study, “may the almighty God bless you for what you have done for me”.

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ABSTRACT

Every corner of the world is already experiencing climate change, and the situation will worsen unless greenhouse gas emissions are reduced and adaptation measures are implemented. As a result, it is necessary to quantify the degree of variation and change in climate and the adaptive capacity of households and identify the potential effective adaptive strategies to buffer against climatic impacts. The goal of this study therefore, is to quantify the level of variation and change in climate, adaptive capacity of the households and the effective adaptive strategies for dealing with climate impacts of Maasai pastoral households in Magadi division of Kajiado County. The specific objectives of the study were to: (i) determine the characteristics of Maasai pastoral households, (ii) assess the level of climate variation and change, (iii) determine the adaptive capacity to climate variability and change of Maasai pastoral households, (iv) evaluate the adaptive strategies to climate variation and change undertaken by Maasai pastoral households in Magadi division of Kajiado County. This study used a mixed-methods research design. Primary data were collected through household surveys, key informant interviews, focus group discussion reports, archival documents, and journals as secondary data sources. A structured questionnaire was used to survey a stratified proportional random sample of 366 households. Thirty-four (34) key informant interviews were conducted on purposely selected respondents based on their knowledge on climate variation and change in the study area. Four Focus Group Discussions of ten (10) participants each were conducted within the four different locations in the study area to triangulate the information from the household survey. Descriptive (mean, median, mode, and frequency distributions) and inferential statistics (*regression analysis, ANOVA, Chi-square, t-test*) were used to analyze the collected data. Statistical tests were performed at a 5% level of significance. Data were analyzed using the Statistical Package for the Social Sciences (IBM SPSS version 26) statistical software. The level climate variability was found to be high, with a coefficient of variation (*CV*) of 35.4 and negative standardized precipitation index (*SPI*) in 17 years. Climate change based on long term rainfall trends was found to be on a decreasing trend. The Maasai pastoralists perceived the level of climate variability and change to be high (M = 3.97, SD = *.204*) on a scale of 1 to 5. There were no statistically significant (t=3.378, df 364, p=.059) differences between the male and female household heads in their rating of climate variability. The level of adaptive capacity to climate variation and change among the Maasai pastoral households was found to be moderate (M=2.55, SD=1.156). There were no statistically significant differences (t=1.688, df 364, p=.092) between the male and female headed households. The nature based adaptive strategies to climate impacts that were recommended included: forage preservation, ranked (M=3.94, SD=1.12) on a scale of 1-5; pasture restoration with enclosures, ranked (M=3.91, SD=1.11). while the non-nature based solutions to climate risks included: diversification to non-livestock livelihoods, ranked (M = 4.17, SD = *.99*); training on the climate mitigation measures (M = 3.88, SD = 1.38). The findings from the study will influence policy development in implementing climate variation and change adaptive and mitigating measures in Kajiado County.

DEFINITION OF TERMS

Adaptation

In human systems, adaptation is the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities (i.e. actions that reduce hazard, exposure and vulnerability).

In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects**.**

Adaptive capacity

The ability of systems, institutions, humans and other organisms to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences

Climate Change

The change in the average conditions such as temperature and rainfall in a region over a long period of time, typically decades or longer.

Climate Variability

Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system such as ocean-atmosphere coupling (internal variability), or to variations in natural or anthropogenic external forcing such as variations in solar output or changing concentrations of greenhouse gases (external variability).

Household

A household consists of one or more people who live in the same dwelling or a manyatta.

Livelihood

A set of activities essential to securing necessities of life.

Resilience

The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation.

Vulnerability

is the degree to which a system is susceptible to, and unable to cope with, unpropitious effects of climate change, including climate variability and climate extremes.

ABBREVIATION AND ACRONYMS

ASAL	Arid and Semi -Arid lands
CVI	Climate Vulnerability Index
IPCC	Intergovernmental Panel on Climate Change
SPI	**S**tandard Precipitation Index
WMO	World Metrological Organization

CHAPTER ONE

INTRODUCTION

1.1 Introduction

The research study focused on the assessment of climate variation and change impacting on Maasai pastoral households in Magadi division of Kajiado county using standardized climatic indices and household heads' perceptions. The household adaptive capacity to climate change and strategies undertaken by Maasai pastoral households were also determined. The households' adoptive strategies were evaluated in terms of their effectiveness and usefulness in alleviating the impacts of climate variability and change to the pastoral communities in Magadi division. Chapter one of this thesis covers; the background to the study, statement of the problem, objectives of the research, research questions, significance of the study, limitations of the study, delimitations of the study, theoretical framework and the conceptual framework of the study.

1.2 Background to the Study

Climate change is one of the most pressing global challenges of the 21st century, with profound implications for ecosystems, livelihoods, and socio-economic structures. The Intergovernmental Panel on Climate Change (IPCC, 2022) underscores the urgency of reducing greenhouse gas emissions while enhancing adaptation measures to mitigate the intensifying effects of climate change. Climate variability and change have led to increased occurrences of extreme weather events, shifts in precipitation patterns, and rising temperatures, all of which have far-reaching consequences on food security, water resources, and human settlements. The agricultural sector, particularly in developing regions, is among the most vulnerable due to its heavy reliance on climatic conditions such as rainfall and temperature (Ahsan et al., 2020; Abbas & Mayo, 2021; Ait-El-Mokhtar et al., 2022).

The impacts of climate variation and change are not uniform across regions, with developing countries disproportionately bearing the brunt of climate-related adversities. It is estimated that approximately 3.3 billion people, primarily in developing nations, are highly susceptible to climate change effects (IPCC, 2022). Poor agrarian communities, characterized by limited adaptive capacity and restricted access to alternative livelihoods, face heightened vulnerabilities (Eriksen et al., 2021; Huong et al., 2019). Rural populations often depend on climate-sensitive sectors such as agriculture and pastoralism, rendering them highly exposed to erratic weather patterns, prolonged droughts, and floods.

In Kenya, climate variability has manifested in prolonged droughts, erratic rainfall patterns, and increased occurrences of extreme weather events such as floods (Kenya Red Cross Society, 2012). The country has experienced cycles of prolonged drought interspersed with intense but short-lived rainfall, a phenomenon described as the *East Africa Climate Paradox* (Lyon & Vigaud, 2017). The Indian Ocean Sea Surface Temperatures (SSTs) have been identified as a key determinant of East African rainfall variability (Rowell et al., 2015). These climatic shifts have significantly impacted rural communities, particularly in arid and semi-arid lands (ASALs), where livelihoods are predominantly climate-dependent (Robina, 2019). The vulnerability of pastoral households in ASALs is exacerbated by unsustainable land use practices, declining pasture productivity, and increased frequency of resource-based conflicts.

Adaptation to climate change is a critical aspect of ensuring sustainable livelihoods and reducing vulnerability to climate risks. Adaptive capacity refers to the ability of individuals, households, and communities to anticipate, respond to, and recover from climatic shocks while minimizing adverse effects. This capacity is influenced by factors such as natural resource availability, economic capabilities, technological access, institutional support, and social networks (IPCC, 2022). Effective adaptation strategies in climate-sensitive regions may include diversification of livelihoods, water conservation techniques, adoption of drought-

resistant crops, improved livestock management practices, and integration of indigenous knowledge with modern climate adaptation frameworks (Mwangi, 2016; Bobadoye et al., 2016).

Despite the recognition of climate change impacts and the growing emphasis on adaptation, there remains a critical knowledge gap in understanding the specific adaptation strategies employed by vulnerable communities and their effectiveness in enhancing resilience. This study seeks to explore the interconnections between climate variation, household adaptive capacity, and adaptive strategies among Maasai pastoral households in Magadi division of Kajiado District, Kenya. By examining how these communities respond to climate variability and change, the research aims to provide empirical insights into the socio-economic and environmental drivers of adaptation, assess the effectiveness of current adaptation measures, and identify pathways for strengthening climate resilience among pastoral communities.

The findings of this study will contribute to the broader discourse on climate adaptation, inform policy interventions, and provide recommendations for improving adaptive capacity in ASAL regions. Understanding the nexus between climate change, adaptive capacity, and resilience is essential for developing evidence-based strategies that enhance the well-being and sustainability of climate-vulnerable populations.

1.3 Statement of the Problem

Magadi Division located in Kajiado West Sub-county, Kajiado County is part of arid and semi-arid lands (ASAL) in Kenya. The area is characterized by erratic rains accompanied with flush floods, extreme temperatures and cyclic and prolonged droughts. These adverse conditions directly impact on the biodiversity and the water resources in the area, which end up affecting pastoralism. Pastoralism is the main livelihood practised by the people, with more than 95 % of the households keeping livestock. The pastoral system depends on grazing of natural pastures and water owned collectively or individually by the Maasai community.

Currently the area has been experiencing an increase in the intensity of climate variation and change, which has led to more frequent extreme weather events like droughts which last longer than usual, irregular and unpredictable rainfall, flooding and increased temperatures. There have been in Kenya cycles of droughts interposed with floods experienced in years 2004, 2006 and 2009 where droughts were interposed with floods, as reported by the Kenya Red Cross Society (KRCS, 2012), a situation described by Lyon and Vigaud (2017) as the *East Africa's Climate Paradox*, where severe long droughts occur in the area, occasionally interrupted by short intense rainfall that has often led to flash floods. Furthermore, anthropogenic influences (Thakur et al., 2022) and other policy changes related to land tenure occurring in the study area, where the land tenure is changing from communal ownership to individual parcels have made the climatic extremes to be more magnified (BurnSilver & Mwangi, 2007; NLC, 2023; Unks, 2022; Unks et al., 2023).

Climate variation and change impacts are more pronounced in ASALs where the economy and rural livelihoods are highly dependent on climate-sensitive activities, such as pastoralism and rain fed cultivation (Gebre et al., 2023; Robina, 2019). Specifically, the reported impacts, include: high vulnerability to food insecurity (Amwata et al., 2016; Gebre et al., 2023); Degradation of pastures (BurnSilver & Mwangi, 2007) harsh environmental conditions, such as lack of water due to severe droughts (Mwangi, 2016), and negative impacts to human health (Balbus et al., 2016; Patz et al., 2005; Rocque et al., 2021; World Economic Forum, 2024).

The current research, therefore, quantified the level of climate variability and change in Magadi division, the adaptive capacity of Maasai households and the strategies that can be adopted by the people to enhance their resilience to the impacts of climate in the area.

1.4 Purpose of the Study

The purpose of this study was to assess climate change and variability, household adaptive capacity and strategies to alleviate the impacts of climate variation and change within Maasai pastoral households in Magadi division, Kajiado County, Kenya.

1.5 General Objective

To assess the contribution of climate variability and change to household adaptive capacity and analyse the strategies employed by Maasai households in Magadi division of Kajiado county, Kenya

1.5 1 Specific Objectives of the Study

The specific objectives of this study were to:

(i) Determine the characteristics of pastoral households in Magadi division of Kajiado county

(ii) Assess the level of climate variability and change in Magadi division using climatic indices and the perceptions of the Pastoralists

(iii) Determine household adaptive capacity to climate variability and change among Maasai households in Magadi division of Kajiado County

(iv) Evaluate climate variability and change adaptive strategies undertaken by Maasai pastoral households in Magadi division of Kajiado County

1.6 Research Questions

The following were the research question of this study:

1. What are the characteristics of Maasai pastoral households in the Magadi division of Kajiado county?
2. What is the level of climate variability and change in Magadi division using climatic indices and Pastoralists perceptions?

3. How good is the adaptive capacity of Maasai pastoral households to climate variability and change in the Magadi division of Kajiado County?
4. What are the adaptive strategies to climate variability and change undertaken by Maasai pastoral households in Magadi division of Kajiado County?

1.7 Significance of the Study

The findings from this study will help in the identification of existing gaps affecting the impartation of necessary skills needed by the pastoral and agro-pastoral households in adapting to the changing climatic conditions in Kajiado County.

Over the last decade, climate change has negatively impacted on global agriculture causing economic, social, and political problems. In order to address this nexus of climate change, agriculture and food security, the nations of the world have to enact policies to address this phenomenon (IPCC, 2014). The government of Kenya is a leader in addressing climate change and was one of the first countries in Africa to enact a comprehensive law and policy to guide national and subnational climate action. The Climate Change Policy 2016, Climate Change Act 2016 and the Climate Change Amendment Act 2023, the National Climate Change Action Plan III 2023-2027, and the long term Low Emissions Development Strategy 2022-2050 guide low-carbon and climate resilient development in Kenya. The best adaptive strategies identified by this study can be used to mediate the negative effects of climate change among the pastoral communities in Kenya.

There is a need to explore the issue of climate change and variation and how it impacts on the vulnerability of the households through localised research. This is important as research has shown that the way households adapt to climate change and variation will depend on local systems (IPCC, 2014). This would create a body of knowledge that will provide skills to farmers to enhance their adaptive and coping mechanisms.

The findings of this study will also be helpful to technical institutions, stakeholders and policy makers in creating and raising the standards of climate change and variation adaptation strategies. Findings will provide insight into the challenges, if any, of the different strategies hence help stakeholders to find better methods of handling the strategies to improve performance.

The findings from this study will add to knowledge on the existing literature and benefit other researchers that may wish to conduct further research to help improve the knowledge and information on climate change and variation. Issues raised in the study and recommendations that are made will be beneficial in the modification of facilities and programmes to improve on methods of dealing with climate change and variation.

The study is significant academically as it provides information on climate change and variation, adaptive strategies and vulnerability of households in the Arid and Semi-Arid Lands of Kajiado county in Kenya.

1.8 Scope of the Study

This study covered all pastoral and agro-pastoral communities living in Magadi division of Kajiado west sub-county in Kajiado county. Kajiado county is primarily an arid and semiarid area located in the southern tip of the former Rift Valley Province between longitudes 36°5' and 37°55' East and 1°10' and 3°10' south. The population residing in the study area is mainly composed of Maasai, these are Maa speaking communities.

Climate variability and change, Household adaptive capacity and strategies undertaken by the pastoralists were determined in the four former group ranches Olkiramatian, Shompole, Olkeri, and Oldonyonyokie. The area covered is the driest in Kajiado county and experiences recurrent droughts and many of the challenges associated with climate change and variation, therefore it was a good representation of the county in terms of climate change and can therefore be used to represent the ASAL areas in Kenya. The results and findings can be used to predict climate

change and variation, household adaptive capacity and adaptive strategies of other regions in Kajiado county and ASAL areas in Kenya.

1.9 Delimitations of the study

This study focused on assessing the household climate change and variations, adaptive capacity of the households and the coping mechanisms adapted by Maasai pastoral households in Magadi division of Kajiado county in Kenya. The study also looked at the different household characteristics that may influence the coping strategies of the pastoral communities, these included: the age of the respondents, the gender, formal education level, and number of people living in the households.

The study did not look at the climate change impacts on the health status of the pastoral communities. The indicator of individual health status was not included in the assessment of the household adaptive capacity to climate change. It has been demonstrated in studies that climate change has negative impacts on the health of individuals (Balbus et al., 2016; Patz et al., 2005; Rocque et al., 2021; World Economic Forum, 2024).

It was not feasible for this study to include the indicator of individual health status in the household adaptive capacity due to the fact health can be impacted by many other factors other than climate change. USAID (2022) groups these factors into three groups: (i) Direct impacts from increased frequency and severity of extreme weather events, including heat, that can lead to physical injuries, death and mental health challenges, (ii) Ecosystem mediated impacts, such as through air pollution, shifting temperature or precipitation patterns that can alter prevalence and distribution of vector-, water- or foodborne diseases and/or impact health outcomes related to nutrition and (iii) Socially mediated effects that occur via impacts on social and human systems, like increased poverty, migration or conflict which can impact the ability to access care or negatively influence care seeking behavior. Even though workable tools have been designed to capture the complex set of interdependent interactions through which climate

change affects human health, such as the Climate change and health indicators (CCHIs) (Di Napoli et al., 2022).

1.10 Limitations of the Study

The study area covered the Magadi division of Kajiado-west sub-county in Kajiado county which was purposely selected for this research. Kajiado county is a very large area and also due to the budget constraints, only a sample of the entire population was covered. This limitation was countered by dividing the area into sections (stratum) and having samples that were proportional to the population of the strata.

Poor infrastructure and language barrier in the study area caused challenges of accessibility. This however was mitigated by the use of research assistants from the area who were conversant with Maa language, their culture and location.

1.11 Assumptions

The researcher considered a number of assumptions:

(i) The respondents' responses were honest, truthful and accurate;

(ii) the sample size chosen was a representation of the whole population of the community in Magadi division;

(iii) The intervening variables remained constant;

(iv) The Key Informants were cooperative in releasing required information.

1.12 Theoretical Framework

The theoretical framework that was used to guide this study was the Household Economy Approach or Household Economy Analysis (HEA). The Household Economy Approach (HEA) is a method for assessing economic disruptions and changes of households over large rural areas, based on livelihood patterns and market data Seaman (2014). The framework is

designed to understand how households sustain their livelihoods, how their income fluctuates annually due to seasonal production shifts, market dynamics, or project interventions, and whether income shortfalls arise during difficult years, comparing it to a baseline year (Grillo & Bush, 2019).

HEA is a rural-level study examining how households obtain food and income through various sources, grown, collected, purchased or received as aid, local and migratory labour, while also analysing their expenditures to assess overall economic stability and vulnerability. (Holzmann et al., 2008). Household vulnerability assessment to climate variability involves complex interactions between multiple climate and non-climate factors across various scales within location-specific socio-economic systems (Seaman, 2014). The Household Economy Approach (HEA) provides a conceptual framework for analysing how households respond to environmental changes, helping policymakers and planners assess the potential impacts of intervention programs. Using household data from a known reference period, the HEA estimates how a shock or change in a future "prediction" year might affect food access. It considers both food and non-food needs and evaluates the use and appropriateness of various coping strategies. While some strategies, like selling all livestock, may ensure short-term survival, they may be deemed unsustainable or undesirable from a policy perspective.

The model enables simulation of local, national, or international events expressed as price or production changes across livelihood zones and wealth groups. It accommodates various hazards like droughts, floods, disease, and price shifts, and can also simulate the effects of proposed interventions to inform planning and response strategies.

The Scholar (Seaman, 2014) observed that, HEA supports climate change response by helping governments and agencies manage short-term shocks and protect household resilience, while enabling scenario planning for long-term climate impacts using projected trends. It also serves

as a valuable data source on rural livelihoods for broader applications and provides a reliable framework for collecting detailed, quantitative household data for research purposes.

1.13 Conceptual Framework

The conceptual framework presented in Figure 1.1 shows the linkages between the independent variable, moderating variable, intervening variable and the dependent variable. The independent variable, Climate variability and change, is represented by the number of drought incidents, rainfall and temperature changes and extremes as well as reliability to rainfall. The independent variable has a direct effect on the moderating variables, that include: household characteristics and household adaptive capacity. The moderating variable has an effect on the dependent variable, household adaptive strategies. Household adaptive strategies are represented by nature-based solutions and non-nature-based solutions. The household adaptive strategies (dependent variable) would vary with the changes in the moderating and independent variables. The variables contained in the framework are developed as multi-indicator indices and are explained in chapter two (2) and three (3).

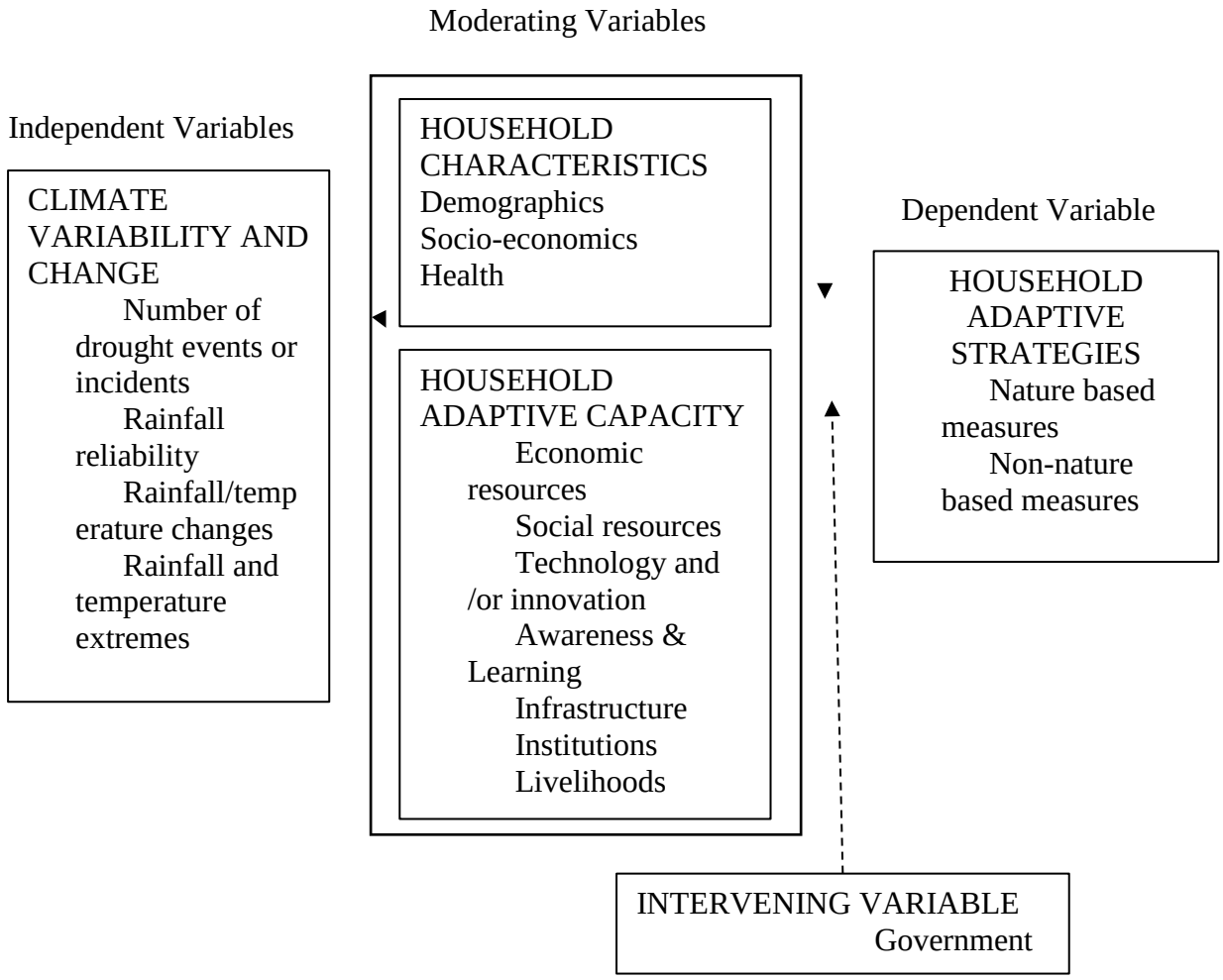


Figure 1.1: Conceptual framework depicting the relationship between climate variability and change, household adaptive capacity and adaptive strategies by Maasai pastoral households in Magadi division of Kajiado county.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter is a review on indicators of household vulnerability to climate change and variations. To begin with, is the vulnerability of pastoral households, household vulnerability, and measurement of household vulnerability to climate variations. Secondly, literature on assessment of climate change to household vulnerability. Further to that, a determination of knowledge related to climate variation and change that includes traditional knowledge and its effect on household vulnerability. Other areas include water scarcity and household characteristics as key indicators of household vulnerability to climate variations.

2.2 Climate Variability and Change

Climate change is already impacting every corner of the world, and much more severe impacts are in store if we fail to halve greenhouse gas emissions this decade and immediately scale up adaptation measures, this was concluded in a report by the Intergovernmental Panel on Climate Change (IPCC, 2022). The IPCC report provides a comprehensive examination of the expected future risks with the intensification of climate change impacts. The 2022 IPCC report also details which climate adaptation approaches are most effective and feasible, as well as which groups of people and ecosystems are most vulnerable to climate change. Agricultural industry is the most vulnerable as it directly depends on rainfall and temperature. Climate change's negative effect on agriculture has been widely reported globally (Ahsan et al., 2020; Abbas & Mayo, 2021; Ait-El-Mokhtar et al., 2022).

Developing countries, especially vulnerable populations, bear the brunt of the climate change phenomenon (Thomas et al., 2019; Winsemius et al., 2018). It is estimated that 3.3 billion individuals residing in these developing countries are highly susceptible to the impacts of

climate change (IPCC, 2022). Poor agrarian communities face higher vulnerability due to limited adaptive capacity and restricted access to alternative modes of production (Eriksen et al., 2021; Huong et al., 2019). It has been demonstrated in studies that climate change has negative impacts on the health of individuals (Balbus et al., 2016; Patz et al., 2015; Rocque et al., 2021; World Economic Forum, 2024). However, it is crucial to recognize that the impacts vary across regions, countries, sectors, and communities (Thao et al., 2019; Wu et al., 2016). Climate change in Kenya has led to more frequent extreme weather events like droughts which last longer than usual, irregular and unpredictable rainfall, flooding and increasing temperatures. There have been in Kenya cycles of droughts interposed with floods experienced in years 2004, 2006 and 2009 where droughts were interposed with floods, as reported by the Kenya Red Cross Society (KRCS, 2012), a situation described by Lyon and Vigaud (2017) as the *East Africa's Climate Paradox*, where severe long droughts occur in the area, occasionally interrupted by short intense rainfall that has often led to flash floods.

Climate variation and change impacts are more pronounced in ASALs where the economy and rural livelihoods are highly dependent on climate-sensitive activities, such as pastoralism and rain fed cultivation (Gebre et al., 2023; Robina, 2019). Specifically, the reported impacts, include: high vulnerability to food insecurity (Amwata et al., 2016; Gebre et al., 2023); Degradation of pastures (BurnSilver & Mwangi, 2007) harsh environmental conditions, such as lack of water due to severe droughts (Mwangi, 2016), and negative impacts to human health (Balbus et al., 2016; Patz et al., 2005; Rocque et al., 2021; World Economic Forum, 2024). Rainfall variability and increased temperature over recent years have resulted in increased vulnerability in an already fragile ASAL environment of Kajiado county (Babadoye et al., 2016; Mwangi, 2016), Baringo county (Pepela et al., 2022; Koskei et al., 2018; Ochieng et al., 2017), Kitui (Mwatu et al., 2020) and Turkana County (Akuja & Kandagor, 2019).

Climate variability has been defined as variations in the mean state and other statistics of the climate on all temporal and spatial scales, beyond individual weather events (WMO, 2019). Climate vulnerability has been described as the propensity to be adversely affected and lack of capacity to cope and adapt (IPCC, 2014). The consequences of climate variations and change can impact on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes and climate events occurring within a categorical duration and the susceptibility of an exposed society or system (IPCC, 2014). Warming of the climate system is unequivocal', as is conspicuous from visual examinations of incremental in ecumenical mean air and ocean temperature, widespread melting of snow and frozen dihydrogen monoxide and ascending ecumenical sea level (Solomon, 2007). Climate variations and changes contribute to extreme events like increase in frequency and astringency of droughts, floods, cyclones, outbreak of pests and diseases which leads to low crop yields, crop failure, widespread hunger and livestock mortality (Morton, 2007; IPCC, 2012). The empirical documentation by various studies has also revealed an increasing trend in the direct economic losses caused by climate variation extremes, particularly in developing nations (Mirza, 2003; Stern, 2007; Bouwer, 2011; IPCC, 2012).

There have been predictions that temperatures are likely to increase by 2^{o}C and increase in annual precipitation and extreme rainfall events (IPCC, 2014). Climate change poses serious threats to livestock production. Increased temperatures, shifts in rainfall distribution, increased frequency of extreme weather events and consequent increased heat stress and reduced water availability are expected to adversely affect livestock production and productivity around the region both directly and indirectly. The IPCC (Niang, 2014) predicts with high certainty that Climate change will amplify existing stresses on water availability in Africa with the Magadi

region being no exception, especially being part of the ASAL. The threats associated with climate change impacts may lock the already marginalized rural population in poverty traps as their livelihoods are exposed to additional risks, thereby perpetuating poverty, deprivation and livelihood insecurity (IPCC, 2014). Although the causes of such vulnerability are multidimensional, they are primarily due to widespread poverty, food insecurity, recurrent droughts, land degradation, inequitable land distribution and over dependence on rain fed agriculture (Notenbaert et al., 2013). Some other common factors postulated to determine adaptive capacity and therefore influence vulnerability at the household level include access to markets, resources, infrastructure, household structure, gender, education, age, farm size, income, access to community-based organizations, access to information, credit facilities, health facilities among others (Opiyo et al., 2014). Developing countries are largely expected to be disproportionately hurt by projected changes in temperature, precipitation, and extreme events (Skjeflo, 2017*)*. On the other hand, the actual household level response to these changes is not well understood, and there are still gaps in the methodological approaches to understanding these issues (Skjeflo, 2017). Rural livelihoods in semi-arid areas are increasingly exposed to climate impacts such as rising temperatures, erratic rainfalls and more intense and frequent climate-related extreme events. This is introducing new risks to the already vulnerable and marginalized societies that lack development and have high poverty rates.

About 80% of Kenya is characterized as arid and semi-arid lands (ASAL) (GOK, 2012, vision 2030). Kajiado County is one of the ASAL regions in Kenya with pastoralism as the main source of livelihood to millions of people residing in these lands (Amwata et al., 2016). Magadi region is characterized by erratic rains accompanied with flush floods, extreme temperatures and cyclic and prolonged droughts, *National Environment Action Plan framework* (NEAP 2009-2013). The variations in the intensity and frequency of these conditions may be the

manifestations of climate changes whose full impacts are yet to be understood. “Although climate change is a global phenomenon, its impacts are felt at the regional and local levels, and it is at these levels where actions to adapt to it and mitigate its effects are required. It is therefore crucial that governments and individuals have access to science-based knowledge that is regularly updated and derived from robust data” remarks (Taalas, 2019). Traditionally, Magadi division has had a bi-modal rainfall pattern whose integrity could be changing. This could lead to devastating effects on people’s livelihoods thus impacting on the Vulnerability of the community. In view of the enhanced vulnerability of semi-arid regions to climate variations and change (IPCC, 2014), this paper identifies the key determinants of household vulnerability to climate variations in Magadi division. It also aims to encourage investment in adaptation strategies that are better suited to the needs of the population.

2.2.1 Methodology for Assessing and Measuring Climate Variation and Change

Climate describes the long-term pattern of weather conditions that occurs in a locality. Thermometers and rain gauges are used to collect weather data. There is no single instrument measuring climate change (Global Green House warming, 2021. The climate system is a complex, interactive system consisting of the atmosphere, land surface, snow and ice, oceans and other bodies of water, and living things (Global Green House warming, 2021).

The atmospheric component of the climate system is what we generally refer to as climate. Climate is often defined as ‘average weather’. Climate is usually described in terms of the mean and variability of temperature, precipitation and wind over a period of time, ranging from months to millions of years (Global Green House Warming, 2021; IPCC, 2007). The major components of climate change measurements include; temperature, rainfall, biomass and vegetation patterns, sea level measurements, solar activity, volcanic eruptions, chemical composition of air or water, and representative compensation pathways.

Temperature, a primary variable when measuring climate change and can be measured or reconstructed for the Earth's surface, and sea surface temperature (SST) (Global Green House Warming, 2021). Precipitation (rainfall, snowfall) offers another indicator of relative climate variation and may include humidity or water balance, and water quality. Biomass and vegetation patterns may be discerned in a variety of ways and provide evidence of how ecosystems change to adapt to climate change. Sea level measurements reflect changes in shoreline and usually relate to the degree of ice coverage in high latitudes and elevations. Solar Activity can influence climate, primarily through changes in the intensity of solar radiation. Volcanic eruptions like solar radiation, can alter climate due to the aerosols that are emitted into the atmosphere and alter climate patterns. Chemical composition of air or water can be measured by tracking levels of greenhouse gases such as carbon dioxide and methane, and measuring ratios of oxygen isotopes. Research indicates a strong correlation between the percent of carbon dioxide in the atmosphere and the Earth's mean temperature. (Global Green House Warming, 2021; IPCC, 2007). The IPCC (2013) recommended the use of Representative Concentration Pathways (RCPs) to analyse climate change.

Assessing vulnerability to climate change is important for defining the risks posed by climate change and provides information for identifying measures to adapt to climate change impacts. It enables policy makers and decision-makers to identify the most vulnerable areas, sectors and social groups. In turn, this means climate change adaptation options targeted at specified contexts can be developed and implemented.

2.2.2 Tools Used in Assessing Climate Change and Variability

Climatological Normal

The climatological normal of a climatic element in a particular location is the average value corresponding to a number of years sufficient to allow it to be admitted that it represents the

predominant value of that element in the location considered (WMO, 2018). The World Meteorological Organization (WMO) has set for this purpose 30 years starting in the first year of each decade (1901-30, ..., 1931-1960, 1941-1970, ..., 1961-1990, 1971-2000). The statistical calculations relating to these intervals are generally referred to as Climatological Normals (the 1931-1960 and 1961-1990 normals being considered the reference normals).

Coefficient of Variation

The coefficient of variation (CV) is a relative measure of variability that indicates the size of a standard deviation in relation to its mean. It is a simple ratio of the standard deviation to the mean. It is a standardized unitless measure that can be used to compare variability between disparate groups and characteristics. It is also known as the relative standard deviation (RSD). The coefficient of variation can be calculated by dividing the standard deviation with its mean. The calculation involves taking the standard deviation and dividing it by the mean.

$$CV = \frac{\grave{o}}{\mu} * 100 \qquad CV = \frac{Standard\ deviation}{Mean}$$

Higher values indicate that the standard deviation is relatively large compared to the mean. higher values represent a greater degree of relative variability.

The statistics produce absolute and relative measures of variability. Absolute measures of variability, is where the variable's unit of measurement is used to describe the variability. Units can be in the form of time (minutes, days, years). The relative measure of variability on the other hand, uses a standardization process that removes the original units of measurement. In the CV ratio, both the standard deviation and the mean use the same units, which cancels them out and produces a unitless statistic. The coefficient of variation is a dimensionless quantity and is usually given as a percentage. It helps to compare two data sets on the basis of the degree of variation.

Coefficient of variation formula:

	Coefficient of Variation	Standard Deviation
Population	$\frac{\sigma}{\mu} \times 100$	$\sigma = \sqrt{\frac{\sum(x_i - \mu)^2}{N}}$
Sample	$\frac{s}{\mu} \times 100$	$s = \sqrt{\frac{\sum(x_i - \mu)^2}{N - 1}}$

Where:

CV is the coefficient of variation,

ò is the standard deviation

µ is the mean precipitation of the recording period.

CV was employed to detect the seasonal and annual rainfall variability for the observation period. As documented by Hare (2003), the degree of rainfall variability is classified as high (CV > 30) percent; moderate (20 < CV > 30) percent and low (CV < 20) percent. Hence the higher the value of CV the higher the variability of rainfall in the study region and the reverse is also true. Values of CV above 33 % are said to exhibit non-equilibrium system characteristics (Ellis, 1995), where the variation in rainfall is very high for the mean annual rainfall figures to be meaningful.

Rainfall Indices

Climate change refers to a change in the state of the climate that can be identified using statistical tests by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer (IPCC, 2013) And so, dry seasons becoming more frequent, higher temperatures than usual, very short rainy seasons in previous dry periods, droughts, and floods, among other consequences, attributed to climate change, are considered the main threats to human development in our generation (UNDP, 2007). This characterization of rainfall variability can be highlighted by the calculation of rainfall indices.

Standardized Precipitation Index (SPI)

One of the most widely used indices is the SPI, which characterizes droughts at different temporal scales using only precipitation data (McKee et al., 1993). The SPI is recommended by the World Meteorological Organization (WMO) for assessing meteorological droughts (WMO, 2012). This index is characterized by relating the accumulated precipitation during a given period with the statistical distribution of the historical rainfall recorded at the location; In addition, it can be obtained for different time scales (1, 3, 6, 12, 24 and 48 months). The SPI is calculated by taking the difference of the normalized seasonal precipitation from the long term seasonal mean and dividing it with the standard deviation, as in the following formula:

$$SPI = \frac{Xij - Xim}{\delta}$$

Xij= seasonal precipitation value

Xim=long term seasonal mean precipitation

Ò= standard deviation

SPI has different output values ranging from -2.0 to 2.0 (Svaboda, 2012) as described in Table 2.1.

Table 2.1: Standard Precipitation Indices (SPI) and their interpretation.

SPI Value	Interpretation	
≥ 2.0	Extremely wet	Wet when index is positive
1.5 to 1.99	Severely wet	
1.0 to 1.49	Moderately wet	
-0.99 to 0.99	Near normal	0= normal
-1.0 to -1.49	Moderately dry	Dry when value is negative
-1.5 to -1.49	Severely dry	
≤ -2.0	Extremely dry	

SPI values have been used to describe drought characteristics such as the duration, magnitude and intensity can be computed for the entire study area and each of the individual climate stations.

Magnitude is the absolute sum of SPI for each identified drought event.

Duration is the time (in months) between the commencement and termination of a drought event (that is, the point when SPI becomes negative until the point when it becomes positive).

Intensity is the SPI value of less than -1 of a drought event. Peak drought intensity is defined as the lowest SPI value of the drought event. Mean intensity refers to magnitude divided by duration.

Drought frequency is the number of times a drought event occurs in a stipulated number of years over a particular times scale.

Rainfall index or Nicholson method

It is used to determine the number of deficit and surplus years. Thus, it is used to identify wet, normal, and/or dry periods from the rainfall dataset. This rainfall index can be computed using Equation 1 below (Nicholson, 1993).

$$lN = \frac{(Xi - Xm)}{\delta}$$

Where

Xi is the precipitation for the year,

Xm is the average precipitation of the study period and

δ is the standard deviation of the annual rainfall that occurred during the study period.

Negative values indicate a rainfall deficit during the period and positive values define excessive rainfall amounts

Standard Anomaly Index (SAI)

Moshe and Beca, 2024

$$SAI = \frac{(Pi - \mu)}{\delta}$$

Pi= is the annual or seasonal rainfall

μ= is the mean of the annual or seasonal rainfall

δ=is the Standard deviation of annual or seasonal rainfall

2.2.3 Climate Change and Variation in Magadi Division

Magadi Division is located in Kajiado County which is primarily an arid and semiarid county located in the southern tip of the former Rift Valley Province between longitudes 36°5' and 37°55' East and 1°10' and 3°10' south. Mean annual rainfall ranges from 300 mm to 800 mm whereby rainfall is bimodal, with the short rains from October to December and long rains from March to May (Said et al., 2019). The arid and Semi-arid lands experience inherently unpredictable rainfall and frequent droughts, which are exerted by climate change (Lutta et al., 2020).

Studies have confirmed variability in rainfall patterns in Magadi division with annual averages of 400mm (Kyuma, 2016; Rongei, 2012). These studies confirmed that rainfall had been on the decline over the years between 2000-2013 (Kyuma, 2016; Rongei, 2012). Rainfall variability also occurred within the season, from season to season, and even from year to year (Kyuma, 2016; Rongei, 2012). A declining trend in the rainfall amounts was observed over the period 2000-2013 which had direct implications on the vegetation, livestock and livelihood dynamics. Droughts are the major climatic conditions which affect vegetation and livelihoods in the ASALs (GOK-PDNA, 2012). During the dry periods the effects of water shortages were most apparent as well as low vegetation in quality and quantity (GOK-PDNA, 2012). A study on the annual average temperatures for the period 2001 to 2013 against time also revealed an increase in average temperatures (Kyuma, 2016).

The Concept of Vulnerability

The concept of vulnerability was first introduced by White (1974) and later expounded by Burton and Kates (1978). Over time, the concept and methods of vulnerability assessment have evolved across different disciplines. In social sciences, vulnerability refers to the risks a system

faces due to natural disasters and the capacity of the affected persons to respond based on the available resources. A social system's vulnerability to climate change is shaped by factors such as level of exposure, physical conditions, sensitivity, and capacity to adapt (Adger, 2003). Furthermore, being vulnerable to climate change extends to more than just being exposed to its effects. It is defined by a number of pre-existing factors such as poverty levels, education, awareness, and livelihood diversification, all of which shape the sensitivity and adaptive capacity of a household (Abid, 2016).

A reflection of ongoing research has seen the Intergovernmental Panel on Climate Change definitions for vulnerability keeps changing over time. For instance, in a recent definition IPCC referred to vulnerability as a confluence of factors, including susceptibility to harm and limited ability to adapt or respond effectively (IPCC, 2021). Additionally, factors that weaken self-protection, restrict access to social protection, hinder recovery, or subject certain households to more frequent and severe hazards contribute to increased vulnerability (Notenbaert, 2013). Analysing vulnerability at the household level aids in recognizing the risks that households face and exploring potential coping and adaptation strategies. The success of adaptation to climate variations and change is the ability to adjust the household environment system in response to changes in climatic conditions thereby mitigating associated risks and implementing adaptive strategies (Wheeler et al., 2013).

2.2.4 Climate Variability and Household Vulnerability

Climate variability is universally accepted as one of the complex and a major environmental problem facing mankind today globally (UNEP, 2014). Literature shows that households in many vulnerable regions in Sub-Saharan Africa are likely to be adversely affected by climate change and variations including parts of Eastern Africa (Thornton, 2008).

The impacts of climate change are predicted to have severe consequences for societies and economies and an overwhelming impact on the vulnerability of households, particularly in rural communities (Nani et al., 2019). Climate change can unfold either gradually or abruptly, with evidence for these patterns derived from historical climate studies, modelling, and contemporary observations (Hansen et al., 2016). Climate change has likely already increased global economic inequality, and is projected to continue doing so (DeFries et al., 2019). Risks contributed by climate variations and change are unevenly distributed with the less fortunate populations in the developing and developed countries facing the greatest impact (IPCC, 2014). In Kenya, climate variations have resulted in extreme weather events like prolonged droughts, irregular unpredictable rainfall, flooding, and increasing temperatures. The impacts are particularly pronounced in the arid and semi arid areas where the economy and livelihoods are highly dependent on climate sensitive activities such as pastoralism and agropastoralism (Robina et al., 2019).

Studies confirm that there are many factors that contribute to household vulnerability. Socio-economic factors influence household vulnerability to food insecurity (Korir et al, 2021). Various factors influence the vulnerability status of households, including the age, education, and job experience of the household head, the number of working members, livestock holdings, and per capita income. These elements collectively impact rural livelihoods and their resilience and capacity to adapt to climate change and variations (Inayatullah, 2012).

Understanding the complex relationships of climate variations and change to household vulnerability and their ability to cope among the Maasai pastoralist Magadi division, Kajiado county in Kenya is a necessary first step toward informed and effective policymaking and interventions as well as community livelihood diversification, food security and adaptation initiatives.

Measurement of Household Vulnerability

Various approaches for measurement, assessment and quantifying vulnerability of households to climate change and variations have been deployed. The Household Vulnerability Index can be assessed using both the economic and indicator approaches (Nkondze et al., 2013).

The economic approach relies on household-level socio-economic survey data to analyse the vulnerability levels of different social groups. Alternatively, the indicator approach measures vulnerability by developing a set of indicators, which are selected using expert judgment, principal component analysis, or correlation with past disaster events (Nkondze et al., 2013). However, the limitation of this approach was in being subjective in selection of variables and their relative weights, the availability of data at various scales, and the difficulty of testing or validating the different metrics (Luers, 2005).

Vulnerability to natural hazards consists of three dimensions; exposure, sensitivity and resilience. Exposure is the degree of experienced natural disaster of climate reliability (Pandey, 2011), while sensitivity is the degree of community or system affected by harm due to exposure to natural hazard, resilience also known as adaptive capacity is the ability of a community or system to mitigate the effect of harmful disaster (Ayesha, 2018). Different Vulnerability studies lead to different dimensions for the measurement of vulnerability. The incorporation of exposure, sensitivity and resilience into a single model demonstrates quantitative interrelationship of household vulnerability to natural hazards (Ayesha, 2018). Vulnerability index development by the net effect of adaptive capacity (socio economic) and sensitivity divided by exposure (biophysical) as depicted in the vulnerability equation 1, which combines adaptive capacity, sensitivity and exposure (IPCC, 2014):

$$\text{Vulnerability} = (\text{Adaptive capacity}) - (\text{sensitivity} + \text{Exposure}) \quad \textit{equation 1}$$

As the equation indicates, if the adaptive capacity of the household exceeds that of sensitivity and exposure, the household becomes less vulnerable to climate change impacts (Opiyo et al.,

2014). As vulnerability is a socially constructed subject (Hinkel, 2011), studies based on primary data collection or those employing a mix of primary and secondary data are better posited to provide insight on socially determined drivers of vulnerability. The IPCC Livelihood Vulnerability Index offers a tested technique that has the ability to identify the determinants of vulnerability and at the same time possesses the capacity to compare scores among different units (Adu, 2017). It also allows contextualizing the choice of indicators to the local scenario. The power of providing household level analysis is also a positive feature of this methodology (Adu, 2017).

For computing the IPCC-Livelihood Vulnerability Index, the researchers perform a categorization of components of socio-demographic profile, livelihoods, health, social networks, food, water and natural disasters and climate variability into aspects exposure, sensitivity and adaptive capacity (Adu, 2017). The data used in the computation of subcomponents measured at different scales, so as to normalize data before measuring vulnerability index (Hahn, 2009). It is important to note that vulnerability is a theoretical concept. It cannot be directly measured or observed (Hinkel, 2011). Measurement is the systematic process of assigning a number to a phenomenon that we can observe (Hinkel, 2011).

2.2.5 Impacts of Climate Change and Variation on Water Resources in Magadi Division

The impacts of climate variation and change on the water resources in Magadi division are discussed under the following sub-topics: water sources in Magadi and water scarcity in Magadi division.

Sources of Water in Magadi Division

Magadi division's main source of fresh water is from Oloibotioto Stream which originates from the Ngurumani escarpment and flows into the Ewaso Nyiro River. The Magadi division piped water supply is tapped from the river at an abstraction source by Tata Chemicals Magadi and

through gravity, it is transported 60 km to Magadi via a pipeline to the water treatment plant (Andere, 2009). Along the pipeline several supply points have been made to supply water to the households and livestock in Magadi division (Andere, 2009). Due to the alkalinity nature of Lake Magadi, the lake doesn't provide any fresh water to the households in the region. However, the lake contains some lagoons of salty water which have been tapped through the Tata Chemicals Magadi for use in processing of trona and also in ablutions in Magadi Township (Andere, 2009). Magadi division has 1725cm^3 of water supply whereby 94.3% of this is the piped water supply of 1626cm^3. Other parts of Magadi division source water from boreholes with a capacity of 18cm^3, 60cm^3 of hand dug wells and 21cm^3 from dams and water pans which generally comes from rain water *National Environment Action Plan framework* (NEAP 2009-2013).

Water Scarcity in Magadi Division

Water scarcity, water stress or water crisis is the lack of fresh water resources to meet the standard water demand. Water use has been growing globally at more than twice the rate of population increase in the last century, and an increasing number of regions are reaching the limit at which water services can be sustainably delivered, especially in arid regions (UN, 2018). About 4 billion people, representing nearly two-thirds of the world population, experience severe water scarcity during at least one month of the year (Mekonnen & Hoekstra 2016). Nearly half the global population are already living in potential water scarce areas at least one month per year and this could increase to some 4.8 - 5.7 billion in 2050. About 73 % of the affected people live in Asia (69% by 2050) (Burek et al, 2016). With the existing climate change scenario, by 2030, water scarcity in some arid and semi-arid places will displace between 24 million and 700 million people (UN, 2009). 700 million people worldwide could be displaced by intense water scarcity by 2030 (Global Water Institute, 2013).

Kenya is ranked as having one of the lowest water replenishment rates in the world with renewable water resources per capita below 1000 cubic meters (UN, 2008). Kenya is limited by an annual renewable fresh water supply of 647 cubic meters per capita, which is expected to decrease as population and economic development in Kenya increase (Mogaka, 2009). In terms of water usage for the whole country, Kenya significantly exceeds the amount of renewable freshwater the country possesses. As previously stated, Kenyans are consuming 33 billion m^3, but their total renewable water resources only equal 30.7 billion m^3, resulting in a difference of 2.7 m^3 (Aquastat, 2006).

Magadi Division is located in Kajiado county and entirely depends on groundwater reserves due to limited number of permanent rivers and reliable rainfall regimes *National Environment Action Plan framework* (NEAP 2009-2013). Water supplied to is far short of the estimated demand for the district. Magadi division has a water demand of 1951m3/day, water availability of 1732m3/day and percent coverage of 89 % *National Environment Action Plan framework* (NEAP 2009-2013). The area is faced with environmental issues that contribute to water scarcity and stress, water use conflicts, siltation of dams and pans, spring degradation, and non-operational water facilities.

Households cover long distance to collect water with average return distance trekked by households to water sources increased by 9 % to 6.1 km in December 2020 National drought Management Authority (NDMA, 2020) due to the drying up of pans and decline in water quality for those still holing water following poor rains, households switched to permanent water sources mainly boreholes/shallow wells and piped. Watering frequencies for all the livestock species has reduced to 3-4 times a week in Kajiado west (NDMA, 2020). The effects of climate change on water resources are manifested through extreme events such as droughts, violent storms, and floods that impact communities dependent on these water resources.

2.2.6 Impacts of Climate Change and Variation onPasture Availability

Climate change and variation through unpredictable rainfall and seasonality patterns have brought stress on rangelands throughout sub-Saharan Africa (Karuku, 2018). Whereas pastoral mobility was the most effective strategy to make use of constantly shifting resources in the arid and semi-arid areas, recurrent droughts, loss of forage, government-led settlement schemes, and enclosure of land for community conservation has made this unsustainable (Annemiek, 2018).

Drought Effect on Pasture Availability

The rapid recurrence of drought-related shocks leaves inadequate recovery time before the next shock occurs. This means that an increasing number of households, the majority of them being pastoralists, are losing their capacity to participate economically and to be self- sufficient. Integrated food security phase classification (IPC 2022) reported approximately 3.5 million people with 24% from ASAL regions faced high levels of acute food insecurity, primarily due to consecutive below-average rainy seasons, leading to poor crop and livestock production. Drought diminishes the quantity and quality of pasture in the rangelands forcing pastoralists to migrate. Frequent and extremely severe droughts in the lead to replacement of perennial grasses with the annuals and the encroachment of non-palatable plant species such as *Sansavellia sp* ("*oldupai")* and *Opuntia amegacantha* (prickly pear), which do not co-exist with grass (Huho et al., 2010).

Overgrazing Effects on Pasture Availability

In an area already stressed by unpredictability in rainfall patterns, overgrazing in the already scarce resource is inevitable. When the pasture sprouts again and before it has matured enough it is then consumed (Rinkesh, 2021). Overgrazing generally reduces the availability of pasture and hence reduces productivity of livestock and distorts the biodiversity of an area. Moreover,

controlled grazing also imposes risks by lack of access to nutritious pastures in turn reduces livestock productivity (Idibu, 2016).

Bush Encroachment Effects on Pasture Availability

The initial pasture vegetation consists of high-quality grasses and herbs that provide substantial nutritional benefits. However, intensive grazing results in the degradation of these pastures, leaving areas devoid of vegetation, which facilitates the proliferation of more resilient species like weeds and less desirable plants. These secondary species offer lower nutritional value and, due to their adaptability, they displace native flora, leading to a decline in valuable plant species (Boles et al., 2019).

A case study from Laikipia, which shares some similarities with the Magadi Division, illustrates the ecological impacts seen when invasive species such as *Acacia mellifera* and *Prosopis juliflora* are introduced. These species, known for their ability to endure in degraded semi-arid conditions, further diminish the availability of pasture. While mechanical removal of these invasive plants is labor-intensive and challenging, biological control methods, including the introduction of specific beetles, have not been successful (Paterson et al., 2011). Additionally, climate variability and land degradation in rangelands have hastened the loss of native pasture resources that are favoured by grazing livestock (Kelvin et al., 2024).

2.2.7 Pastoralists Knowledge on Climate Variation and Change

Despite access to climate information which has been essential for pastoralists to adapt effectively to climate change (Kedir, 2016), pastoralists remain the most vulnerable to climate variability and change (Muchuru, 2017). Pastoralists use indigenous forecasts (IFs) (Nganzi, 2015) and scientific forecasts (SFs) in their adaptation to extreme weather events (Lybbert, 2007). Although indigenous forecasts have been used widely in predicting weather patterns, (Joshua, 2011) scientific forecast is used to complement the trusted and familiar indigenous forecast (Michael et.al, 2021).

Pastoral Indigenous Knowledge Systems

Local and indigenous knowledge refers to the understandings, skills and philosophies developed by societies with long histories of interaction with their natural surroundings. For rural and indigenous peoples, local knowledge informs decision-making about fundamental aspects of day-to-day life (UNESCO, 2017).

Indigenous knowledge builds on long-term understanding and practices of socioecological systems of various societies across the world. It is a social learning process by which practices and behaviors are adjusted towards embracing better uses of the surrounding environment and contributing to the well-being at individual, communal and societal levels. As such, indigenous knowledge has guided societies and supported sustainable management of resources, especially in regions where practices have been known for hundreds of years. In contrast, Western science often produces knowledge from simulating the real world through modelling. Therefore, not only is indigenous knowledge an important indicator of how sustainable development can be achieved, but it can also complement science and policy by placing them in the local context for better implementation, Global sustainability development report, (GSDR, 2019).

Indigenous communities have direct experience of the environmental impacts of climate change. Their knowledge can thus be of great help in better understanding climate change impacts and identifying more effective ways of tackling them (Yadav & Hugo, 2012). Historical and scientific data are lacking for some regions, but Indigenous cultures have retained practices and knowledge acquired over countless generations and could thus complement scientific approaches (Yadav & Hugo, 2012).

Historical and scientific data are lacking for some regions, but Indigenous cultures have retained practices and knowledge acquired over countless generations and could thus complement scientific approaches (Yadav & Hugo, 2012). Indigenous or traditional knowledge may prove useful for understanding the potential of certain adaptation strategies that are cost-

effective, participatory and sustainable (IPCC, 2010). Indigenous peoples and local communities hold highly specialized traditional knowledge and technologies (TKT), rooted in local ecosystems, that have been shown to be beneficial to environmental conservation and climate action (CIF, 2020).

Technical Knowledge Systems

Early Warning Systems (EWS) (Sommer, 1998) Climatic uncertainty and associated risk is high in pastoral areas and this has led to a number of efforts to develop systems for Early Warning of impending stress or disaster, including climatic shocks and livestock disease. Meteorological droughts cannot be avoided, but their impact can be mitigated, particularly by supporting pastoralists to plan ahead for impending drought.

Effective EWS can allow livelihood stress to be detected before lives are threatened, although impact depends on how these early warnings are used and responded to. However, to date EWS have not always been effective, providing either the wrong type of information or at the wrong time to allow effective response.

Measuring rainfall, forage performance and water sources will provide an early warning, but measurement of these 'endowments' needs to be complemented with monitoring of entitlements such as grain and livestock markets, access rights to water and forage, or access to alternative sources of revenue. Climate shocks in particular can lead to a "price scissors", where livestock values plummet just as cereal costs surge, leading to a large shift in the terms of trade. Effectiveness of early warning and response depends on the institutions responsible, which is determined particularly by connectivity to pastoralists on the ground both for effective monitoring and for effective communication. To be useful, warning and response cannot be effective in isolation and need to be integrated into a broader process of Drought Cycle Management or Disaster Risk Reduction, or similar approaches to strengthening adaptive capacities and entitlements.

Strengthening adaptive capacity requires an awareness of the implications of a threat, knowledge of the options for reacting effectively to the threat, the means to implement a chosen strategy and the freedom and right to pursue the chosen course of action (IUCN, 2010). A study done in Kenya investigated agro-pastoralists' use of climate information in their adaptation strategies (Bryan, 2013). The findings revealed that the use of weather forecasts positively influenced adaptation. Another study revealed that the use of weather forecasts increased the likelihood of livestock migration among pastoralists in Kenya (Silvestrietal, 2012).

Pastoral Knowledge on Climate Variation and Change and Household Vulnerability

Pastoralists in Africa use detailed knowledge of their environments, characterized by highly variable and unpredictable resources, to maximize livestock productivity and minimize asset loss (Schareika, 2010). Most households in the pastoralist areas have no basic primary education, and majority are not able to read and write, this reduces a household's ability to understand climate information and early warnings hence making the households more vulnerable (Opiyo, 2014)

Pastoral Household Characteristics

Studies have indicated that the vulnerability level of households to frequently occurring climate induced stresses is largely determined by the Gender and education level of household heads (Opiyo, 2014). Most households in the pastoralist areas have no basic primary education, and the majority are not able to read and write, this reduces a household's ability to understand climate information and early warnings hence making the households more vulnerable. In addition, dependence on livestock as the main source of income rendered the households more vulnerable (Opiyo et al., 2014). Factors that contribute to higher adaptive capacity include education of household heads, access to information and communication technologies and strong social networks (Hahn et al., 2009; Connolly, 2015; Panthi, 2015). Higher education

level reflects higher ability to receive, interpret and comprehend risks and hazards, thus, it positively impacts adaptive capacity (Byrne 2014).

Gender of Household Head

The household head is responsible for making the final household level decisions, his/her education level determines the capacity of the household to anticipate risks and respond to them through changes in livelihood strategies (Panthi, 2015). Women generally are less involved in decision-making processes and have limited access to information and facilities (Samee et al., 2015). Comparison of female and male-head household-differentiated livelihood vulnerability showed that female-headed households were more vulnerable than male-headed households (Nani et al., 2019). In terms of natural hazards and climate variability, communication and knowledge, water, and health, female-headed households were highly vulnerable compared to male-headed households (Nani et al., 2019). The result shows limited access of female-headed households to communication and proper information about climate-related hazards, as well as to membership in local organizations (Nani et al., 2019).

Women are also disproportionately affected by climate change impacts: they often lack land rights and access to financial resources, training and technology, and they may have little influence on political decision-making. Similarly, many indigenous peoples do not possess the financial resources or technological capacity required for climate change adaptation. However, women, indigenous peoples and other vulnerable communities can be powerful agents of change when included in the design of solutions, since they are first-hand witnesses of climate change impacts (GSDR, 2019).

Household Number

Previous study of pastoral communities revealed that the majority of the household had more than five persons and more than five dependents (Opiyo et al., 2014). The highly vulnerable

Households had more than five dependents and no access to early warning information on climate change and variability (Opiyo et al., 2014).

Land Tenure in Magadi Division

Before the promulgation of the Constitution of Kenya, 2010, customary lands were recognised through trust land and group ranches, governed by Trust Land Act, Cap 288 and Land (Group Representatives) Act, respectively. The concept of group ranches in Kenya involved setting aside and registering land that was shared by a group of people, often Indigenous and local communities, most of whom practised pastoralism. This provided a window through which group or community ownership could be exercised in Kenya.

Group ranches faced a number of challenges, including the inefficient and inequitable management of communal land by the group ranch representatives; pressure from different actors to privatise the ranches; and increasing demands for the communal land to be subdivided into individual smaller parcels for personal use. These prevailing issues informed policy reforms introduced through Sessional Paper No. 3 of 2009 on National Land Policy, the Constitution of Kenya, 2010, and Community Land Act, 2016.

The Community Land Act (CLA) repealed the Land (Group Representatives) Act, Cap 287 and Trust Lands Act, Cap 288. It provided a mechanism for transitioning group ranches held under Land (Group Representatives) Act to "community land" to improve tenure security and facilitate more equitable, inclusive, and accountable management of communal land.

In 2021, the National Land Commission (NLC) in collaboration with NAMATI Kenya commissioned a study to monitor and assess this transition process. Specifically, the study sought to document the status of the transition of group ranches to community land in Kenya; establish the level of involvement of women, youth, and other minority groups during the transition process; identify challenges to and with the process; determine the extent to which state actors were involved in the process; and identify practical measures to fast-track and

improve the process. The initial research on these changes revealed that progress on transitioning group ranches across Kenya to community land has been slow. While efforts began in 2017, by May 2023 only 46 out of 315 group ranches nationally had fully transitioned. To determine why progress has been slow, the NLC and NAMATI, Kenya studied sixteen (16) undissolved group ranches in four counties (Laikipia, Samburu, Kajiado, and West Pokot) that had either started or had yet to start the transition process (NLC, 2023).

2.2.8 Adaptive Strategies to Climate Variability and Change

Climate variability and change pose significant threats to global ecosystems, economic stability, and human livelihoods. Communities, particularly in vulnerable regions, have developed various adaptive strategies to mitigate the adverse effects of climate-related stressors. These strategies range from technological innovations to indigenous knowledge systems, all aimed at enhancing resilience and reducing vulnerability (IPCC, 2022). This review explores the adaptive strategies employed in different socio-ecological systems, evaluating their effectiveness and implications for future sustainability.

Agricultural Adaptation Strategies

Agricultural practices are highly sensitive to climatic variations, necessitating adaptive strategies to sustain productivity. Common adaptation measures include crop diversification, conservation agriculture, and the use of drought-resistant crop varieties (Abbas & Mayo, 2021). Conservation agriculture, characterized by minimal soil disturbance and crop rotation, has been widely adopted to enhance soil moisture retention and reduce erosion (Ait-El-Mokhtar et al., 2022). Additionally, agroforestry has been identified as a viable adaptation strategy, integrating tree planting with crop production to provide ecological and economic benefits (Eriksen et al., 2021).

Water Management Strategies

Water scarcity, exacerbated by climate change, has necessitated the adoption of improved water management techniques. Rainwater harvesting, irrigation efficiency improvements, and the development of water conservation policies are fundamental adaptive strategies (Huong et al., 2019). In arid and semi-arid lands (ASALs), water storage infrastructure such as sand dams and boreholes has been instrumental in ensuring water availability during prolonged dry spells (Mwangi, 2016).

Livelihood Diversification

Livelihood diversification is a key adaptation strategy that enhances economic resilience against climate shocks. Households in climate-vulnerable regions often engage in multiple income-generating activities, such as combining agriculture with small-scale businesses or engaging in non-farm employment (Bobadoye et al., 2016). Diversification reduces dependence on climate-sensitive livelihoods, thereby mitigating the risks associated with climate extremes (Robina, 2019).

Indigenous Knowledge and Traditional Practices

Indigenous knowledge plays a crucial role in climate adaptation, particularly in communities with limited access to modern technologies. Traditional weather forecasting methods, seed preservation techniques, and communal resource management practices have proven effective in responding to climate variability (Thao et al., 2019). The integration of indigenous knowledge with modern climate adaptation strategies can enhance resilience and foster sustainable development (Wu et al., 2016).

Institutional and Policy-Based Adaptation

Government policies and institutional frameworks play a vital role in climate adaptation. Policies promoting sustainable land management, climate-smart agriculture, and financial support mechanisms such as climate insurance are critical in enhancing adaptive capacity

(Winsemius et al., 2018). Additionally, international collaborations and funding initiatives support the implementation of adaptation projects in climate-vulnerable regions (IPCC, 2022).

Effectiveness of Adaptive Strategies

The effectiveness of adaptive strategies depends on several factors, including socio-economic conditions, access to resources, and institutional support. While technological advancements and policy interventions have facilitated climate adaptation, challenges such as inadequate funding, lack of awareness, and socio-cultural barriers hinder effective implementation (Rowell et al., 2015). The success of adaptation measures requires an integrated approach that combines scientific research, local knowledge, and participatory governance.

Adaptive strategies to climate variability and change are essential in building resilience and reducing vulnerabilities. A combination of agricultural innovations, water management techniques, livelihood diversification, and policy interventions enhances the capacity of communities to cope with climate-related challenges. Future adaptation efforts should focus on integrating indigenous knowledge with modern technologies, strengthening institutional frameworks, and promoting sustainable resource management practices. By doing so, societies can enhance their resilience and secure livelihoods in the face of an uncertain climate future.

2.3 Summary of Literature Review and Research Gaps

Climate change and its impacts on livelihood have become an area of prime concern in the scientific and political community. Current climate shocks and stresses have an overwhelming impact on the vulnerability of households, particularly in rural communities. Household Vulnerability to climate variations consists of three dimensions; exposure, sensitivity and adaptive capacity. The incorporation of exposure, sensitivity and adaptation into a single model demonstrates quantitative interrelationship of household vulnerability to climate variations which this study wishes to adopt. While assessing climate change and variations, the major components of measurements include; temperature, precipitation (rainfall, snowfall), biomass

and vegetation patterns, Sea level measurements and Chemical composition of air or water can be measured by tracking levels of greenhouse gases such as carbon dioxide and methane, and measuring ratios of oxygen isotopes. The studies have shown that household vulnerability is caused by a broad range of factors. These include; political, institutional, economic, environmental and socio-cultural factors such as insufficient knowledge, organizational gaps, lack of personal and financial resources and inadequate legislation. Magadi division being an ASAL is susceptible to impacts of climate variations and change. A study of these impacts to household vulnerability is deemed necessary. The next chapter covers the research methodology, data collection and analysis.

Various studies have projected significant climate change impacts in Africa and beyond. Vulnerability is one of the key terms in the climate change literature, but little progress has been made in the field of its quantification at household level. Typically, indicators are combined according to a weighing scheme, with the identification of indicators and the weighing schemes based on expert judgment rather than empirical evidence. In addition, most quantitative assessments are applied to countries or other administrative units, whereas managing climate risk has traditionally been the responsibility of households. Poor understanding by policy makers and planners of the rationale of pastoralism and its significant contribution to local livelihoods and the wider economy compared to other land uses in the same environment, partly explains why policy and planning has failed to enhance pastoral mobility and protect the rangelands from further encroachment (Hesse & MacGregor, 2006; Hatfield & Davies, 2007; Behnke, 2006, 2008, 2010; Krätli, 2014).

The inability of pastoralists to articulate the deep knowledge they have of their environment, and how they utilize it, compounds the problem. The menace of overgrazing looms large in historical and political narratives of ecological degradation in savannah ecosystems. While pastoral exploitation is a conspicuous driver of landscape variability and modification,

assumptions that such change is inevitable or necessarily negative deserve to be continuously evaluated and challenged. Science and technology have at times exacerbated global problems by contributing to unsustainable growth and climate change, for example or by making efficiency breakthroughs that eventually lead to greater aggregate use of scarce resources. Moreover, the existing science system has failed on occasion to translate its findings on issues such as climate change into workable policy recommendations (GSDR, 2019).

Despite available international literature on climate vulnerability and climate vulnerability index, the literature of Kenyan ASALs are handfuls which have not focused on pastoralists' household vulnerability to climate variations in Magadi division. Available literatures have covered such issues on perceptions and adaptation coping strategies of the Maasai community, except the correlation between climate variability and household vulnerability at local level in Magadi division. Still, there is a query whether climate variability and climate change induced stresses in the Magadi division have affected the vulnerability of households or not, and whether the correlation between climate change hazards and household vulnerability occur or not. This study therefore focuses on building more on the vulnerability of households, analysing the vulnerability to climatic stresses of Maasai households in Magadi Division and test the validity of a number of vulnerability indicators and assessing more on use of indigenous knowledge and documenting it for sustainable adaptation strategies.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter three (3) on research methodology outlines the procedures and activities that were conducted in order to obtain the data used in this study. The chapter is organized in the following sections: research design, research site, target population, study sample (size and sampling procedure), data collection (instruments, piloting, reliability, validity and data collection procedure), data analysis, and legal and ethical considerations.

3.2 Research Design

A mixed method research design was used that involved four different designs, these included: cross sectional household survey, descriptive research, correlational and evaluative research designs. The evaluative design was used to systematically assess the effectiveness, efficiency, and impact of strategies used in climate change management. The descriptive design was used to observe and describe the characteristics of the climate of Magadi division. Correlational design was used to investigate the relationship between household vulnerability and climate variation and change, while the cross-sectional survey design was used to collect information on pastoral households. The data collection methods included: the use of a household survey, in-depth Key Informants Interview (KII) and Focus Group Discussions (FGD). Secondary sources of data were also used to collect data for this study, this included climate data and socioeconomic characteristics of the respondents. A summary of the specific objectives, the measurable variable(s) / indicators and specific research designs for the study are shown in Table 3.1.

Table 3.1: Summary of Specific Objectives, Measurable Variable(s)/Indicators and Specific Research Designs for the study

Specific Objectives		Measurable Variable(s) / indicators	Research Design
(i)	Determine the characteristics of pastoral households	Characteristics of Pastoralists	Cross-sectional household Survey
(ii)	Assess the level of climate variation and change in Magadi division using climatic indices and the perceptions of the Pastoralists.	Standardized Precipitation Index (SPI), Pastoral Perceptions	Descriptive research designs
(iii)	Determine household vulnerability to climate variation and change of Maasai households in Magadi division.	Independent vulnerability to climate change Dependent adaptive strategies and capacity	Correlational research design
(iv)	Evaluate climate variability and change adaptive strategies undertaken by Maasai pastoral households in Magadi division of Kajiado County	Strategies and capacity	Evaluation research design

3.3 Research Site

The study was conducted in Magadi Division, in Kajiado west Sub County of Kajiado County, Kenya. Magadi division lies in the south western part of Kajiado County as shown in Figure 3.1 and Appendix K and L. The sub-county covers an area of 7,862.1 sq km., while the Magadi division covers an area of 2,562.7 sq km. Magadi Division is divided into four wards (ranches), these include: was selected because of its climatic conditions and its proneness to drought being on the leeward side of the Ngong hills. Magadi division is sparsely populated with a population density of 13 persons per km (KNBS, 2019).

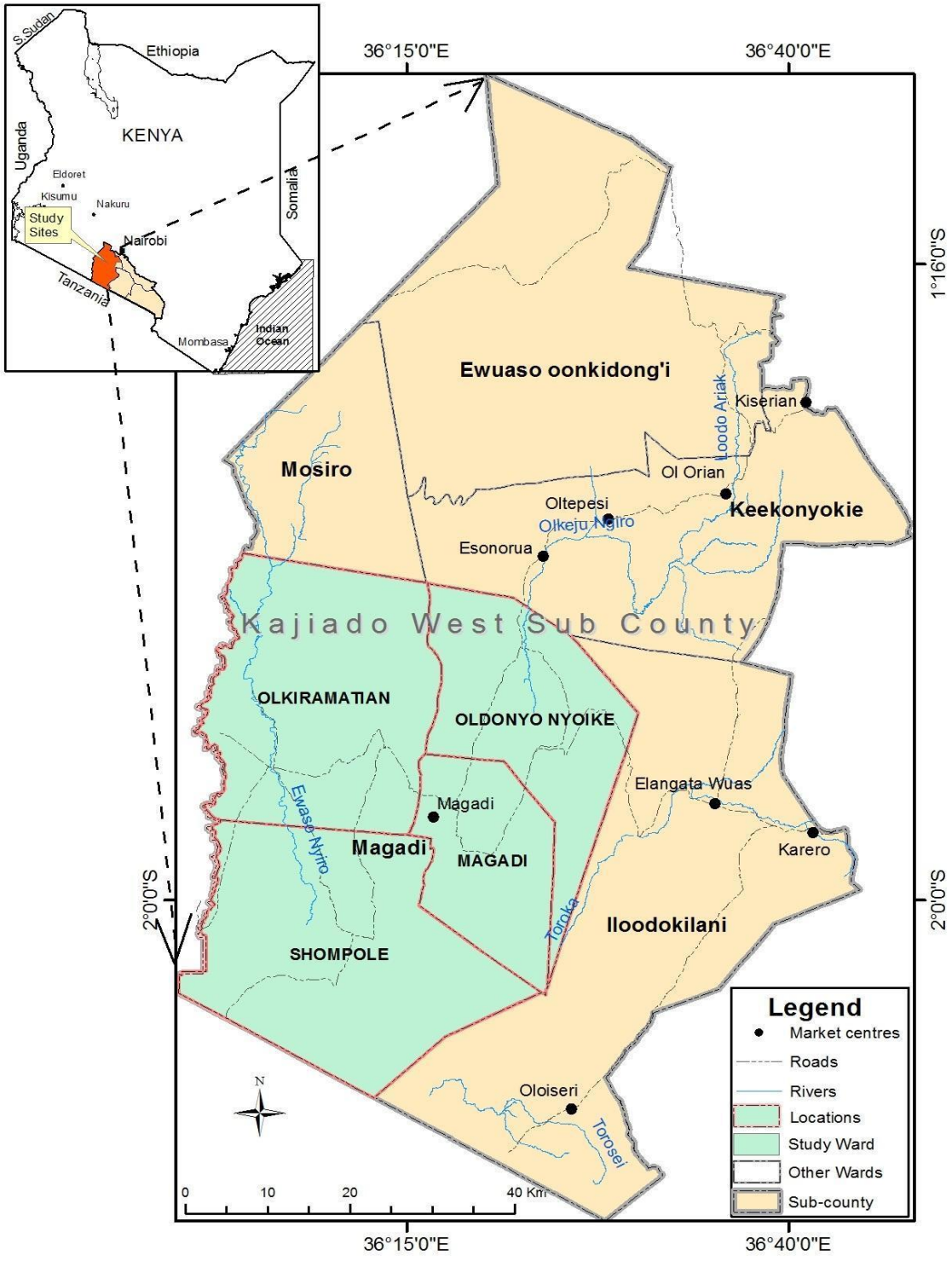


Figure 3.1: Map of Kajiado west sub-county showing Magadi division and the four wards which formed the study area

The study area lies in the Great Rift Valley which is a low depression on the western side of Kajiado County running from north to south. It is made up of steep faults giving rise to plateau, scarps and structural plains. The depression has important physical features such as Lake Magadi. The lake has substantial deposits of soda ash and it is commercially exploited. The altitude ranges between 600 and 1740 meters above sea level. The region has a bi-modal rainfall pattern. The long rains fall between March and May, and the short rains between September and November, with an average annual rainfall of around 500mm. Magadi division has the highest temperatures in Kajiado county with temperature ranges from 29^{o}C to 41^{o}C giving an evaporation rate of 3500 mm per year, *National Environment Action Plan framework* (NEAP 2009-2013). The study area is mainly arid and semi-arid. The dominant vegetation type is a mixture of grasses, shrubs and trees. Ground cover throughout the area varies seasonally with rainfall and grazing intensity, *National Environment Action Plan framework* (NEAP 2009-2013). The people in the area are predominantly nomadic pastoralists with small areas of irrigated agriculture and tourist attraction sites such as Lake Magadi, Nkuruman escarpment and wildlife conservancies such as Shompole, *National Environment Action Plan framework* (NEAP 2009-2013). The area benefits from various corporate social responsibilities majorly from Tata Chemicals Magadi Limited. The land tenure system in the area is communal owned group ranches.

3.4 Target Population

Target population is the entire group of people or objects to which the researcher wishes to generalise the research findings. The group must meet the criterion set by the researcher (Mishra & Alok, 2017). The target population for this study was the Maasai pastoralists found in Kajiado west sub-county numbering 182,849 living in 42,774 households (KNBS, 2019). The study population (a sub-set of the target population available for study) consisted of all pastoral households found in Magadi division of Kajiado West Sub County. The households

(n= 7,523), were found in five group ranches within the division (KNBS, 2019). The five group ranches are Olkiramatian, Shompole, Olkeri, Oldonyonyokie and Musenke. The households are mainly engaged in pastoralism, tourism, small businesses and crop farming.

3.5 Study Sample

A sample is defined as a smaller set of data that a researcher chooses or selects from a larger population by using a pre-defined selection method. These elements are known as sample points, sampling units, or observations. Creating a sample is an efficient method of conducting research. In most cases, it is impossible or costly and time-consuming to research the whole population. Hence, examining the sample provides insights that the researcher can apply to the entire population (Mishra & Alok, 2017). According to Ogula (2005), sampling is a procedure, process, or technique of selecting a subgroup from a population to participate in a study. That is, it is the process of choosing a number of individuals for a study in such a way that the individuals chosen represent the larger group from which they were selected.

3.5.1 Study Sample Size

Sample size represents the total number of respondents retrieved from the study population that the researcher intends to study (Mugenda & Mugenda, 2012). The study used the households that were found within Magadi Division in Kajiado County. The study sample size was calculated using the formula of Krejcie and Morgan (1970), which is based on the number of households in the study area. Magadi division comprises four group ranches with 7,523 households (KNBS, 2019) The study was composed of pastoralists from each group ranch for the individual household survey cutting across different ages, gender and social standings. The study sample was estimated as follows using the formula described by Krejcie and Morgan (1970) equation 2:

$$n = \frac{\chi^2 * N * P(1-P)}{(ME^2 * (N-1)) + (\chi^2 * P(1-P))}$$

Where:

n = The required sample size, given by the following:

χ^2 = The table value of chi square for one degree of freedom relative to the desired level of confidence which was 0.95. [The chi-square value used was 3.841].

N = The population within the study area [7,523] households]

P = The population proportion [assumed to be 0.50], as this magnitude yields the maximum possible sample size required.

ME = desired margin of error (expressed as a proportion). This is the degree of accuracy as reflected by the amount of error that can be tolerated in the fluctuation of a sample proportion about the population **P**. The value of d was taken as 0.05, which is equal to plus or minus 1.96σp. $\boldsymbol{ME^2}$= [0.05^2 =0.0025]

n = 366

The study sample size based on this calculation was 366 households.

3.5.2 Sampling Procedure

The stratified random sampling technique was used in selecting the households to be included in this study. The study used stratified random sampling technique to select the study sample. Stratified random sampling provides a sample that is highly representative of the population being studied (Laerd, 2012). The four group ranches (Olkiramatian, Shompole, Olkeri, Oldonyonyokie and Musenke) formed the strata. In each stratum the households were selected proportionally based on the population of the stratum. Random sampling was used to select the individual households; a simple random sample is a randomly selected subset of a population (Gravetter & Franzano, 2011; Thomas, 2020). In this sampling method, each member of the population had an exactly equal chance of being selected. The names of the household heads

will be obtained from the Chiefs register and then listed to form a sampling frame and using a Table of random numbers, the households selected. The proportional allocation method was used to distribute the samples within the different sub locations as shown in Table 3.2.

Table 3.2: Proportional Allocation of the Study Samples to the Sub locations

Sub locations (Ranches)	Households	Proportional allocation	Sample
Olkiramatian (East & West)	1,663	1,663/7523*366	81
Shompole (East & West)	2,331	2,331/7523*366	113
Olkeri	1,920	1,920/7523*366	93
Musenke	710	710/7523*366	35
Oldonyonyokie	899	899/7523*366	44
Total	**7,523**		**366**

The summary of the sampling methods, and sample sizes used in this study is given in Table 3.3.

Table 3.3 Summary of Sampling Methods and Sample Size for the Study

Study Population Units	Sampling Methods	Sample size
Maasai Pastoral households	Stratified random sampling	366
Key Informant Interviews: Agricultural Extension officers, County environmental officers, Natural resources NGOs	Purposive	34
Focus Group Discussions	Quota	40 members 4 FGD each having 10 members

The Table 3.3 shows that there were three hundred and sixty-six (366) Maasai pastoral households selected using stratified random sampling, with the five ranches acting as the strata. They were interviewed using a structured questionnaire.

There were also thirty-four (34) Key Informants used in this study. The Key Informants who participated in the study were selected using the purposeful sampling method. Tongco (2007) observes that purposeful sampling, also known as judgement sampling, is the intentional choice of a respondent based on their attributes. In this study, the key respondents, or "informants", at the county level were purposely selected due to their wealth of knowledge and experience in the community and climate variation and change. They included agricultural extension officers, county officers in environment and natural resource management and NGOs dealing with pastoralism in the study area. They were selected using the purposive sampling method and were interviewed using a structured interview schedule (Appendix F).

The Focus Group Discussion (FGD) participants were selected using the purposive sampling method. The group participants were selected from pastoral communities in the study area, each group consisted of ten (10) participants. There were four (4) groups, one from each of the four (4) strata forming the study area.

3.6 Data collection

This section explains the process that was used to collect data from the household heads. This is a systematic process of gathering, making observations or measurements on the qualitative and quantitative information of the study variables. During the process care was taken to collect good data that is clean, consistent and reliable to enable the evaluation of the outcome (Tan, 2018).

3.6.1 Data Collection Instruments

Primary Data

Primary data for this study was collected using four different type of instruments: an observation checklist, a household questionnaire, a Key Informants Interview schedule, and a Focus Group Discussion guide. The summary of the data collection instruments is given in Table 3.4.

Table 3.4: Summary of Data Collection Instruments Used

Study Population Unit	Sampling Method	Size (n)	Data Collection Instrument	Appendix Number
Maasai Pastoral households	Stratified random sampling	366	questionnaire	D
Key Informants Interview	Purposive	34	Interview Schedule	F
FGD Maasai pastoralists	Quota	40	FGD guide	G
Observation check list	Purposive	1	Observation checklist	A

The data collection instruments in Table 3.4, include an observation checklist, which was used to collect information on climate of the area, vegetation and drought incidences. The observation checklist is outlined in Appendix A. The observation checklist was used to collect information on the type, quantity and quality of the existing natural resources in Magadi division.

A researcher-administered structured questionnaire (Tan, 2018) was used to collect information from the Maasai pastoral households in Magadi Division. The questionnaire is shown in Appendix D. The researcher administered a questionnaire for Maasai households, consisted of

six sections, as follows: the biodata of the participants, the pastoralists perception on climate change and variability, household vulnerability to climate change, and the dependent variable household adaptive strategies to climate change and household adaptive capacity to climate change. The information was collected using a six-point rating scale (0 to 5 points) as follows: 0 used to indicate none or no level, 1 very low level, 2 low level, 3 moderate level, 4 high level and 5 very high level.

A Key Informants Interview (KII) interview schedule for agricultural extension officers, county officials dealing with environment and natural resources and NGOs dealing with natural resource management was used to collect information on the level of use of natural resources and strategies used in climate change. The Key Informants interview guide (Appendix F) was used to collect information on the different types of strategies and the capacity of the adaptive strategies, natural resources that were available in the study area, their condition, their use by the pastoralists, strategies for effective use of the resources, challenges faced by the pastoralists in applying the resources, and strategies to improve on the resources.

A Focus Group Discussion (FGD) guide used for Maasai pastoral community is given in Appendix G, was used to triangulate the KII and the information from the Maasai pastoralists. The Focus Group Discussion guide (Appendix G) was used to guide the discussions conducted with the pastoral communities in the study area.

Secondary Data

Secondary information was sourced from published and unpublished sources for use in content analysis. The specific sources of information included: Kenya Metrological reports, journal publications, technical institutions reports, textbooks, stakeholder's reports, teaching manuals and progress reports from all the stakeholders. Specific information sought from these documents included: climate data, natural resources, agriculture policies, institutions dealing with climate change. Secondary data obtained from the review of relevant and related studies

were used to complement primary information gathered from the study respondents on the use and management of natural resources in Magadi Division.

3.6.2 Pilot Testing of Research Instruments

Pilot-testing involves trying out a questionnaire on a small group of individuals (preferably 10 % of the sample size) to get an idea of how they react to it before the final version is created. The pilot testing enables the researcher to fine-tune the questionnaire for objectivity and efficiency of the process (Creswell, 2014). A pilot-test was conducted on 30 households in the adjoining Kajiado central sub-county. The results of the pilot test assisted in fine tuning of the research instrument for objectivity and efficiency of the data collection.

3.6.3 Instrument Reliability

The study established the reliability of structured questionnaires by use of Cronbach's alpha coefficient (Cronbach, 1951). Lee Cronbach in 1951, factors in scale size in reliability estimation, calculated using the following formula:

Equation 3: Reliability estimation alpha coefficient by Lee Cronbach (1951)

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum_{I=1}^{K} O^2 yi}{O^2 x}\right) \text{ ……,,,,,,, equation 3}$$

Where:

K is the number of items in the measure,

$O^2 x$ is the variance (square of standard deviation) of the observed total scores,

$O^2 yi$ is the observed variance for item *i.*

A reliability coefficient alpha of above 0.7 will be acceptable.

3.6.4 Instrument Validity

Validity is the accuracy and meaningfulness of inference and the degree to which the results obtained from the analysis of the data actually represents the phenomenon and investigation

(Murithi et al., 2016). Outcomes of the pilot testing phase were used to improve the initial drafted questionnaire to enable it to capture appropriate, useful and dependable data whose finding and inferences presented a true reflection of the study population.

3.6.5 Data Collection Procedures

A letter of clearance was sought from the Board of PostGraduate Studies at Africa Nazarene University, to enable the researcher to seek research permit from National Council of Science, Technology and Innovation (NACOSTI) and the Kajiado County Government.

The sampling frame was then developed from the Chiefs register of the households in the division. The sample households were then randomly selected using a table of random numbers. The enumerators were then trained and allocated households to cover in their survey. Data collection involved face to face interviews with the ranchers. The filled questionnaires were collected after one week. The FGDs were then conducted in each of the four ranches forming the strata.

3.7 Data Analysis

Data collected in this study was mainly quantitative data. The method of analysis involved systematically arranging and organizing interview questionnaire forms, field notes, data and other materials obtained from the field into summary tables (Creswell, 2011). Data analysis was done by the application of a computer software Statistical Package for Social Sciences (SPSS version 26) which is a comprehensive, integrated collection of computer programs for managing, analyzing and displaying data. The data was subjected to statistical analysis to determine relationships and comparison of variables. The target analytical tools; time series, mean comparisons (*ANOVA*), and regression equations were used since the study was based on estimation of population parameters and testing of statistical hypotheses. The critical value for significance p was set at 0.05. Data summary and classification was done using descriptive

statistics; mean and variance. Inferential statistics and hypothesis testing was used to determine the associations between variables. Descriptive statistics was used to determine the characteristics of a study sample in terms of mean and standard deviations. The data was then displayed and presented using graphs, charts and tables as summarized in Table 3.5.

Table 3.5: Summary of Data Analysis

Study Objectives		Independent variables	Dependent variables	Statistics
(i)	Determine the characteristics of pastoral households in Magadi division of Kajiado county	Socio-demographic	Adaptive strategies and capacity	Descriptive and regression analysis
(ii)	Assess the level of climate variability and change in Magadi division using climatic indices and the perceptions of the Pastoralists	Rainfall and temperature data	Adaptive strategies	Descriptive and regression analysis
(iii)	Determine Maasai pastoral households' adaptive capacity to climate variability and change in Magadi division of Kajiado County	Household adaptive capacity to climate variability and change	Adaptive strategies	Descriptive and regression analysis
(iv)	Evaluate climate variability and change adaptive strategies undertaken by Maasai pastoral households in Magadi division of Kajiado County	Household adaptive capacity to climate variability and change	Adaptive strategies	Descriptive and regression analysis

3.8 Legal and Ethical Consideration

The ultimate goal of ethics is to ensure that no one is harmed or suffers adverse consequences from research activities. To safeguard against these, O´Sullivan and Rassel (1999) put forward the following guidelines which include: Respect for the individual (encompassing respect for autonomy and protection of vulnerable affected persons, non-maleficence (minimizing harm to affected persons), beneficence Explaining study benefits to the respondents, explaining respondents' rights and protections and finally obtaining informed consent which was observed in accordance with the Africa Nazarene University (ANU) ethics requirements for certification and NACOSTI conditions for research in Kenya.

In line with ethical requirements, privacy which is a cornerstone of research was observed. Consent at all stages to carry out the study was sought, this included NACOSTI permit (Appendix I), letter to the participants (Appendix C), and letter to the Key Informants (Appendix E). Confidentiality and anonymity was observed: respondent numbers were used instead of names and no particular information was linked to any of the respondents directly. Ethical issues were observed during the collection and analysis of data. The researcher endeavoured to be as objective as possible by collecting full, correct data without subjective selectivity. The research process was followed and all care was taken to avoid compromising the integrity of the study.

An application for a research permit was first made to the National Commission for Science, Technology and Innovation (NACOSTI) by the researcher through the Board of Post-graduate studies at ANU. Permission to access the Maasai pastoral households was then sought from the County Government at the county level and the Chief at the division. A list of the Maasai pastoral households found in Magadi division was then made. A random sample was then drawn from this list for an interview. The selected household heads were then contacted with the help of the enumerators in the different localities of the study area. The participants were

then explained by the researcher on the purpose of the study and their consent was sought and they were assured of confidentiality before they were interviewed using the questionnaire by the enumerators. Data collection period lasted one month (the month of April, 2022).

The four (4) Focus Group Discussions (FGD) were conducted to triangulate the information received from the Key Informants Interview and the household questionnaire. Each of the FGD had ten members who were used to identify the different strategies and rank them in terms of their usefulness.

CHAPTER FOUR

DATA ANALYSIS AND FINDINGS

4.1 Introduction

Chapter four of this thesis deals with the analysis of data, results, interpretation of the results and the findings of the study. The chapter is divided into the following sections: (i) introduction, (ii) response rate (iii) characteristics of the participants, (iii) assessment of climate variation and change in Magadi, (iv) adaptive capacity to climate variation and change of Maasai pastoral households, (v) household adaptive strategies undertaken by Maasai pastoral households in Magadi.

4.2 Response Rate

The sample size for this study was calculated as 366. The respondents that responded to the interview were 366, giving a 100 % response rate. The selected household heads that were not available for interview were replaced by other households within the locality.

4.3 Characteristics of the Pastoral Households in Magadi Division

This section (section 4.3) of the thesis presents results, interpretation of results and findings arising from the analysis of objective number one of this study, which was stated as:

"To Determine the characteristics of pastoral households in Magadi division of Kajiado county"

The characteristics of the participants for this study are presented in the following sub-sections: age of respondents, gender of respondents, marital status, formal education, household number and land size owned by the respondents.

4.3.1 Age of Respondents

Respondents were asked to indicate their year of birth, which was then used to calculate the exact age. The descriptive statistics and frequency distribution were calculated and are represented in Table 4.1.

Table 4.1: Age Distribution of Heads of Pastoral Households

Age Categories	Frequency	Percent
20-30	85	23.2
31-40	143	39.1
41-50	66	18.0
51-60	51	13.9
61-70	19	5.2
Above 71	2	0.5
Total	**366**	**100.0**

Source: Field Data (2025)

Mean 39.2±.61, Median 39, Mode 40, Std. Dev 11.85, minimum 18, Maximum 78

The majority (62.3 %) of the respondents were below 40 years old, while 37.6 % were above 41 years old. The average age for the respondents was (*M*=39.2, *SD*=11.92), while the minimum age was 18 and the maximum age was 78 years old. The chi-square test was performed on the age distribution to determine the equality of the categories and the results are given in Table 4.2.

Table 4.2: Chi-square Test for Equality of the Categories of Age of Pastoral Household Heads in Magadi County

Age Categories	Observed N	Expected N	Residual	Chi-square Statistics
18-30	85	61.0	24.0	χ^2=207.70
31-40	143	61.0	82.0	*df*=5
41-50	66	61.0	5.0	*p*=.001
51-60	51	61.0	-10.0	
61-70	19	61.0	-42.0	
Above 71	2	61.0	-59.0	
Total	**366**			

Source: Field Data (2025)

The chi-square test (Table 4.2) indicates that the majority of the pastoral household heads' ages that were between 31 and 40 years old, which had the highest residual value. The chi-square test returned a highly statistically significant value (χ^2=212.61, *df*=5, *p*< .001), meaning that the differences between the categories were true differences and did not occur by chance.

4.3.2 Gender of the Household Head

Gender is a vital variable in determining how vulnerable households are to climate variation and change. Gender of the respondents was noted during the interview and the information is summarised in Table 4.3.

Table 4.3: Gender Distribution of Household Heads

Gender	Frequency	Percent
Male headed households	255	69.7
Female headed households	111	30.3
Total	**366**	**100.0**

The majority (69.7 %) of the households were male led, while the women led households were 30.3 %. The chi-square test was performed on the gender distribution to determine the equality of the categories and the results are given in Table 4.4.

Table 4.4: Chi-square Test for Equality of the Categories of Gender of Pastoral Household Heads in Magadi County

Gender	Observed N	Expected N	Residual	Chi-Square
Male headed households	255	183.0	72.0	χ2=56.65
Female headed households	111	183.0	-72.0	*df*=1
Total	**366**			*p*=.001

The gender distribution was statistically (χ^2 =56.65, *df* =1, *p* =.001) significantly different from each other, meaning that the differences in the two categories were true differences and did not occur by chance (Table 4.4).

4.3.3. Marital Status

The respondents were asked to state their marital status. Four categories emerged in the study area and their frequency distribution are presented in Table 4.5.

Table 4.5: Marital Status of Respondents

Marital Status	Frequency	Percent
Married	265	72.4
Single	50	13.7
Widowed	41	11.2
Separated	8	2.2
Divorced	2	0.5
Total	**366**	**100.0**

The majority (72.4 %) of the household heads were married, 13.7 % were single, 11.2 % widowed and 0.5 % were divorced.

4.3.4 Formal Education

The highest level of formal education attained by the household head was determined by asking the respondents to indicate the highest level in formal education they had attained. The information was analysed and the frequency distribution is presented in Table 4.6.

Table 4.6: Highest Level of Formal Education Attained by the Household Head

Level of Formal Education	Frequency	Percent
No formal education	74	20.2
Lower Primary (1-4)	61	16.7
Upper Primary (5-8)	106	29.0
KCSE (Form 4)	58	15.8
Teacher (P1)	39	10.7
College (Diploma)	17	4.6
Undergraduate Degree	9	2.5
Master and above	2	0.5
Total	**366**	**100.0**

The percent of the household heads who had not attended formal schooling was 20.2 %, while 34.1 % had attained the level of form four and above.

4.3.5 Household Number

The respondents were asked to state the number of people in their households. The information was analysed and the descriptive statistics and frequency distribution are shown in Table 4.7.

Table 4.7: Number of People Living in a Household

Number	Frequency	Percent
1.00	49	13.4
2.00	8	2.2
3.00	45	12.3
4.00	53	14.5
5.00	54	14.8
6.00	26	7.1
7.00	51	13.9
8.00	12	3.3
9.00	29	7.9
10.00	8	2.2
11.00	18	4.9
Above 11	13	3.5
Total	**366**	**100.0**

Mean 5.6±0.20, Median 5, Mode 5, Std. Dev 3.78, Minimum 1, Maximum 26

The average number of people living in the households was (*M*=5.6, *SD*=3.92), and ranged between 1 and 26. Majority of households (57 %) had between 1 and 5 people.

4.3.6 Descriptive Statistics and Frequency Distributions of the Number of Livestock Owned by Maasai Pastoral Households in Magadi Division

The descriptive statistics for the number of different livestock owned by Maasai pastoral households are shown in Table 4.8.

Table 4.8: Descriptive Statistics of the Number of Livestock Owned by Maasai Pastoral Households in Magadi Division

Variable	Description / Definition	Mean	Std. Dev	Minimum	Maximum
Cattle	Number	27	32	0	274
Goat	Number	42	43	0	182
Sheep	Number	32	40	0	190
Poultry	Number	44	43	0	15
Donkeys	Number	2	5	0	10

The number of livestock owned by Maasai pastoral households varied highly among the different households as can be seen in the high standard deviation (Table 4.8). This means there are some households with no animals, while others have very high numbers. A situation that is common among the pastoral communities.

The livestock numbers were grouped into ten (10) categories as follows: group 1, households with no animals; group 2, households with 1 to 4; group 3, households with 5 to 9 animals; group 4, households with between 10 and 14 animals; group 5. Households with between 15 to 20 animals; group 6, households with between 21 to 25 animals; group 7, households with between 26 to 30 animals; group 8, households with between 31-35 animals and group 10, with 36 and above animals. The frequency distribution of the categories were determined and are presented in Table 4.9.

Table 4.9: Frequency Distributions of the Number of Livestock Owned by the Maasai Pastoralists in Magadi Division

	Categories and Percentage								
Animal Type	None (%)	1-4 (%)	5-9 (%)	10-14 (%)	15-20 (%)	20-24 (%)	25-30 (%)	31-35 (%)	>36 (%)
Cattle	26.5	4.9	2.7	9.8	6.0	9.6	2.5	5.7	32.2
Goats	26.0	2.7	3.0	2.2	8.2	0.8	5.7	4.6	46.7
Sheep	30.1	9.8	4.1	7.4	4.9	4.9	0.8	0.8	37.2

Poultry	75.4	13.7	6.6	3.8	0	0	0	0	0.5
Donkeys	80.0	13.1	3.6	2.5	0.8	0	0	0	0

The frequency distribution of the animals owned by the pastoral communities in Magadi Division (Table 4.9) varied significantly. The distribution for cattle shows that 26.5 % of the households did not keep cattle, while 32.2 % had more than 36 animals. Similarly, the goat distribution was also varied, with 26 % of the households without goats and 46.7 % of the households with more than 36 animals. The households with more than 36 Sheep in their herd were found to be 37.2 %, while the households that did not keep sheep were 30.1 %.

The majority of the households (75.4 %) did not keep poultry, while 80 % of the households did not keep donkeys. Few households (0.5 %) kept more than thirty-six chickens. The poultry are housed and are mainly kept for commercial purposes.

4.4 Assessment of Climate Variation and Change in Magadi Division of Kajiado County

This section (section 4.4) of the thesis presents results, interpretation of results and findings arising from the analysis of objective number two of this study, which was stated as:

"To assess the level of climate variability and change in Magadi division using climatic indices and the perceptions of the Pastoralists"

The variable climate variability and change was assessed using two different methods, as follows: (i) using climatic data from Kenya Metrological Department (KMD) to calculate climatic indices such *CV, SPI* and long-term climatic trends as shown in section 4.4.1 and (ii) using perceptions of the Pastoralists, section 4.4.2.

4.4.1 Measurement of Climate Variability within Magadi Division using Climatic Indices

Climate variability in Magadi division was assessed using two statistical indices, which included: (i) Coefficient of variation (*CV*), and (ii) Standardized precipitation index (SPI).

Mean Monthly Rainfall

Using the long-term data (39 years) from 1983 to 2021 (Appendix B), the monthly rainfall was calculated and the results are summarized in Table 4.10 and Figure 4.1.

Table 4.10: Mean Monthly Rainfall for Magadi

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rain (mm)	44.5	40.4	73.2	106.8	54.6	11.4	2.4	5.9	6.9	39.2	79.3	64.1

The results show that the rainfall distribution in the study area was a bimodal type with two rainy seasons: a long rainy season from March to May and a short rainy season from November to December. In between the two rainy seasons is a dry season from June to September. This is also depicted in the monthly rainfall distribution graph Figure 4.1. A bi-modal type of rainfall distribution is experienced in the Magadi division. The long rainy season (March to May) and a short rainy season (October to December).

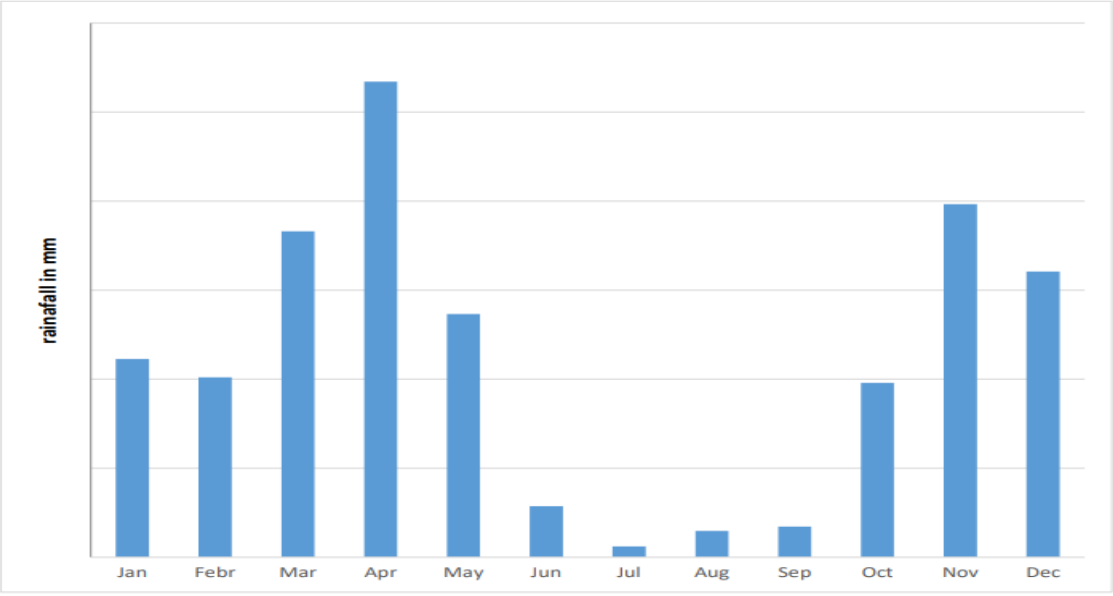


Figure 4.1 Mean Monthly rainfall for Magadi Division

Coefficient of Variation

The variability in rainfall was calculated using the coefficient of variation (*CV*) formula by dividing the standard deviation by the mean and multiplying it by 100;

15.619/44.07* 100 = 35.44

The CV was found to be 35.44, indicating a high level of variation in the rainfall.

Standardized Precipitation Index (SPI)

The SPI was calculated for the data and the results are presented in Table 4.9 in Appendix C and graph Figure 4.2. The results show that for the 39 years studied the area had 17 years that had below normal rainfall. These years are denoted with the negative *SPI*. The negative SPI indicates droughts (below normal rainfall), while the positive indicate high rainfall or floods.

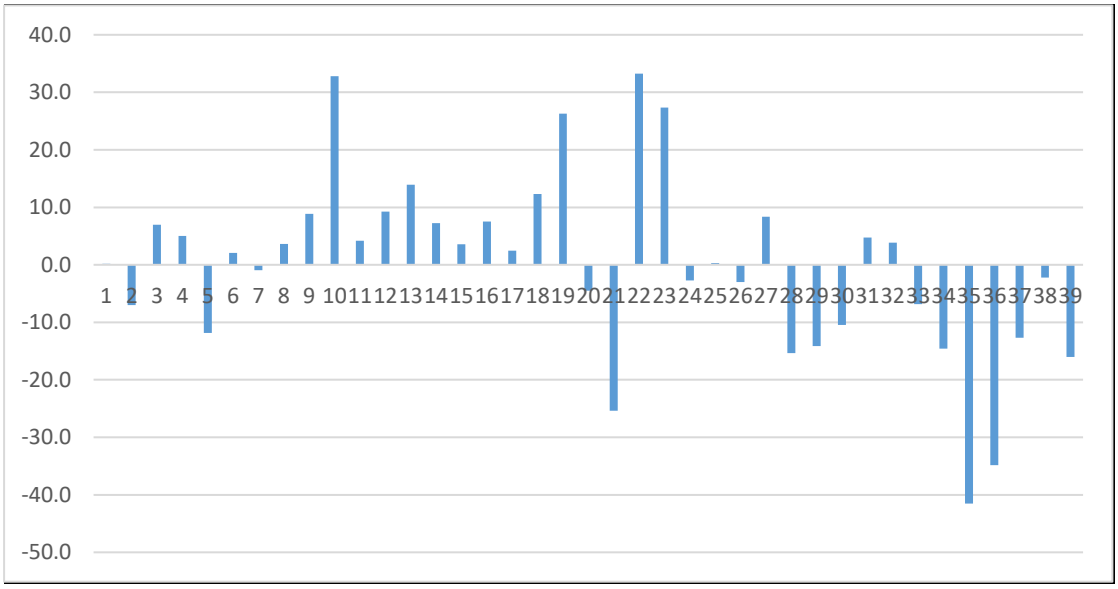


Figure 4.2: Rainfall Variability for Magadi Division Based on *SPI*

4.4.2 Measurement of Climate Change within Magadi Division using Climatic Indices

Climate change was assessed using Linear regression analysis. The linear trend line of the yearly mean rainfall was computed by slope value. The confidence level was evaluated at 95 %. Using the long-term rainfall data (Appendix B) in Magadi division presented in figure 4.3 the linear equation is y= 0.5828 +55. 728 and the R square was 0.1763 or 17.63. The trend in

Figure 4.3 shows a decline in the amount of rainfall over the 39 years of this study. The R^2 is a weak correlation indicating that there is a wide variability in the rainfall trends. The negative slope on the rainfall trend shows the decline in rainfall trend which confirms that there is indeed climate change in the region. The spikes and drops in the rainfall show high variability and erratic rains which is an indication of climate change.

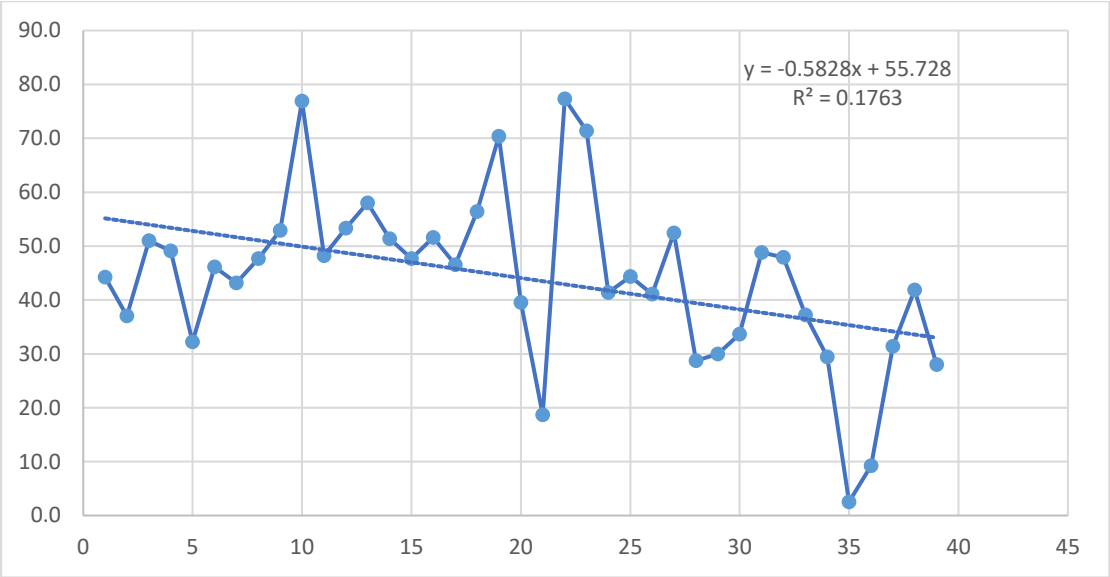


Figure 4.3: Linear Regression and the Regression equation for Magadi Division rainfall data

4.4.3 Measurement of Climate Variability and Change Using Perceptions of the Pastoralists in Magadi Division

The variable climate variation and change for this study was operationalized as an index that combined household heads rating of the frequency, risk and intensity of climate indicators associated with the variation and change of climate in the area. The multi-indicator variable had 15 indicators, listed as follows: failure of two rainy seasons consecutively, floods, failure of short rains, failure of long rains, delayed seasonal rains, intense aridity during dry season, reduced rainfall amount, early termination of seasonal rains, strong winds, shortage of depletion of pastures, shortage of water, reduced spatial extent of seasonal rains, increased temperatures and fog.

The household heads were asked to rate the indicators on a scale of 1 to 5, 1 depicting low level and 5 indicating a high level of the indicator in relation to their frequency of occurrence, level of risk caused and the intensity of the element when it occurs. The individual household ratings were summed up and averaged to create the index of climate variability and change. The calculated scores for households rating of the frequency of occurrence of the indicators are shown in Table 4.11.

The frequency of occurrence of thirteen of the indicators of climate variability and change were found to be high (above a rating of 3 on a scale of 1 to 5). Two indicators floods (*M*=1.64, *SD*=.856) and fog (*M*=1.87, *SD*=.780) were found to have a low occurrence in the area., while failure of seasonal rains (*M*=4.13, *SD*=.926) and reduced spatial extent of seasonal rains (*M*=4.13, *SD*=1.01).

Table 4.11: Frequency of the Indicators

No	Indicators of climate Variability	Total	Mean	SD
1	Failure of two consecutive seasonal rains	1419	3.87	1.160
2	Floods (high amount of rain than normal)	602	1.64	.856
3	Failure of short seasonal rains	1514	4.13	.926
4	Failure of long seasonal rains	1345	3.67	1.32
5	Delayed seasonal rains	1255	3.42	1.27
6	Intense aridity during dry season	1383	3.77	1.07
7	Reduced amount of rain	1248	3.40	1.27
8	Early termination of seasonal rains	1181	3.22	1.31
9	Shortage or depletion of pastures	1327	3.62	1.25
10	Shortage of water	1324	3.61	1.25
11	Reduced spatial extent of seasonal rains	1510	4.12	1.01
12	Increased wind speed/ strong winds	1502	4.10	1.03
13	Increased temperatures	1399	3.81	.891
14	Fog	686	1.87	.780
	Frequency of the Occurrence of the Indicators	**1232**	**3.36**	**.261**

The household heads were asked to rate the level of risk associated with the climatic indicators on a scale of 1 to 5, 1 depicting low level and 5 indicating a high level of risk associated with their occurrence. The individual household scores were summed up and averaged to create the risk rating. The calculated scores for households rating of the risk of occurrence of the indicators are shown in Table 4.12.

The risk rating (Table 4.12) shows that the highest risk was experienced when there was an early termination of the rains (M= 4.36, SD= .777) and when two consecutive seasons lacked rain (M= 4.23, SD=1.00). Low risk rating was found in fog (M=1.81, SD=.877) and fog (M=1.21, SD=.877)

Table 4.12: Risk Rating by Maasai Pastoralists of the Indicators

No	Indicators of climate Variation	Total	Mean	SD
1	Failure of two consecutive seasonal rains	1551	4.23	1.00
2	Floods (high amount of rain than normal)	708	1.93	.737
3	Failure of short seasonal rains	1179	3.22	1.25
4	Failure of long seasonal rains	1306	3.56	1.59
5	Delayed seasonal rains	665	3.81	.877
6	Intense aridity during dry season	625	1.51	.877
7	Reduced amount of rain	781	2.13	1.15
8	Early termination of seasonal rains	1596	4.36	.777
9	Shortage or depletion of pastures	1434	3.91	1.03
10	Shortage of water	1434	3.91	1.03
11	Reduced spatial extent of seasonal rains	1391	3.80	1.24
12	Increased wind speed/ strong winds	665	1.81	.877
13	Increased temperatures	1541	4.21	.907
14	Fog	641	1.21	.877
	Risk Associated with the Indicators	**1083**	**2.95**	**.416**

The household heads were asked to rate the level of intensity associated with the climatic indicators on a scale of 1 to 5, 1 depicting low level and 5 indicating a high level of intensity

associated with their occurrence. The individual household scores were summed up and averaged to create the intensity rating. The calculated scores for households rating of the intensity of occurrence of the indicators are shown in Table 4.13. The intensity rating (Table 4.13) shows that the highest intensity was experienced when there was an early termination of the rains (M= 4.91, SD= .274) and when two consecutive seasons lacked rain (M= 4.76, SD=.422). Low risk rating was found in fog (M=1.81, SD=.877) and floods (M=1.81, SD=.877).

Table 4.13: Intensity Rating by Maasai Pastoralists of Climatic Indicators

No	Indicators of climate Variation	Total	Mean	SD
1	Failure of two consecutive seasonal rains	1745	4.76	.422
2	Floods (high amount of rain than normal)	665	1.81	.877
3	Failure of short seasonal rains	1385	3.78	.933
4	Failure of long seasonal rains	1472	4.02	.678
5	Delayed seasonal rains	1606	4.38	.812
6	Intense aridity during dry season	1446	3.95	.914
7	Reduced amount of rain	1585	4.33	.877
8	Early termination of seasonal rains	1800	4.91	.274
9	Shortage or depletion of pastures	1585	4.33	.877
10	Shortage of water	1385	3.78	.933
11	Reduced spatial extent of seasonal rains	1606	4.38	.812
12	Increased wind speed/ strong winds	1472	4.02	.678
13	Increased temperatures	1446	3.95	.914
14	Fog	665	1.81	.877
	Level of Intensity of the Indicator	**1440.53**	**3.93**	**.314**

The three indicators (frequency, risk and intensity) were combined to form an index of climate variability and change. The index of level of climate variation and change for each household was determined by adding the scores for each indicator, the summed scores were averaged to create an index with a scale of 1 to 5, 1 indicating no variation and change and 5 indicating a high level of variation and change in the climate.

The index of climate variability and change generated by the Maasai pastoral households in Magadi division was then grouped into five categories as follows: .0-1 depicting very low level, 1.01-2 Low level, 2.01-3 medium level, 3.01-4 High level and 4.01-5 Very High Level of variation. The descriptive statistics and the frequency distribution for the index in ten categories are shown in Table 4.14.

Table 4.14: Index of Climate Variability and Change Generated by Maasai Pastoral Households in Magadi

Category	Level	Frequency	Percent
3.01-4	High	213	58.2
4.01-5	Very High	153	41.8
	Total	**366**	**100.0**

Mean 3.97±.010, Median 3.95, Mode 4.02, Std. Dev .204, Min 3.48, Max 4.84

The mean of the rating of climate variability and change by the household heads in the Magadi division was (*M*=3.97, *SD* =204) on a scale of 1 to 5 and ranged between 3.48 and 4.84.

Table 4.15: Chi-square Test for the Equality of Categories for the Rating of the Level of Climate Variation and Change by Household Heads in Magadi Division

Category	Level	Observed N	Expected N	Residual	Statistics
3.01-4	High	213	183.0	30.0	χ^2=9.836
4.01-5	Very High	153	183.0	-30.0	*df*=1
	Total	366			*p*=.002

A chi-square test was performed on the index of climate variation and change to determine the equality of the categories (Table 4.15). The chi-square test revealed statistical ($p < .002$) significant differences among the different categories of household rating of the level of climate variation and change in Magadi division. The category of High (3.01-4) was statistically significantly (χ^2=9.02, $df = 9.836$, $p < .002$) higher than the other categories, indicating that the majority of the households rated the level of climate variation and change as high. Climate

variation and change in Magadi Division was found to be high. A phenomenon that was comparable to the calculated climatic indices.

4.4.4 Gender Differences in the Assessment of Climate Variation and Change

The independent variable gender of the household head is described in 4.2.2. The effect of gender differences in the rating of the level of climate variation and change among the Maasai pastoral households was determined by the use of the t-test. The means for male and female-headed households' level of climate variation and change are shown in Table 4.16.

Table 4.16: Mean Comparison among the Male and Female Headed Households

Household head Gender	N	Mean	Std. Deviation	Std. Error Mean
Male headed household	255	3.98	.21196	.01327
Female headed household	111	3.96	.18645	.01770

The mean level of climate variability and change for the male-headed households was 3.98, while for the female headed households was 3.96. The differences in the two means were tested using the *t*-test for the equality of means and the results are given in Table 4.17.

Table 4.17: *t*-test for Equality of Means

T	*Df*	*p*	Mean Difference	Std. Error Difference
3.579	364	.059	.515	.01515

The mean differences for the adoption of environmental conservation practices for the male and females headed household were not statistically significantly ($t = 3.579$, $df = 364$, $p = .059$) different form each other, meaning that gender did not affect the rating of climate variation and change by the Maasai pastoralists.

4.5 Household Adaptive Capacity to Climate Variability and Change Among Maasai Pastoral Communities in Magadi Division

This section (section 4.5) of the thesis presents results, interpretation of results and findings arising from the analysis of objective number three of this study, which was stated as:

"To determine Maasai pastoral households' adaptive capacity to climate variability and change in Magadi division of Kajiado County"

The variables of Maasai pastoral households' adaptive capacity to climate variation and change was assessed from ratings by Maasai pastoralists in Magadi division. The section is divided into two, as follows: (i) household adaptive capacity section 4.5.1 and (ii) Household adaptive strategies, section 4.5.2.

4.5.1 Maasai Pastoral Households' Adaptive Capacity to Climate Variation and Change in Magadi Division

The variable Maasai pastoral households' adaptive capacity to climate variability and change was operationalized as a multi-indicator index composed of 32 indicators listed in Table 4.17. The indicators are divided into six dimensions that included: technology or innovations, economic resources, social capital, awareness and training in climate change, infrastructure, and social institutions.

The household heads were asked to rate their capacity to adapt to climate variation and change based on the 31 indicators on a 6-point rating scale, where 1 indicated very low level of adaptability, 2 low level of adaptability, 3 moderate level of adaptability, 4 high level of adaptability and 5 very high level of adaptability. The individual ratings for each statement were then summed up together and averaged to create the index of household adaptive capacity. The descriptive statistics for the index are shown in Table 4.18.

Table 4.18: Descriptive Statistics of the Household Heads' Ratings for the Indicators of Maasai Pastoral Household Adaptive Capacity to Climate Variability and Change

No	Indicators of Adaptive Capacity	Total	Mean	SD
	Technology / Innovations			
1	Pasture restoration Practices (seeding, closure)	833	2.28	1.158
2	Enclosures	710	1.94	.561
3	Migration (animal movement)	949	2.59	1.068
4	Destocking (Sale of animals early)	1201	3.28	1.036
5	Herd splitting	1012	2.77	1.154
6	Supplementary feeding (hay, molasses)	1075	2.94	.933
7	Storage of Fodder/pasture (hay, grass)	918	2.51	1.156
8	Slaughter old animals	1088	2.97	1.209
	Economic Resources			
9	Increase number of livelihood sources	874	2.39	.826
10	Diversify to non-livestock activities	931	2.54	.890
11	Remittances to households	797	2.18	1.195
12	Access to credit	907	2.48	.958
13	Household income	1038	2.84	.851
	Social Capital			
14	Access to family labour	1045	2.86	.978
15	Participation in collective action (No)	423	1.16	.451
16	Change household diet composition	1058	2.89	.875
17	Change of consumption patterns	994	2.72	.715
18	Labour export (move to work in towns)	748	2.04	.059
	Awareness and Training			
19	Early warning systems	916	2.50	1.062
20	Level of literacy in climate change	1073	2.93	1.064
21	Access to climate information	920	2.51	1.082
22	Training in climate change	828	2.26	1.099
23	Ranching experience (number of years)	728	1.99	.922
	Infrastructure			
24	Increase use of groundwater	833	2.27	1.121

25	Access to market	681	1.86	.614
26	Access to health facilities	800	2.18	1.048
27	Irrigation	1018	2.78	1.144
28	Access to road network	742	2.02	1.014
	Institutions			
29	Land size owned	798	2.18	.827
30	Disaster relief	687	1.87	.893
31	Famine relief	851	2.32	1.055
32	Cash transfer to households	862	2.35	.840
	Maasai Households' Adaptive Capacity	**950**	**2.55**	**1.156**

The descriptive statistics for the six dimensions of Maasai households' adaptive capacity is given in Table 4.19.

Table 4.19: Descriptive Statistics for the Dimensions of Adaptive Capacity to Climate Variation and Change by Maasai Pastoral Households in Magadi Division

No	Dimensions of Adaptive Capacity	Total	Mean	SD
1	Technology / Innovations	973.25	2.65	.707
2	Economic Resources	909.40	2.48	.644
3	Social Capital	711.33	1.94	.277
4	Awareness and Training	744.17	2.03	.458
5	Infrastructure	814.80	2.22	.686
6	Institutions	639.60	1.74	.536
	Index of Adaptive Capacity	**950**	**2.55**	**1.156**

The index of Maasai Pastoral households' adaptive capacity to climate variability and change was found to be of medium level (M=2.55, SD= 1.156) on a scale of 1 to 5 (1=very low and 5=very high) and ranged between 1 and 5. The reliability of the index using Cronbach alpha was found to be (α=.777). The descriptive statistics and the frequency distribution for the index are shown in Table 4.20.

Table 4.20: Descriptive Statistics and Frequency Distribution for the Maasai Pastoral Households' Rating of the Index of Adaptive Capacity to Climate Variability and Change for Magadi Division

Score	Level	Frequency	Percent
0-1	Very Low	84	22.6
1.1-2	Low	87	23.4
2.1-3	Medium	141	37.9
3.1-4	High	31	8.3
4.1-5	Very High	29	7.8
Total		**372**	**100.0**

Mean 2.55±.059, Median 3, Mode 3, Std. Dev 1.156, minimum 1, maximum 5

The index was grouped into five categories as follows: 0-1 very low, 1.1-2=Low, 2.1-3 medium, 3.1-4 high and 4.1-5 very high and the chi-square test for the equality of categories of the index was performed and the results are given in Table 4.21.

Table 4.21: Chi-square Test for the Equality of Categories for the Index of Maasai Pastoral Households' Adaptive Capacity to climate Variability and Change

Score	Level	Observed N	Expected N	Residual	Statistics
0-1	Very Low	84	74.4	9.6	χ^2=116.01
1.1-2	Low	87	74.4	12.6	*df*=4
2.1-3	Medium	141	74.4	66.6	*p*=.001
3.1-4	High	31	74.4	-43.4	
4.1-5	Very High	29	74.4	-45.4	
Total		**372**			

The chi-square test (Table 4.21) revealed highly statistically (*p*=.001) significant differences among the different categories of the index of Maasai pastoral households' adaptive capacity to climate change. The category of medium (2.01-3) of the index was statistically significantly (χ^2=166.01, *df*=4, *p*= .001) higher than the other categories,

indicating the majority of the Maasai households' adaptive capacity was in the level of medium.

4.5.2 Gender Differences in Adaptive Capacity to Climate Change and Vulnerability of Maasai Pastoral Households

The independent variable gender of the household head is described in 4.2.2. The effect of gender differences in the rating of the level of adaptive capacity to climate variation and change among the Maasai pastoral households was determined by the use of the *t*-test. The means for male and female-headed households' level of adaptive capacity to climate variation and change are shown in Table 4.22.

Table 4.22: Mean Comparison among the Male and Female Headed Households

Household heads' Gender	N	Mean	Std. Dev	Std. Error Mean
Male headed household	255	2.64	1.148	.071
Female headed household	111	2.41	1.155	.109

The mean level of adaptive capacity to climate variability and change for the male-headed households was 2.64, while for the female-headed households was 2.41. The differences in the two means were tested using the *t*-test for the equality of means and the results are given in Table 4.23.

Table 4.23: *t*-test for Equality of Means

T	*df*	*p*	Mean Difference	Std. Error Difference
1.688	364	.092	.22088	.13086

The mean differences for the adaptive capacity to climate variation and change for the male and females headed household were not statistically significantly ($t = 1.688$, $df = 364$, $p = .092$)

different form each other, meaning that gender did not affect their rating of adaptive capacity to climate variation and change by the Maasai pastoralists.

4.6 Household Adaptive Strategies to Climate Variation and Change Utilised by Maasai Pastoral Households in Magadi Division

This section (section 4.6) of the thesis presents results, interpretation of results and findings arising from the analysis of objective number four of this study, which was to:

"Evaluate climate variability and change adaptive strategies undertaken by Maasai pastoral households in Magadi division of Kajiado County"

This section presents the analysis, results, and interpretation of results of the strategies that can be used to enhance the effectiveness of Climate variation and change adaptive strategies in Magadi division. The section is divided into three parts: type and level of climate variation and change challenges faced by Maasai pastoral households in effectively implementing adaptive strategies, strategies for enhancing climate variation and change adaptive measures and the recommendations for enhancing the sustainability of climate variation and change adaptive measures.

4.6.1 Type and Level of Challenges Facing Maasai Pastoral Households to Effectively Implement Climate Variation and Change Adaptive Strategies in Magadi Division

The type and level of challenges facing Maasai pastoral households to effectively implement climate variation and change adaptive strategies in Magadi division were assessed by use of two instruments: a Focus Group Discussion guide (Appendix G) and Key Informants Interview questionnaire (Appendix F). The FGD were used to identify the challenges and the KII were used to triangulate the information and rate the identified challenges (Amadi & Adejoh, 2020; Harry & Ejiofor, 2022; Okon et al., 2014).

The Key Informants ranked the challenges based on a five-point rating scale (0-5) as demonstrated by Okon (2016). The data was analysed using descriptive statistics (means, standard deviations) with a mean of 2.5 as the benchmark. The 2.5 mark was used to accept the strategic remedial measures to eliminate impediments created by climate variability and change. The participants for the Key Informants Interview and FGD were asked to identify the different challenges the Maasai pastoral households face in implementing adaptive strategies to climate variability and change. The participants were then asked to rank the severity of the challenges using a 5-point rating scale as follows:

1=Very Low challenge, 2=Low challenge, 3= Moderate challenge,
4=High challenge, and 5=Very High challenge.

The results of the ranking for the challenges to the implementation of adaptive strategies by Maasai pastoral households in Magadi division are shown in Table 4.23. The participants identified fourteen (14) different types of challenges in the use of climate variation and change adaptive strategies (Table 4.24). The challenges were arranged in their level of severity, the highest being challenges of drought (M=4.91, SD=1.13) and the challenge with the lowest level of severity was lack of information on climate change (M=2.32, SD=1.38). Twelve (12) of the challenges were above the cut-off point of 2.5.

Table 4.24: Descriptive Statistics for the Level of Challenges Facing Maasai Pastoral Households in Effectively Utilising Adaptive Strategies to Climate Variation and Change

No	Statements on the Level of Challenge in Effective Use of Adaptive Strategies to Climate Variation and Change	KII Rating in Terms of Level of Challenge		
		Total	Mean	SD
1	Challenges of droughts	167	4.91	1.13
2	Land degradation (loss of grass and soil)	164	4.82	1.16
3	Lack of technical knowledge on climate variation and change adaptive strategies	162	4.76	1.23
4	Lack of land to migrate to migrate to	159	4.67	1.51
5	Lack of finances in implementing adaptive strategies	152	4.47	1.56
6	Lack of pasture restoration activities (Seeding, enclosure)	143	4.20	1.27
7	Lack or increased distance of permanent water sources in the area	142	4.17	1.38
8	Challenges in animal marketing	130	3.82	1.35
9	Shortage of animal feed	122	3.58	1.55
10	Small piece of land available to the household for implementing strategies	107	3.14	1.86
11	Lack of effective social institutions dealing with climate variation and change (networks, famine relief, disaster)	91	2.67	1.17
12	Lack of infrastructure	89	2.61	1.27
13	Animal diseases	80	2.35	1.20
14	Lack of information / understanding on climate variation and change adoption strategies	79	2.32	1.38

4.6.2 Effectiveness of Strategies for Enhancing Climate Variability and Change Adaptive Measures

The participants for the Key Informants Interview and FGD were asked to identify different strategies that can be used to enhance households' adaptive strategy to climate variability and change. The participants were then asked to rank the effectiveness of these strategies using a 5-point rating scale as follows:

1=Very Low effect, 2=Low effect, 3= Moderate effect,

4=Highly effect, and 5=Very High effect.

The results of the strategy identification, assessment of effectiveness and descriptive statistics of the ranking by the participants are summarised in Table 4.25.

Table 4.25: Descriptive Statistics and Ranking of the Strategies' Effectiveness in Enhancing Climate Variation and Change Mitigation Measures

No	Strategies for enhancing climate variation and change Adaption	Usefulness of Strategy		
		Total	Mean	SD
1	Provision of permanent water on pasture	154	4.52	1.72
2	Provision of information on climate variation and change adaptive and mitigating strategies	135	3.97	1.67
3	Training of household heads on all aspects of climate variation and change	128	3.76	1.67
4	Creation of alternative livelihood sources	115	3.38	1.27
5	Development of Infrastructure	106	3.17	1.64
6	Provision of credit sources for households	103	3.02	1.52
7	Development of collective action	100	2.94	1.32
8	Improving on early warning systems (EWS)	92	2.70	1.50

** cut-off point at 2.50. Accepted Strategies'on Effectiveness in Enhancing Climate Variation and Change Mitigation Measures*

The participants identified and ranked eight (8) strategies that can be used to increase the effectiveness of adaptive strategies in mitigating against climate variation and change by Maasai pastoral households in Magadi division.

The highly ranked effective strategy was provision of permanent water whose effectiveness was rated at (*M*=4.52, *SD*=1.72) and the strategy that was lowly rated was improving on early warning systems, whose effectiveness was rated at (*M*=2.70, *SD*=1.50).

4.6.3 Recommendations for Enhancing the Sustainability of Climate Variation and Change Strategies Undertaken by Maasai Pastoral Households in Magadi Division

The KII and FGD participants were asked to make recommendations that can assist in enhancing the sustainability of the adaptive strategies undertaken by Maasai pastoral households in Magadi division. The sustainability of the climate variation and change strategies were rated based on the practicability or usefulness of the recommendation. Three factors were used in the rating, these included the amount of time needed to accomplish the recommendation, the total cost needed to perform it, and the human resources required. This was accomplished using a 5-point rating scale as follows:

1=Very Low usefulness, 2=Low usefulness, 3= Moderate usefulness,
4=High usefulness, and 5=Very High usefulness.

The recommendations and their ranking in terms of their usefulness by the KII and FGD participants are shown in Table 4.25.

The ranked recommendations (Table 4.26) can be categorised into two: strategies that deal with natural based solutions, such as activities that deal directly with natural resources and the non-natural based solutions.

The three highly ranked nature based solutions recommended strategies for alleviating climate variation and change included: forage preservation practices (*M*=3.94, *SD*=1.12), increase grazing resources through pasture restoration practices (*M*=3.91, *SD*=1.11) and introduction of crop production (*M*=2.47, *SD*=1.26). The highly ranked non-nature based solutions recommended included: diversification into non-livestock livelihoods (*M*=4.38, *SD*=1.04), permanent water development (*M*=4.17, *SD*=.99) and Training households in technology related to climate variation and change mitigating measures *(M*=3.88, *SD*=1.38). Labour export (*M*=1.82, *SD*=1.54) and enhancement of Agroforestry practices (*M*=1.29, *SD = .67*), two of

the recommendations suggested, were lowly rated in terms of their usefulness in alleviating the impacts of climate variation and change.

Table 4.26: Descriptive Statistics of the Rating of the Usefulness of the Recommendations by KII and FGD Participants in Magadi Division

		Usefulness of Strategy		
No	**Adaptive Strategies to Climate**	**Total**	**Mean**	**SD**
1	Diversification into non-livestock livelihoods	149	4.38	1.04
2	Permanent water development (boreholes, rain water harvesting)	142	4.17	0.99
3	Forage preservation practices (standing hay, hay making, sale of carbon credits from grasslands)	134	3.94	1.12
4	Increase grazing resources through grassland restoration practices (Seeding, closure)	133	3.91	1.11
5	Training households in technology related to climate variation and change mitigating measures	132	3.88	1.38
6	Improve on infrastructure	129	3.79	1.29
7	Information on climate change (early warning systems)	112	3.29	1.21
8	Improve animal marketing system	104	3.05	1.34
9	Enhance social institutions (networks, famine relief, collective action, cash transfer)	90	2.64	1.17
10	Increase the number of livelihood sources (business, tourism related)	89	2.61	1.12
11	Introduce crop production	84	2.47	1.26
12	Labour export (involve in provision of labour)	62	1.82	1.54
13	Enhance Agroforestry practices	44	1.29	0.67

** cut-off point at 2.50. Accepted Strategies'on Effectiveness in Enhancing Climate Variation and Change Mitigation Measures*

CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This section of the thesis presents the summary of the study, discussion of the results, conclusions of the study and the recommendations made.

5.2 Discussion

The study findings for this study are discussed in this section based on the specific objectives stated in section 1.4 of this thesis.

5.2.1 Characteristics of Maasai Pastoral Households in Magadi Division

The demographic and socio-economic characteristics of the Maasai pastoral households were found to affect the choice of adaptation strategies undertaken by the households in alleviating the impacts of climate change and variability. Specifically, the effects varied with the characteristics being reviewed. This reflects the findings of Mugisho et al. (2023) that demographic and socioeconomic factors influenced farmers' perceptions and adaptation strategies to climate change.

The study found no significant gender differences between the male and female headed pastoral households in Magadi division on their level of adaptive capacity. This finding was found to be similar to a study conducted in northern Kenya, where an inclusion of women at a community level produced no significant action in terms of drought preparedness (Grillos, 2018). Significant differences between male-headed households, (MHHs) and female-headed households (FHHs), were found to exist in their choice of adaptation strategies, Generally, MHHs were found to be more likely to seek additional employment and change their agricultural practices, while FHHs and households headed by older persons tend to reduce their consumption and rely on savings and borrowing (Aryal et al., 2021). The male-headed households tend to have greater access to financial resources and external employment

opportunities, allowing them to diversify livelihoods, while in contrast, female-headed households often rely on subsistence practices, social networks, and informal credit sources, making them more vulnerable to climate shocks.

The majority of the household heads in Magadi division were in the age bracket of 31 to 40 years, meaning that they were in the study area for more than twenty years. This was taken as a positive indicator to the dealing with the problem of climate change and variation in that the number of years of farming experience influenced the farmers' awareness of climate change and variability and their impacts (Hassan & Knight, 2023).

Education is particularly crucial, as households with higher education levels are more likely to adopt climate-smart strategies, including diversification of income sources and improved rangeland management practices (Mugisho et al., 2023; Mugisho et al., 2024). The education level of the Maasai pastoralists in Magadi was found to vary much among the household heads. The level of education attained by the household head was found to have a significant positive influence on the adoption of strategies aimed at reducing the impacts of climate change and variation. The study by Hassan and Knight, (2023) showed that householders' education level significantly influenced ($p = 0.001$) the adaptation strategies adopted by farmers, including diversification of household income sources, and planting disease/drought resistant varieties of seeds. However, literacy levels among the Maasai in Magadi remain relatively low, limiting their ability to access climate information and adopt modern adaptation technologies (Mugisho et al., 2023; Mugisho et al., 2024).

Livestock keeping remains central to Maasai identity and sustenance, but climate change has necessitated shifts in herd composition and grazing practices. Unlike other pastoral communities in Kenya, some Maasai households in Magadi do not keep a fully diversified herd of cattle, sheep, and goats. Instead, they selectively manage their livestock in response to climatic conditions, a strategy that has helped some households withstand severe droughts.

Comparatively the households in the study area kept less cattle and more of the small stock (sheep and goats). This is due to the fact that frequent droughts have led to increased livestock mortality and distress sales, undermining long-term economic stability (Mwangi, 2016). Strategic destocking, controlled grazing, and fodder preservation are among the key adaptive practices that could enhance resilience in the face of climate change.

5.2.2 The Level of Climate Variability and Change in Magadi Division

The extent of climate variation and change in Magadi division was found to be high meaning the impacts of climate in the area were highly rated, necessitating the need for measures to be put in place in order to mitigate against the phenomenon. This finding is in line with what other studies in Kenya and elsewhere have found. Studies in Baringo county an ASAL area found the coefficient of variation (*CV*) for annual rainfall was above 30 % (Koskei et al., 2018; Ochieng et al., 2017), in an Ethiopian study, it was estimated at 56 % (Belay et al., 2021). Likinaw et al. (2022) found a high coefficient of variation above 30 % in a north west Ethiopia study.

Meteorological data provided evidence to support farmers' perception on climate change and variation (Chepkoech, 2018). Statistically significant relationships were found to exist between some of the pastoralists' perceptions and Agro-climatic zones (ACZs). The study area, Magadi Divisions' ecosystem was found to have experienced recurrent severe droughts and erratic rainfall during the period studied. This observation is supported by the study of Umar (2022), who concluded that most of the respondents perceived an increase in temperature, fluctuation in the rainy seasons, and a decrease in the amount of rainfall. These insights provided by climatic evidence have important implications in the development of strategies to mitigate climate change impacts on ecosystems' biodiversity and human welfare (Ogutu et al., 2022)

Evidence from other areas support the finding that the Maasai pastoral community is able to perceive climatic changes and variations. Hassan and Knight (2023) showed that householders

are aware of climate change and had noted its various expressions as decrease in rainfall and a rise in temperatures. Studies by Likinaw et al. (2022) and Abdella (2022) showed that respondents perceived an increase in temperature, fluctuation in the rainy season, a decrease in the amount of rainfall and perceived that they are vulnerable to local climate variability. There were no statistically significant gender differences in the assessment of climate variability and change, this was found to be deviation from other studies that found out there actually existed significant gender differences in the way they rated climate change (Ezenwa et al., 2018). Bessah et al (2021) found differences in how climate change is perceived and tackled by male and female genders. In the perception of male farmers, for example, they were found to be more vulnerable to increased temperature, and changes in rainfall and growing season, whereas female farmers on average were considered to be less resilient to floods and droughts for different reasons.

Seblodo et al. (2021) found that all the surveyed farmers were aware of climate change and perceived diverse manifestations including the delay in rainfall regarded as the most important risk. In Baringo, it was observed that 78.7% of the respondents were informed of climate change, mostly through the media (34.62%) (Ezenwa et al., 2018b)

About 64% of the farmers perceived climate variability that was consistent with the meteorological data, whereas 36% either held contrary observations or were unable to discern. Age, level of education, farming experience and accessibility to information influenced the likelihood of farmers to correctly perceive climate variability. No significant differences in perceptions based on gender were observed. This study concludes that coping and adaptation strategies of over one-third of the farmers could be negatively impacted by wrong perceptions of climate variability (Rapholo & Makia, 2020).

The results of this study showed that a majority of the farmers were knowledgeable of climate change, and they mostly got climate information through the media. Floods and high

temperatures were perceived as the most occurring climate change-related disaster risks. Majority of the farmers perceived climate change as high risk and have taken up multiple adaptation strategies in response to it, including changing planting times, mulching their land and digging irrigation pits. Farmers' responses indicated that they want to do more but are restricted by financial resources (Elum & Snijde, 2023). More than two-third of the farmers (68%) identified that they had knowledge of climate change (see Table A1 in Appendix). The majority (79%) identified it to be very likely that climate change would impact their livelihoods and that the occurrence of floods is largely a consequence of climate change (Elum & Snijde, 2023). Githiora et al. (2023) observed that the majority of the respondents had observed changes in climate parameters as: severe droughts (88.5%), increased frequency of floods (86.0%) and irregular onset and termination of rains (90.9%) in the past 20 years. The perceptions corresponded with climate trends that showed a significant increasing trend in the short rains and the average maximum temperature, high incidence of very wet years and variability in onset and termination of rainfall between 1981 and 2018.

5.2.3 Household Adaptive Capacity to Climate Variability and Change in Magadi Division

The household adaptive capacity to climate change was found to be of moderate level, and the number of households with moderate adaptive capacity was significantly higher than the other categories. There were no existing gender differences in adaptive capacity of the pastoral households. This finding has the implication that the pastoral community in Magadi division were not able to effectively cope with the challenges caused by climate variability and change. This finding is common in most African pastoral societies. A study conducted in Ghana's northern region concluded that the majority (63.5 %) of the female farmers interviewed had low adaptive capacity to climate change and variability (Alhassan et al., 2018). In Tigray, Ethiopia a low adaptive capacity (M=0.553 ± 0.113), was realised (Manaye, 2024). A similar

situation was realised with female headed pastoral households in northern Kenya (Grillos, 2018) and in three Agro-ecological sites in Kenya (Chepkoech et al., 2020).

In a study conducted in the Philippines by Colting-Pulumbarit et al. (2018) a higher adaptive capacity index (HACI) of organic farmers was found to be due to farm practices related to organic agriculture such as crop diversification, sustainable land management, and participation in organizations. This indicated that organic farming potentially enhances the adaptive capacity of vegetable farming households.

The adaptive capacity to climate change tended to vary with the locality, and variations were found in different localities. Variation in the adaptive capacity varied in different localities North central Ethiopia from a low of .361 to .417 to a high of from .803 to .859 (Asfaw et al., 2021). A comparative study conducted by Aryal et al. (2021) in Ethiopia and Kenya (East Africa; EA) and households in Bangladesh, India, and Nepal (South Asia; SA) found that the studied households had low adaptive capacity to address climate change, which is further weakened by inadequate governance and inefficient institutions. A low adaptive capacity (0.47), was also found in Ethiopia by Tofu et al. (2023).

Mwatu et al. (2020) in his study sought to establish the extent to which rain-fed crop farming households in Kitui South sub-county in semi-arid Southeastern Kenya are vulnerable to rainfall variability. The study established that indices for exposure, sensitivity and adaptive capacity were 0.71, 0.09 and 0.19 respectively and that 97.4% of the households in the study area were vulnerable to rainfall variability. Addis and Abirdew (2021) found that smallholder farmers perceived climate change in the past two decades and in response; the majority (91.47%) of the farmers applied adaptation options.

Indices of vulnerability to climate change have been developed for different livelihoods and areas. Nigam et al. (2024) developed a coastal vulnerability index (CVI) with 21 indicators that combined social vulnerability (SOVI) and physical vulnerability index (PVI) to assess coastal

vulnerability to climate variability and change at the village level, they found out that the CVI were high above 20. Mekonen and Berlie (2021) found low adaptive capacity and high levels of climate vulnerability index (CVI) using a framework with twenty-four vulnerability indicators identified for exposure, sensitivity, and adaptive capacity components. Ebrahim et al. (2022) developed a Livelihood Vulnerability Index (LVI) and LVI-IPCC were used for analysis for two areas Kolla and Daga. LVI and LVI-IPCC results revealed that Kolla was the most vulnerable (0.18) because of its highest exposure (0.74) and sensitivity (0.71) values and lowest adaptive capacity (0.49) while Daga was the least vulnerable (0.08) because of its lowest exposure (0.61) and sensitivity (0.42).

Huynh et al. (2020) The results showed that the Thoi Lai District, with a vulnerability indicator estimated at 0.59, was more vulnerable to the impacts of climate change than other districts because of its lower adaptive capacity and higher sensitivity. In contrast, Ninh Kieu District's climate change indicator of 0.24 demonstrates that it has a higher resilience to climate change impacts. Suvdantsetseg et al. (2020) The pastoral vulnerability assessment results reveal that drought, pasture usage and normalized difference vegetation index are the main drivers of vulnerability.

5.2.4 Household Adaptive Strategies Undertaken by Maasai Pastoral Households in Magadi Division

The Maasai pastoral households in Magadi division were found to apply adaptive strategies to alleviate the impacts of climate variation and change on their livelihoods. The adaptive capacities were also ranked based on their effectiveness in alleviating the impacts of climate change. The adaptive capacities were divided into two nature-based solutions relying on natural resources and the non-nature based solutions.

Hassan and Knight (2023) study classified the farmer adaptation strategies into two; a range of on-farm and off-farm adaptation strategies. On-farm strategies included: changing the crop

planting time; crop diversification; irrigation farming; the use of fertilizers, manure, and agrichemicals to boost crop yield; and planting disease-resistant and drought-tolerant crop varieties. Off-farm strategies included small-scale trading and artisanal ventures that can augment the household income. These activities were found to enhance households' resilience to the negative effects of climate variability.

In general, farmers faced several multiple climate risks simultaneously and they responded with multiple adaptation strategies (Aryal et al., 2021) These strategies include: change in farming practices, sustainable land management, reduction in consumption, sell off assets, use of savings and borrowings, seeking alternative employment and assistance from government or NGO. The application of adaptive strategies by farmers was found to be a common feature of the households that were experiencing climate change and variability in Ethiopia (Gebre et al., 2023). A review by Akuja and Kandagor (2024) on the application Climate Smart Agricultural (CSA) practices in the Arid and Semi-Arid Lands (ASAL) of Kenya found that there existed gaps and barriers in policy development and implementation, which needed to be addressed to enable the households to adapt these practices. Agricultural productivity policies for ASAL areas tend to lack the element of adaptation strategies for climate change and variation, this was observed in a case study of Turkana County (Akuja & Kandagor, 2019). Diversification of income sources common with the Maasai pastoral households in this study was also identified as a solution by other communities in Kenya (Gebre et al., 2023; Ndiritu, & Muricho, 2021; Tower & Plano, 2023).) and in Ethiopia by 45 % of the respondents and who also increased their food security (Gebre et al., 2023a). Other studies recommended the diversification of livelihoods (Hassan & Knight, 2023).

Land conservation and restoration was found to enhance resilience of the ecosystems studied (Berhanu et al., 2024). Dechassa et al. (2020) advocated for soil and water conservation and planting trees.

All the surveyed farmers were aware of climate change and perceived diverse manifestations including the delay in rainfall regarded as the most important risk. The pastoral communities in Kajiado west sub-county applied adaptive strategies by alleviate the challenges caused by climate variation and change as an ongoing activity (Babadoye et al., 2016; Mwangi, 2016)

Climate information, though lacking, is needed by farmers in order to make decisions on adapting adaptive strategies. Studies on climate information have shown a significant and positive impact on farmers' adaptive capacity, with farmers who had access to climate information using three more adaptation strategies than they would have used otherwise (Belay et al., 2017; Ogundeji et al., 2022). Emerging evidence indicates that climate-smart agriculture (CSA) can help smallholder farmers adapt to climate change and increase agricultural productivity, thereby enhancing household income and food security (Belay et al., 2023).

The adoption of the adaptive strategies by farmers are influenced by other factors (Gebre et al., 2023c), they include: farmers experience, household numbers, sex of farmers, age of farmers, formal education level, membership of group, credit availability and contact with extension officers. Balay et al. (2022) The empirical results revealed that farmer's adaptation to climate change through adoptions of CSA practices was significantly influenced by education, family size, gender, landholding size, farming experience, access to climate information, training received, social membership, livestock ownership, farm income and extension services. The adoption of adaptation strategies was influenced either negatively or positively by the household size, land size, education level, membership to rice farmer's association, training in rice production, access to extension services, use of improved varieties and the location in climatic zones (Seblodo et al., 2021).

Pepela et al. (2022) found out the vulnerability to climate change in Baringo county was influenced by the following factors, that included: lack of access to weather information (52.5%), lack of government support (47.1%), lack of emergency preparedness systems

(87.3%); geographical location (67%) while majority (100%) blamed the absence of insurance for animals respectively. All these were statistically significant with p-value = 0.001 tested at $p < 0.05$ level.

The results of this study will be useful in policy formulation and mitigation of vulnerability to climate change among households. Ezenwa et al. (2018) studying in Baringo concluded the majority (56.8 %) of the pastoralists used gathering and storage of grasses and fodder as an adaptation strategy, while 48.52 % adopted livestock migration as the coping strategy.

The study to determine the choices adapted by the farmers, identified sex, family size, agroecology, climate information, crop-failure history and formal extension service as significant determinants for farmers' adaptation choices as these variables significantly affected more than two farmers' adaptation strategies simultaneously (Addis & Abirdew, 2021). The result from the binary logistic regression model showed that age and sex of household heads, as well as their education, family size, access to agricultural extension services and training on climate change significantly influence the practices of adaptation measures (Hirpha et al., 2020). Menghistu et al. (2020) concluded that the most important determinant factors of Climate change adaptation (CCA) by pastoralists were household income, access to information, access to extension services, government support and access to market. In the case of agro-pastoralists, access to information, household income, age and land/livestock ownership were found as the major determinant factors. Household income, land ownership, access to information, farm size, household size and access to extension services were the determinant factors found for CCA by smallholder farmers.

Aboye et al. (2023), found that the majority of farmers used simple and low-cost adaptation strategies like changing planting dates, selling livestock and off-farm and nonfarm work. A minority of farmers used advanced adaptation strategies like crop diversification and water harvesting for irrigation. The result further revealed that: the age of the household head,

educational status of household heads, farm size, livestock ownership, farming experiences, household income, access to credit and access to climate information significantly influenced the adoption of the adaptation strategies. Public policy should provide water harvesting and irrigation technology, climate-related information and the provision of microcredit facilities to enhance the farmers' resilience to climate change risks. Tagwi and Khoza (2024), study showed that resources (extension services), institutional (association membership) and societal influence (farm produce theft, and animal trespassing in the farming plots) to be associated with the use of modern climate change adaptation measures in the study area. The study recommended expanding extension services, strengthening community policing, creating community grazing guidelines, and training farmers on climate change causes, social cohesion, and mitigation strategies to address farm produce theft and animal trespassing. Institutional support for adaptation is much less in Ethiopia and Kenya and East Africa (EA) as a region when compared to households in Bangladesh, India, and Nepal and South Asia (SA) as a region. Training on alternative farming practices, enhancing non-farm employment options, better institutional support, and social security for older farmers are crucial for climate change adaptation in both regions (Aryal et al., 2021).

5.3 Summary of Main Findings

This study aimed at assessing climate variability and change, adaptive capacity and adaptive strategies to climate impacts by Maasai pastoral households in Magadi division of Kajiado county. The study specifically examined the effect of climate variation and change on the adaptive capacity of the households, strategies adopted by the households in alleviating the negative effects of climate. In achieving the study objectives, the study used primary data which was collected using a structured questionnaire that was organized according to the key thematic areas corresponding to specific objectives of the study. Key Informants Interview and Focus

Group Discussions were conducted to triangulate the household survey data. The study then utilized descriptive and inferential statistics to analyse the data.

The results showed that climate variation and change was experienced by the pastoralists in Magadi division, the adaptive capacity of the pastoralists was found to be low, while the pastoralists recognised the different adaptive strategies recommended could alleviate the effects of climate variability and change within their pastoral system.

5.4 Conclusions

The following conclusions were made from the study:

(i) The assessed level of climate variation and change in Magadi Division using both climatic indices and perceptions of pastoralists was found to be high.

(ii) The adaptive capacity for the majority of the Maasai pastoral households in Magadi division was found to be of moderate level.

(iii) The Maasai pastoral households in Magadi division practised a number of nature based and non-nature based practical and effective adaptive strategies aimed at alleviating the impacts of climate variation and change.

5.5 Recommendations

Based on the study findings, the following recommendations were made:

1. Application of nature based solutions to climate variability and change by pastoralists; pasture rehabilitation programmes using enclosures and grass seed planting and forage preservation practices.
2. Apply non-nature based solutions to climate change; diversification into non-livestock based livelihoods, and training of pastoralists on climate variation and change mitigation

measures. The county government to enhance the distribution of permanent water points in places without water for people and animals.

3. The county government should provide inputs needed in environmental conservation practices. This can be done by creating tree nurseries to provide seedlings to the households, provision of grass seeds for planting, and equipment for making soil conservation structures.

5.6 Areas for Further Research

The following are recommended to be done for further research:

a) The study covered Maasai pastoral households in Kajiado west sub-county (formerly Magadi division), there is need to cover other Maasai pastoral households in other areas of Kenya in order to get a clearer picture of the situation in the country.

b) Determine the influence of large-scale grassland soil carbon removal project on the impacts of climate variation and change in arid lands ecosystems.

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APPENDICES

Appendix A: Protocol for Collecting Rainfall Distribution Data

Location of rain gauge _____

Instrument used _____

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Appendix B: Long Term Rainfall Data for Magadi Division from 1983 to 2021

Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1980	36.4	20.8	39.8	105.8	227.4	14	0	0	0	1.0	51.7	25.1	531
1981	0	0	154.2	122.7	12.2	0	0.1	0		20.5	1.0	15.2	444.7
1982	0	0	3.1	1.0.7	55.8	19.5	4.3	0.7	14.9	42.5	227.7	136.9	612.4
1983	0	20.13	24.6	13.15	2.0	12.7	20.4	7	1.3	1.4	0	106.2	589
1984	27.6	2.3	7	47.6	0.5	0.8	5.2	1.8	11.8	84.1	142.2	55.9	386.8
1985	0	88.5	72.8	13.4	49.5	9	0	0	5	25.5	67.3	51.9	553.5
1986	21.4	0	16.6	204.7	56.2	2.3	0	0	0	11.3	133.5	7.1.9	517.9
1987	39.5	9.6	65.3	145.9	45.5	84.6	0	5.8	34.8	0	98.9	42.3	572.2
1988	13.2	13.3	160.5	226.7	3.6	2.8	0	7.5	3.9	0	1.0.2	36.1	634.9
1989	6.7	14.8	133.7	198.4	85.8	19.3	0	1.2	26.5	112.9	75.8	176.5	922.7
1990	64.4	9	153.5	196.9	60.7	5	0	6.5	8.8	0	74.1	0	578.9
1991		17.5	127.9	56.8	99.4	22.5	0	13.5	0	89.9	62	150.5	640
1992	0	53.5	33.4	33.4	15.9	1.3	5.7	0	0	4.9	98.1	93.4	696
1993	24.4	138.6	8.4		50.4	23.7	0	0	0	44.2	7.1.2	35.6	6.15.1
1994	24	58.8	69.1	127.6	29.8	7.6	5	4.1	0	59.4	149.3	37.1	5718
1995	34.2	76.2	137.9	88.9	64.4	6.5	0	0	12.6	70.6	26.1	51.7	619.1
1996	9.8	50.6	142.7	11.5.1	56.7	11.3	0	0	27.5	0	144.7	0	558.4
1997	1.5	0	1.2		96.4	0	0	53.3	0	177.9	177.9	157.9	676.9
1998	1.8	195.3	77.3	83.3	162.5	82.1	3.5	8	10.7	0	35.8	8	844.5
1999	7	13.2	138.7	27.7	0	0	0	1.0	0	37.7	130.7	59.5	474.5
2000	2	0	2.9	42.6	6.6	3.4	0	9.5	0	20.9	64.9	7.1.5	224.3
2001	282.4	11.4	245.9	116.4	11.8	11.2	20.9	0	0	2.6	222.1	2.9	927.6
2002	7.3	24.6	6.7	158.5	234.2	0	0	4	1.2	99.2	7.8	106.4	856.9
2003	3	7.9	17.9	83.1	179.3	0	2.6	20.3	7.2	28.2	75.7		496.3
2007	174.3	3.3	12.7	133.8	38.6	0	5.4	10.1	5.9	6.2	6.1.7	50.5	532.2
2008	60.5	44.7	126.9	54.6	2.3	0	12.8	0	14.5	7.4.2	1.0.2.3	0	492.8
2009	3.5	11.3	33.4	86.7	7.2.9	43.9	0	0	0	29.8	7.5.2	241.2	629.4
2010	17.5	7.3.8	6.8	16.2	6.1.2	0	0	0	3.4	19.9	15.7	68.7	344.4
2011	32.4	87.4	65.3	0	22.6	0	0	0	1.5	46.4	52.3	3.8	359.4
2012	16.5	15.3	15.8	150.2	7.2.4	1.0.8	0	13.7	0	22.5	49.7	36.7	403.6
2013	9.3	0	186.9	144.8	5.5	0	0.5	0	0	36.5	42.2	1.60	585.7
2014	5.2	13.5	120.5	4.2	8.6	0	0	3.0	2.9	19.9	8.4	64.6	575.3
2015	0	52.8	15.2	154.1	35.3	6.6	0	2.5	1	1.7	1.0.1	6.0	446.5
2016	8.1.6	7.1.9	35.7	7.5.6	1.0.5	0	0	0	0	0	58.3	2.0	353.6
2017	5.1	4	3.1	0	1.0.4	0	0	0	0	7.8	0	0	30.4
2018	0	0	0	0	8.7.6	0	7.8	4.6	3.4	6.2	15.2	63.6	1.10.56
2019	5.8	1.0.4	1.4.4	86.6	1.3.4	3.8	0.8	2.6	2	30.8	32.4	173.6	376.6
2020	1.8	0	125.2	1.3.12	8.8	4.8	0	2.4	5.6	1.3.2	46.2	2	502.4
2021	46.8	7.4.8	17.8	85.3	2.4	0	0.2	0	3.2	1.3.4	36	30	336.5
Total	1736	1576	2854	4166	2129.7	446.4	95.2	229.9	269	1528	3092.9	2501	
Mean	44.52	40.42	73.13	106.8	54.607	11.45	2.44	5.895	6.897	39.19	79.305	64.14	

Appendix C: SPI values for Magadi Division from 1983 to 2021 (Table 4.9)

Years	Total	Mean		SPI

1980	531.0	44.3	0.2	0.01
1981	444.7	37.1	-7.0	-0.45
1982	612.4	51.0	7.0	0.45
1983	589.0	49.1	5.0	0.32
1984	386.8	32.2	-11.8	-0.76
1985	553.5	46.1	2.1	0.13
1986	517.9	43.2	-0.9	-0.06
1987	572.2	47.7	3.6	0.23
1988	634.9	52.9	8.8	0.57
1989	922.7	76.9	32.8	2.10
1990	578.9	48.2	4.2	0.27
1991	640.0	53.3	9.3	0.59
1992	696.0	58.0	13.9	0.89
1993	616.1	51.3	7.3	0.47
1994	571.8	47.7	3.6	0.23
1995	619.1	51.6	7.5	0.48
1996	558.4	46.5	2.5	0.16
1997	676.9	56.4	12.3	0.79
1998	844.5	70.4	26.3	1.69
1999	474.5	39.5	-4.5	-0.29
2000	224.3	18.7	-25.4	-1.63
2001	927.6	77.3	33.2	2.13
2002	856.9	71.4	27.3	1.75
2003	496.3	41.4	-2.7	-0.17
2007	532.2	44.4	0.3	0.02
2008	492.8	41.1	-3.0	-0.19
2009	629.4	52.5	8.4	0.54
2010	344.4	28.7	-15.4	-0.99
2011	359.4	30.0	-14.1	-0.91
2012	403.6	33.6	-10.4	-0.67
2013	585.7	48.8	4.7	0.30
2014	575.3	47.9	3.9	0.25
2015	446.5	37.2	-6.9	-0.44
2016	353.6	29.5	-14.6	-0.94
2017	30.4	2.5	-41.5	-2.66
2018	110.6	9.2	-34.9	-2.23
2019	376.6	31.4	-12.7	-0.81
2020	502.4	41.9	-2.2	-0.14
2021	336.5	28.0	-16.0	-1.03

Appendix D: Introduction Letter

Dear Participant,

RE: REQUEST FOR YOUR PARTICIPATION IN SURVEY

My name is Phiah Muya, a Master of Science (MSc) student at Africa Nazarene University (ANU) taking a course in Environment and Natural Resource Management. I am currently conducting my field research on a topic related to drought management entitled "Assessment of climate change and its influence on the vulnerability of Maasai pastoral households in Kajiado West Sub-county (Magadi division) of Kajiado County, Kenya"

This is to inform you your household was randomly selected from the 42,774 households in the sub county to be interviewed for this study. This is a voluntary exercise and would kindly ask you to respond to the questions on this questionnaire. Your name and responses will not be disclosed to anyone and will be used for the purpose of my study only.

Your participation will be highly appreciated.

Yours Sincerely,

Phiah Wanjiru Muya

Appendix E: Household Questionnaire

Instructions

Please answer all questions appropriately and tick (☑) *all that apply*

Part **I: Demographic Information**

Age: _____

Marital Status: _____ (Married/ Single/ Widow/ Divorced/

Ethnicity: _____

Household Number: _____ Male_____ Females _____

Education level: Kindly indicate your highest and partner's academic qualification

Highest academic level	Myself	Partner
Never went to school		
Lower primary (1-4)		
Upper primary (5-8)		
K.C.S.E (form 4)		
A' Level		
Teacher (P1)		
College (diploma)		
Undergraduate degree		
Masters and above		
Other (specify)		

Professional training: _____

Training in soil and water conservation: (Yes/ No)

Duration of training ……..

Farmer field schools ……..

Type of activities involved in: _____

Give some details of the enterprise: _____

Please answer each of the following questions as honestly as you can.

Your answers will be treated confidential

Please answer each of the following questions as honestly as you can.

Your answers will be treated confidential

Part A: General information (Kindly tick on the box appropriately)
Household Head

1. SEX: ☐ Male ☐ Female	AGE (Yrs): _____yrs	Marital status: ☐ Single ☐ Married ☐ Separated ☐ Divorced ☐ Widowed
2. Education: Did you attend school? Yes ( ) No ( )	What is the highest level of education reached?	Education reached ☐ None ☐ Primary ☐ Secondary ☐ College ☐ University Other …….
3. Location: What is the current location of residence?	Group Ranch name	
4. Dependents. What is the size of your household (……no. of persons) living with you?		
5. Breakdown your household number in the following ages: 0-10yrs ____, 11-20 ___, 21-30____, 31-40 _____, 41-50 ____, 51-60 ___, 61-70 _____, above 71_____		

6. What is your source of your income?	Farmer	Employment	Business
	Pastoralist	Other specify	

Part B: Socioeconomic characteristics of the households

1. Provide the numbers of the different type of animals owned by the household

Type of Animal	Numbers 2021	Numbers 2015	Numbers 2010	Numbers Increased / decreased	Reason for change in numbers
Cattle					
Sheep					
Goats					
Donkeys					
Poultry					

2. Provide production figures for the different crops grown by the household

Type of crop	Amount 2021 Production in kg	Amount 2015 Production in kg	Amount 2010 Production in kg	Amount Increased / decreased	Reason for change in Amount
Maize					
Pawpaw					
Bananas					

Tomatoes					
Onions					
Beans					

3. Source and amount of farm and non-farm income generated by the household

Sources of income	Amount 2021	Amount 2015	Amount 2010	Numbers Increased / decreased	Reason for change in numbers
Animal sales					
Crop sales					
Business					
Tourism related					
Remittances					
Poultry					

4. Assets owned by the household

Assets owned	Yes /No	Number	Condition
Land size (ha)			
Radio			
TV			
Solar panel			
Vehicle			
House			
Toilet			
Generator			

5. Infrastructure available to the household

Infrastructure	Yes /No	Number	Condition
Access to health facility			
Roads to market			
Administration office			
Church			
Social hall			
Water tanks			
Electricity			

6. Sources of information and access to information by the household

Source of information	Yes /No	Frequency of access (low, medium and high)	Provision of climate information
Extension service			
Radio			

NGOs			
TV			
Agricultural shows			
Other ranchers			

Part C: Climate Variability and extremes in the area

1. Asses the variability of climate and climatic extremes in the last 10 years by noting the occurrence and frequency of the following events in the area.

Rate the level of frequency using a 0-5 scale (0 = None; 1=Very low, above 6 years; 2=Low 4-5 years; 3=Medium, 3-4 years; 4=High, 1-2 years, 5=Very high, every year).

Rate the level of risk on a 0-3 scale (0=no risk, 1=low risk, 2=medium risk, 3=high risk)

Climatic events	Occurrence Yes/ No	Frequency	Risk
Droughts			
Floods			
Hail storms			
Short rainy season			
Low amount of rains			
Delayed rains			
High temperatures			
Very low temperatures			
Long dry periods			
Strong winds			
Other			

2. Note the changes in climate that have occurred within the last 10 years

Climatic events	Changed/ Not changed	Frequency Increased /reduced	
Reduced rains			
Increased rains			
Reduced temperatures			
Increased rains			
Frequency of dry spells			
Frequency of droughts			
Frequency of floods			
Other			

3. Effects of climate variability on the livelihoods of the households

Rate the level of frequency using a 0-5 scale (0 = No effect; 1=Very low effect, 2=Low effect, 3=Medium effect, 4=High effect, 5=Very high effect).

Climatic events	Household livelihood activities				
	Pastures availability	Water availability	Crop production	Food security	Household income
Droughts					
Floods					
Hail storms					
Short rainy season					
Low amount of rains					
Delayed rains					
High temperatures					
Very low temperatures					
Strong winds					
Other					

4. How do the following aspects of climate change affect the following household activities?

Rate the level of frequency using a 0-5 scale (0 = No effect; 1=Very low effect, 2=Low effect, 3=Medium effect, 4=High effect, 5=Very high effect).

Household livelihood activities	Climatic events				
	Droughts	Floods	High temperatures	Low temperatures	Low rains
Pastures availability					
Water availability					
Crop production					
Distance to water					
Migration					
Prices of foodstuffs					
Long distance to grazing					
Death of livestock					
Conflicts over resources					
Lack of infrastructure					
Decrease in livestock prices					
Lack of market for animals					
Livestock Diseases					
Crop pests					

Part D: Water sources, Scarcity (Kindly tick appropriately)

1. Where do you get drinking water from?	☐ Rain Harvesting ☐ River ☐ Dam ☐ Tapped water ☐ Borehole	Other
2. Is the water clean for human consumption?	Yes	No
3. Where do you get water for livestock?	☐ Rain Harvesting ☐ River ☐ Dam ☐ Tapped water ☐ Borehole	Other
4. What is the distance covered to fetch water?	km	Other specify
5. Whose role is it for fetching water?	Women ……Girls .. Men ……Boys ……All	All
6. Whose role is it for watering animals?	Women ……Girls .. Men ……Boys ……All	
7. How has the rainfall seasons affected availability of water for the last 10yrs?	☐ More water available	☐ Less water available
8. What mechanisms have you put in place to cope with water scarcity?		
9. Do you use water for irrigation? Yes ( ) No ( ) 10. If Yes Where do you get the water from? 11. How do you ensure equal distribution to the famers?		
12. What has the government done to avail water?	☐ Piped water ☐ Borehole construction ☐ Dams construction	Other specify

Part E: Livestock and Grazing areas (Kindly tick appropriately)

1. What is the size of herd? Less than 20 ( ) 20- 50 ( ) 50-100 ( ) more than 100 Other specify?		
2. Is the land communally owned? Yes ( ) No ( )		
3. Who controls the grazing area? Own ( ) Communal ( )		
4. Has the grazing area changed in the last 10yrs?	Increased ( ) Decreased ( )	
5. If decreased what is the cause?	Drought ( ) Bush Encroachment ( )	Other specify

	Overgrazing ( )	
6. Are there measures you are taking to mitigate the lack of grazing areas?	Yes ( ) No ( )	
7. What government intervention has been affected in your area to improve on the lack of grazing areas?		

Part F: adaptation measures to climate variability undertaken by households in the area

Name and rate the different adaptation strategies to climate variability undertaken by the household in the last 10 years

Level of importance: Rate the level of importance using a 0-5 scale (0 = Not important; 1=Very low importance, 2=Low importance 3=Medium importance, 4=High importance 5=Very high importance).

Household Adaptation strategies to climate variability	Climatic events				
	Droughts	Floods	High temperatures	Low temperatures	Low rains
Nature based					
Restoration of grazing					
Enclosures					
Water developments					
Migration					
Sale of animals					
Herd splitting					
Supplementary feeding					
Alternative water sources					
Agroforestry					
Destocking					
Storage of fodder/pasture					
Slaughter old weak animals					
Change of diet and consumption patterns					
Collective action					
Herd splitting					
Wild fruits consumption					
Non-nature based					
Diversification into non-livestock activities					
Famine relief					
Business					
Tourism related activities					
Climate information					
Training in climate change					

Take children to school					
Cash transfers					
Table banking					
Labour migration to towns (labour export)					

Appendix F: Letter to Key Informants

(Agricultural Extension Officers, Environment and Natural Resource Managers at County office, NGO officers in Environment and Natural Resource Management)

Dear Respondent,

I am a graduate student at Africa Nazarene University carrying out a study on:

Climate Variation and Change, Household Vulnerability to Climate change and Adaptive Capacity and Strategies to Climate Change Undertaken by Maasai Pastoralists in Magadi Division of Kajiado County, Kenya.

It is important that I obtain your opinion and the other required information for this study.

You are requested to complete the following short questionnaire regarding climate change, household vulnerability and adaptive capacity and strategies undertaken by Maasai pastoral households. It will take you approximately 20-30 minutes to complete the questionnaire. While completing this questionnaire, do not write your name anywhere on the questionnaire.

There are no correct or wrong answers; what is required is your honest opinion. Please, respond to all questions. Your first spontaneous reaction is the most valid; do not ponder too long over a particular question or response.

Information gathered in this study will assist in policy review on strategies towards strengthening climate change adaptive strategies.

Thank you.

Phia Muya

Researcher/ MSc Student

Appendix G: Interview Schedule for Key Informants

Section A: Background Information

County ……. Sub County …….. Institution ……

Gender ……. …… Date ……

1. Job Designation……
2. Please indicate your age _____
3. State the number of years you have worked in your institutions _____

4. Please indicate the level of your professional qualifications:
PhD [ ]; Masters [ ]; Bachelor's degree [ ]; Diploma [ ]; Certificate [ ]

Section B: Level of Challenges Facing Instructors in Effectively Using of climate variation and change adaptive capacity

Assess the different challenges and rate them in. Rate the level of the challenge in using Demonstration farms on a 5-point rating scale, as follows:

1=Very Low challenge, 2=Low challenge, 3= Moderate challenge,
4=High challenge, and 5=Very High challenge.

No	Statements on the Level of Challenge in Effective Use of Adaptive Strategies	KII Rating in Terms of the Level of challenge				
1	Challenges of droughts	1	2	3	4	5
2	Land degradation (loss of grass and soil)					
3	Lack of technical knowledge on climate variation and change adaptive strategies					
4	Lack of land to migrate to migrate to					
5	Lack of finances in implementing adaptive strategies					
6	Lack of pasture restoration activities (Seeding, enclosure)					
7	Lack or increased distance of permanent water sources in the area					
8	Challenges in animal marketing					
9	Shortage of animal feed					
10	Small piece of land available to the household for implementing strategies					
11	Lack of effective social institutions dealing with climate variation and change (networks, famine relief, disaster)					
12	Lack of infrastructure					
13	Animal diseases					
14	Lack of information / understanding on climate variation and change adoption strategies					

Section C: Effectiveness of Climate variation and change Strategies

Rate the given strategies in terms of their level of effectiveness in enhancing effective application of adaptive strategies. Rate of the strategy on a 5-point rating scale, as follows:

1=Very Low effectiveness, 2=Low effectiveness, 3= Moderate effectiveness,

4=High effectiveness, and 5=Very High effectiveness.

No	Statements on the Level of Effectiveness of the strategies	KII Rating in Terms of the Level of effectiveness				
		1	2	3	4	5
1	Provision of permanent water on pasture					
2	Provision of information on climate variation and change adaptive and mitigating strategies					
3	Training of households heads on all aspects of climate variation and change					
4	Creation of alternative livelihood sources					
5	Development of Infrastructure					
6	Provision of credit sources for households					
7	Development of collective action					
8	Improving on early warning systems (EWS)					

Section D: Recommendations of adaptive strategies for alleviating climate variation and change and their sustainability

The following selected strategies rate them in terms of their sustainability and practicability in implementing them. In rating the practicability consider the resources needed (monetary cos, time needed and professional labour).
Rate the given strategies in terms of their level sustainability. Rate of the adaptive strategy for alleviating climate variation and change on a 5-point rating scale, as follows:

1=Very Low Sustainability, 2=Low Sustainability, 3= Moderate Sustainability, 4=High Sustainability, and 5=Very High Sustainability.

No	Statements on the recommended strategies	KII Rating sustainability of strategy				
		1	2	3	4	5
1	Diversification into non-livestock livelihoods					
2	Permanent water development (boreholes, rain water harvesting)					

3	Forage preservation practices (standing hay, hay making, sale of carbon credits from grasslands)
4	Increase grazing resources through grassland restoration practices (Seeding, closure)
5	Training households in technology related to climate variation and change mitigating measures
6	Improve on infrastructure
7	Information on climate change (early warning systems)
8	Improve animal marketing system
9	Enhance social institutions (networks, famine relief, collective action, cash transfer)
10	Increase the number of livelihood sources (business, tourism related)
11	Introduce crop production
12	Labour export (involve in provision of labour)
13	Enhance Agroforestry practices

Appendix H: Focus Group Interview Guide

Discussion Guide One:

Identify the challenges facing Maasai pastoral households in effectively and sustainably implement climate variation and change adaptive strategies

Discussion Guide Two:

Rate the level of challenges facing Maasai pastoral households in effectively implementing climate variation and change adaptive strategies

Discussion Guide Three:

Identify the adaptive strategies that can be used in enhancing climate variation and change impacts

Rate the level of each strategy in enhancing the climate variability and change impacts

Discussion Guide Four

Rate the recommendation of the strategies based on sustainability

Rate the recommendation of the strategies based on Practicability (cost, time and professional labour required)

Appendix I: Field Photos



Plate 1: A panorama view of the study area. Bush encroachment and shallow rocky soils (viewed from Ngurumani escarpment)



Plate 2: Water developments- digging wells in search of water



Plate 3: Sheep grazing in Magadi division



Plate 4: Small stock heading to a watering point



Plate 5: A grazing area during the dry season, grass species are missing



Plate 6: A pasture in Magadi Division

Appendix J: ANU letter of Approval to Undertake Research

AFRICA NAZARENE
UNIVERSITY

17th August 2021

RE: TO WHOM IT MAY CONCERN

Phiah Muya (18S01DMEV001) is a bonafide student at Africa Nazarene University. He has finished his course work and has defended his thesis proposal entitled: -

"Assessment of household vulnerability to climate variations of Maasai pastoralists in Kajiado West."

Any assistance accorded to him to facilitate data collection and finish his thesis is highly welcomed.

Rodney R. Reed

Prof. Rodney Reed
DVC Academic & Student Affairs

Appendix K: NACOSTI Research License

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RESEARCH LICENSE



This is to Certify that Miss.. Phiah Wanjiru Muya of Africa Nazarene University, has been licensed to conduct research in Kajiado on the topic: Assessment of household vulnerability to climate variations of Maasai pastoralists in Kajiado West. for the period ending : 23/September/2022.

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Appendix L: Study Area Map



Appendix M: Map of Study Area

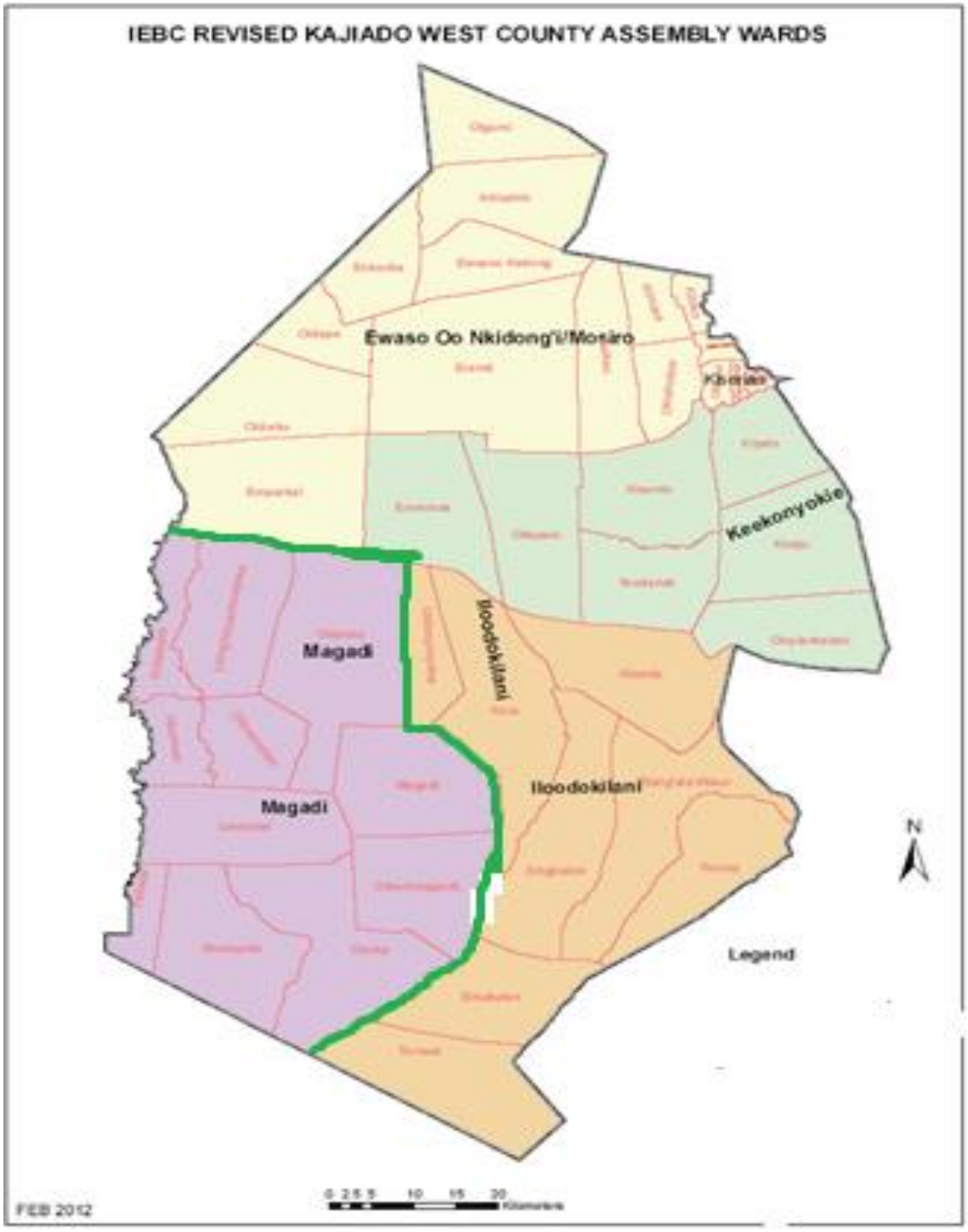


Figure 3.1: Map of Kajiado West Sub-County, with the four group ranches