INFLUENCE OF CLIMATE CHANGE MITIGATION APPROACHES ON LIVELIHOODS' SECURITY OF PASTORALISTS IN GARISSA TOWNSHIP SUB-COUNTY, KENYA

IQRAM ABDI ABDULLAHI

A RESEARCH PROJECT REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF ARTS DEGREE IN DEVELOPMENT STUDIES OF

MOUNT KENYA UNIVERSITY

Mount Kenya University

JULY 2025

DECLARATION AND APPROVAL

Declaration by Student

This study is entirely original with no submissions for awards or degrees to any other university.

Signature……  ……Date……01/07/2025……

Names: IQRAM ABDI ABDULLAHI

Reg no. MDS/2022/31326

Approval by the Supervisor

I confirm that the work reported in this research project report was developed by the candidate under my supervision.

Signature…… Date……

Dr. Kefa Nyandoro

School of Social Sciences

Mount Kenya University

DEDICATION

This project report is dedicated to my family; Mother- Sahara Abdi Gure, Husband-Mohamed Ali Hassan, Daughter- Aliyah Mohamed Ali and Late father- Abdi Abdullahi Afey; friends and relatives for their love and support in my academic endeavors.

Mount Kenya University

ACKNOWLEDGEMENT

I would like to thank my supervisor, Dr. Kefa Nyandoro, for his immense contribution to this work. I recognize and appreciate his guidance in drafting as well as refining this document. To the faculty at the school of social sciences, Mount Kenya University, thank you for creating a conducive environment to guide me through the undertaking of this program. I thank my fellow students for their positive criticism of making the document better.

Mount Kenya University

ABSTRACT

The sustainability of pastoralists' livelihoods is indeed significant, yet it faces considerable challenges due to climate change. Pastoralists depend on natural resources such as grazing land and water sources, which are increasingly vulnerable to climate variability and extreme weather events. Climate change poses significant threats to the livelihood security of pastoralists in Garissa Township Sub County, through its impacts on water availability, forage quality, and overall ecosystem stability. Prolonged droughts, erratic rainfall patterns, and increasing temperatures are leading to reduced livestock productivity and exacerbating land degradation, thereby compromising the economic, social, and environmental resilience of pastoralist communities. This study aims to evaluate how mitigation approaches to climate change affect the security of livelihood for pastoralists in Kenya's Garissa Township subcounty. The following specific objectives will guide the study: To assess the relationship between water management and livelihoods security of pastoralists in Garissa Township subcounty; To establish the relationship between climate resilient infrastructure and livelihoods security of pastoralists in Garissa Township subcounty; and to determine the relationship between diversification of livelihood and sustainable livelihoods security of pastoralists in Garissa Township subcounty, Kenya. Resilient theory and livelihoods theory serve as the foundation for this investigation. It makes use of both correlational and descriptive research designs and is based on a mixed research methodology. The target population entails about 7383 households keeping cattle, sheep, goats, and camels for the past five years make up the target population. Yamane sampling formula was used to determine a sample size of 379. Semi-structured questionnaires was used to gather primary data. There was the use of both inferential and descriptive statistics to analyze the quantitative data, while thematic analysis was used to analyze the qualitative data. At the 0.05 significance level, the hypothesis was tested. The data analyzed was presented in the form of tables and figures. The study found that water management's critical role in livelihoods security. Enhancing boreholes, purification, and community capacity is essential for resilience, aligning with Resilience. Regression analysis ($p = 0.003$) showed that water management underscores infrastructure's significance in Garissa Township subcounty. Strengthening shelters, fodder systems, and ecological restoration, while leveraging veterinary gains, is vital for resilience, supporting Resilience Theory's emphasis on robust systems in Garissa's semi-arid context. Regression analysis ($p = 0.000$) showed that climate resilience infrastructure had a strong impact on livelihoods security. Per Livelihoods Adaptation Theory, enhancing water access, infrastructure, and skills training is crucial to broaden diversification beyond pastoralism. The study recommends that the County Government of Garissa and other relevant organizations prioritize Water Infrastructure Development in Garissa Township subcounty. The Ministry of Agriculture should Strengthen Climate-Resilient Infrastructure as well. The study's findings may support policy makers in garnering support from stakeholders, including government agencies, development partners, and local communities, for the implementation of climate change adaptation policies.

Kenyatta University

TABLE OF CONTENTS

Mount Kenya University

Mount Kenya University

Mount Kenya University

Mount Kenya University

LIST OF TABLES

Mount Kenya University

LIST OF FIGURES

Mount Kenya University

ABBREVIATIONS AND ACRONYMS

FAO	Food and Agriculture Organization of the United Nations
UNDP	United Nations Development Programme
NGO	non-governmental organizations
NPIs	Non-pastoral Income-earning Activities
CBN	Cost of Basic Needs
CVI	Content Validity Index

Mount Kenya University

Mount Kenya University

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The sustainability of secure pastoralists' livelihoods in critical in the current global environment prone to climate change. To curb this menace sufficient measures are required to safeguard and ensure secure livelihood of the pastoralists. By integrating these measures into a comprehensive strategy, it is possible to enhance the resilience of pastoralist communities and ensure their sustainable means of subsistence in the context of climate change. However, this has not been the case in many countries (Lolemtum, 2023). This section provides an international, regional and local perspectives of the research problem.

Pastoralism in the USA has a rich history, evolving from the practices of Native American tribes and early European settlers to the modern ranching industry. The development of pastoralism has been shaped by the vast landscapes of the American West, characterized by open plains, arid deserts, and mountainous regions. Over time, technological advancements, improved livestock breeds, and the integration of pastoralism into the national and global economy have transformed traditional practices. Today, ranchers not only produce livestock for meat and dairy but also engage in agro-tourism and conservation efforts (Mathwich, 2021). Since then, pastoralism has been a cornerstone of rural livelihoods in the United States, particularly in the western states. Traditionally, pastoralists, often referred to as ranchers, have managed extensive tracts of land to graze cattle, sheep, and other livestock. However, the sustainability of this way of life is increasingly jeopardized by the impacts of climate change. Rising temperatures, prolonged droughts, and unpredictable weather patterns present significant challenges that require innovative approaches and policies to ensure the resilience of pastoralist communities (Holechek, et al. 2020).

Pastoralism in India has a deep-rooted history. It has evolved to integrate modern practices and engage with market economies, with pastoralists selling livestock products such as milk, meat, wool, and hides (Ghai, 2021). Despite modernization, many pastoralists continue to follow age-old customs and practices that have been passed down through generations. Pastoralism is considered an integral part of rural livelihoods in India, especially in arid and semi-arid regions. This traditional way of life supports millions of people and contributes significantly to the rural economy. In spite of all these, sustainability of pastoralist livelihoods is under severe threat due to climate change. The increasing frequency of droughts, erratic rainfall patterns, and rising temperatures pose significant challenges that necessitate innovative approaches and policies to ensure the resilience and sustainability of pastoral communities (Ahmad & Afzal, 2021).

Research shows that pastoralism is a crucial livelihood for many communities in Afghanistan, particularly in the arid and semi-arid regions. This way of life supports a significant portion of the rural population and plays a vital role in the local economy (Manduzai & Volpato, 2023). Despite this, the sustainability of pastoralist livelihoods is increasingly affected by frequent climate changes. This has significantly impacted pastoralism in Afghanistan. Prolonged droughts and unpredictable rainfall patterns reduce the availability of water and forage, essential for livestock survival and productivity. Rising temperatures and increasing frequency of heatwaves cause stress to animals, affecting their health and output. Shifting ecosystems, characterized by changes in vegetation and the encroachment of invasive species, further degrade pasture lands, making them less suitable for grazing (Tugjamba, Walkerden & Miller, 2023).

For millions of people in Ethiopia, especially in the country's arid and semi-arid regions, pastoralist work provides an important source of income. Many ethnic groups, including as the Afar, Somali, Borana, and Karamojong, have a strong cultural and economic tie to this traditional way of life.

The livelihood of pastoralists in Ethiopia is facing growing threats due to the effects of climate change. High temperatures, irregular rainfall patterns, and extended droughts present formidable challenges that call for creative solutions and policies that support them (Ayele, Dedecha & Duba, 2020).

For many people in Kenya, especially those in the country's arid and semi-arid regions, pastoralism is an essential source of income. Millions of people are supported by this traditional way of life, which entails herding livestock including cattle, goats, and camels and makes a major economic contribution to the country (Ndiritu, 2021). However, the effects of climate change are posing a growing danger to the sustainability of pastoralist lifestyles. In order to ensure the resilience and sustainability of pastoral communities in Kenya, creative solutions and supporting policies are required in light of the persistent problems posed by rising temperatures, irregular rainfall patterns, and protracted droughts (Ndiritu & Muricho, 2021).

Pastoralists in Garissa County, Kenya, face significant challenges to sustainable livelihoods due to climate change, socio-economic pressures, and resource-based conflicts. Prolonged droughts and erratic rainfall patterns have severely reduced the availability of water and forage, crucial for livestock survival and productivity. This has led to increased livestock mortality and decreased income for pastoralists. Additionally, market volatility, fluctuating prices for livestock products, and land tenure issues exacerbate economic instability. The encroachment of agriculture and urban development into traditional grazing lands further restricts access to vital resources. Insecurity and conflicts over dwindling resources, often exacerbated by climate change, also threaten the stability and resilience of pastoral communities (UNDP, 2021). According to a 2021 report by the Food and Agriculture Organization (FAO), these factors, combined with inadequate infrastructure and access to services, have intensified the vulnerability of pastoralists in Garissa County, necessitating

urgent intervention and sustainable management practices to ensure their livelihoods (FAO, 2021). In light of this, the study aims to determine how climate change mitigation approaches affect the security of pastoralists' livelihoods in Kenya's Garissa Township subcounty.

1.2 Statement of the Problem

The relationship between sustainable secure livelihoods of pastoralists and climate change approaches is inherently intertwined, marked by mutual dependence and reciprocal impacts. Sustainable secure livelihoods for pastoralists rely fundamentally on effective climate change approaches that mitigate risks and enhance resilience to environmental changes. Climate change, with its escalating impacts like prolonged droughts, erratic rainfall patterns, and rising temperatures, directly threatens the availability of water and forage crucial for livestock (Scoones, 2021). In response, climate change approaches such as improved water management, climate resilient infrastructure and diversification of livelihood not only safeguard natural resources but also promote economic stability by reducing vulnerability to climate-related shocks, enhancing market access, and diversifying income sources. Conversely, secure and sustainable pastoralist livelihoods contribute to effective climate change adaptation by preserving ecosystems, reducing carbon emissions through sustainable practices, and fostering community resilience. This symbiotic relationship underscores the critical need for integrated strategies that address both climate change impacts and livelihood security, ultimately fostering sustainable development and resilience in pastoralist communities (Srivastav, et al. 2021).

Garissa County in Kenya has been facing significant hardships due to climate change. The county has experienced prolonged droughts, with three consecutive failed rainy seasons. This has severely affected water availability for both people and livestock. The unpredictable rainfall patterns have made it difficult for pastoral and agro-pastoral communities to sustain their livelihoods. Due to the

lack of water and pasture, many pastoral communities have been forced to migrate in search of better conditions. This has led to increased pressure on resources in other areas. Climate change poses significant threats to the livelihood security of pastoralists in Garissa Township Sub County, through its impacts on water availability, forage quality, and overall ecosystem stability. Prolonged droughts, erratic rainfall patterns, and increasing temperatures are leading to reduced livestock productivity and exacerbating land degradation, thereby compromising the economic, social, and environmental resilience of pastoralist communities (FAO, 2021; UNDP, 2021). Despite various climate change adaptation approaches being implemented, significant gaps persist in understanding their effectiveness within the context of Garissa Township. This study seeks to explore these issues comprehensively, examining how climate change mitigation approaches impact are perceived, experienced, and mitigated by pastoralist communities, and identifying key factors influencing the sustainability of their livelihoods amidst changing environmental conditions. By filling in these gaps in the research, the purpose of the study is to offer insights and recommendations that would assist in to enhance and make the livelihood of pastoralists sustainable against the agents of climate challenges in Garissa Township.

1.3 Purpose of the Study

The purpose of this research was to investigate the influence of climate change mitigation approaches on livelihoods' security of pastoralists in Garissa Township sub-county, Kenya

1.4 Objectives of the Study

The research was guided by the following objectives:

i. To assess the relationship between water management and livelihoods security of pastoralists in Garissa Township subcounty, Kenya

ii. To establish the relationship between climate resilient infrastructure and livelihoods security of pastoralists in Garissa Township subcounty, Kenya

iii. To determine the relationship between diversification of livelihood and sustainable livelihoods security of pastoralists in Garissa Township subcounty, Kenya

1.5 Null Hypothesis

The following null hypotheses was used to narrow the study scope

H01 There is no significant relationship between water management and livelihoods security of pastoralists in Garissa Township subcounty, Kenya

HO2 There is no significant relationship between climate resilient infrastructure and livelihoods security of pastoralists in Garissa Township subcounty, Kenya

HO3 There is no significant relationship between and diversification of livelihood livelihoods security of pastoralists in Garissa Township subcounty, Kenya

1.6 Justification of the Study

1.7 Significance of the Study

This study would have implications to various stakeholders, each benefiting in distinct ways.

1.7.1 Pastoral Communities

Pastoralists would benefit directly by gaining a deeper understanding of how climate change affects their livelihoods. The study could identify specific vulnerabilities and provide insights into effective adaptation strategies, such as improved water management or diversified income sources, enhancing their resilience to climate impacts. This knowledge empowers pastoralists to make informed decisions about resource management and livelihood diversification.

Mount Kenya University

1.7.2 Governmental Organizations and Local Authorities

Governmental organizations and local authorities responsible for agriculture, environment, and rural development would benefit from the study's findings. It could inform policy and decision-making processes by highlighting priority areas for intervention, such as infrastructure development (water storage, roads), livestock management practices, and social services (healthcare, education) tailored to climate resilience. Evidence-based policies can enhance resource allocation and improve coordination among various departments to support pastoralist communities effectively.

1.7.3 NGOs and Development Organizations

NGOs and development organizations working in Garissa County would benefit by gaining insights into the specific needs and problems encountered by pastoralists on climatic conditions changes. The study could guide the design and implementation of targeted interventions, such as capacity-building programs, community-based adaptation projects, and advocacy efforts aimed at securing sustainable livelihoods and promoting environmental sustainability.

1.7.4 Researchers and Scholars

Researchers and scholars interested in climate change adaptation, rural development, and livelihood security would benefit from the study's findings as it contributes to the academic comprehension of the intricate relationships related to between climate change impacts and pastoralist livelihoods. This study could generate new knowledge, methodologies, and empirical data that advance scholarly discourse and inform future research directions in similar contexts.

Mount Kenya University

1.7.5 International organizations and donors

International organizations and donors supporting climate change adaptation and sustainable development initiatives would benefit from the study's outcomes. The findings could justify investments in resilience-building projects and programs aimed at improving livelihood security among pastoralist communities. This can foster partnerships and collaborations to mobilize resources effectively towards achieving sustainable development goals related to climate change adaptation and poverty reduction.

1.7.6 Policy Makers

The study may provide policy makers with empirical evidence and a deeper understanding of the specific impacts on changes occasioned by the climatic conditions on pastoralist livelihoods. This evidence base is crucial for designing targeted policies and strategies that address the unique vulnerabilities and challenges faced by pastoralist communities, such as water scarcity, land degradation, and livestock management under changing climatic conditions.

By understanding the priorities and needs identified in the study, policy makers can allocate resources more effectively. This includes investments in climate-resilient infrastructure, capacity-building programs for pastoralists and social services that support livelihood diversification and community resilience.

The study's findings can support policy makers in garnering support from stakeholders, including government agencies, development partners, and local communities, for the implementation of climate change adaptation policies. It provides a basis for dialogue and collaboration among various sectors and encourages coordinated efforts towards achieving sustainable development goals related to climate resilience and poverty reduction. Policy makers can use this research’s

Mount Kenya University

results as a baseline in monitoring progress and evaluating the effectiveness of climate change adaptation policies over time. This allows for adjustments and improvements in policy frameworks based on real-time data and feedback from pastoralist communities, ensuring that interventions remain relevant and impactful.

Internationally, the study may enhance Kenya's position in climate change negotiations and collaborations by demonstrating proactive efforts to address climate impacts on vulnerable populations like pastoralists. It may attract international support and funding for climate resilience projects, leveraging partnerships with international organizations and donors committed to sustainable development and climate action.

1.8 Scope of the Study

This study's geographical boundaries encompass Garissa Township, which is located in Garissa County, Kenya. Garissa Township serves as the focal point due to its significance as a hub for pastoralist communities in the region. This includes rural and peri-urban areas within Garissa Township where pastoralists reside and practice their livelihoods.

The content scope of the study includes various thematic areas related to climate change approaches on pastoralist sustainable livelihoods. In this study, climate change approaches will act as the independent variable whose constructs will include water management, climate resilient infrastructure and diversified livelihoods. On the other livelihoods security of pastoralists was the dependent variable. This was measured using indicators such as financial capital, social and human capital, food security, natural capital and adaptive capacity.

Mount Kenya University

In terms of time, the study focuses on the livelihood's security of pastoralists in the last five years. The duration is considered adequate to assess the impact and implementation of climate change approaches. The study endeavors to be carried out between Dec 2024 and February 2025.

1.9 Limitation of the Study

Several limitations are anticipated in conducting this study. The study's scope may be constrained by logistical challenges in reaching remote pastoralist settlements and engaging effectively with diverse community stakeholders, potentially impacting the representativeness of findings. However, this was handled through proper planning as well as budgetary allocations to enhance reach to sampled populations.

Thirdly, the dynamic nature of climate change and its localized impacts necessitate ongoing monitoring, which this study may not capture comprehensively within a fixed timeframe. Thus, the researcher will design the research tools to lie within a manageable scope for achevemtn within the planned timing.

Moreover, to overcome the limitations inherent in this study, several strategic approaches was employed. Data collection will involve fostering close collaboration with local authorities and community leaders to improve access to reliable and comprehensive data. Utilizing participatory will provide both qualitative insights and quantitative data directly from pastoralist communities, helping to fill data gaps and ensure a more holistic understanding of local contexts.

1.10 Delimitation of the Study

This study delimits itself to households practicing pastoralism in Garissa Township subcounty only for the last five years. This was delimited to keepers of cattle, sheep, goats and sheep as the target population. The study will delimit to semi structured questionnaires in terms of data

collection instruments. The study will delimit itself to three approaches of climate change that will include diversification of livelihood, water management and climate resilient infrastructure. The study will rely on relevant secondary sources of literature to discuss the results.

1.11 Assumptions of the Study

This study was conducted under the following assumptions

i. Firstly, it assumes that climate change is a significant and ongoing phenomenon affecting Garissa Township. This leads to changes in rainfall patterns, temperature fluctuations, and increased frequency of extreme weather events.

ii. Secondly, the study assumes that pastoralist communities in Garissa Township because they rely on natural resources for their livelihood. They are particularly vulnerable to the effects of climate change., primarily through livestock rearing. This assumption suggests that disruptions in water and pasture availability directly threaten the economic stability and food security of pastoralists, influencing their adaptive strategies and resilience.

iii. Thirdly, the study assumes that there are existing climate change adaptation efforts and strategies being implemented within Garissa Township by various stakeholders, including governmental agencies, NGOs, and community-based organizations. It seeks to explore these assumptions by examining the effectiveness, challenges, and limitations of these adaptation measures in mitigating climate risks and enhancing pastoralist livelihoods.

Mount Kenya University

1.12 Operational Definition of Terms

Adaptive Capacity: The ability to adjust practices, processes, and structures to mitigate the impacts of climate change, including the adoption of sustainable grazing practices, diversification of income sources, and mobility strategies.

Climate Change Approaches: Refer to strategies, actions, and interventions aimed at mitigating the adverse impacts of climate change and enhancing the resilience of pastoralist communities.

Climate Resilient Infrastructure: Includes systems and facilities designed to withstand and adapt to the impacts of climate variability and change**.**

Financial Capital: Availability of financial resources such as savings, credit, and insurance that help pastoralists manage risks and invest in adaptive strategies.

Food Security: Ensuring consistent access to sufficient, safe, and nutritious food, which is directly influenced by the health and productivity of livestock.

Human Capital: Skills, knowledge, health, and education of pastoralist communities that enable them to manage their livestock and adapt to changing environmental conditions.

Livelihood security: Refers to the sustained ability of pastoralist communities to maintain and improve their means of living despite the challenges posed by climate variability and change.

Natural Capital: Access to and quality of natural resources such as grazing lands, water sources, and biodiversity which are critical for livestock rearing.

Pastoralists: individuals who predominantly rely on the herding and raising of livestock as their primary source of livelihood. These livestock can include cattle, goats, sheep, camels among others

Physical Capital: Infrastructure such as housing, livestock shelters, roads, water storage, and veterinary services that support pastoral livelihoods.

Social Capital: Social networks, community organizations, and traditional institutions that provide support, share resources, and facilitate collective action.

Sustainable Livelihoods: Encompasses to livelihoods that are resilient, adaptive, and capable of withstanding long spells of climatic changed conditions.

Water Management: Means the planning, implementation, and optimization of strategies and practices aimed at ensuring reliable and sustainable access to water resources amidst climate variability and change**.**

Mount Kenya University

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This section consists of research gaps, theoretical review, empirical review, conceptual framework, and overview of the literature. The section was discussed and presented in relation to existing literature and the current study.

2.2 Empirical Review

This section presents empirical research conducted by experts concerning effects on climatical changes' approaches against security of pastoralists' livelihoods, particularly with regard to water management, climate resilient infrastructure, and diversification of livelihood.

2.2.1 Influence of Water Management on Livelihoods Security of Pastoralists

The disempowerment of pastoralist women in light of the limitations on their domestic water security was investigated by Balfour, Obando, and Deepali (2020). The study discovered anecdotal evidence suggesting that women who have many sources of income and social capital are less

susceptible to water stress. The purpose of the follow-up research was to identify variables that improve resilience for pastoralist communities that are at risk of drought and to present empirical data on the factors underlying water security. A mixed-approaches research strategy was employed in the study, combining quantitative and qualitative research methods, and it examined both urban and rural groups in Samburu County. A scale to measure household water insecurity was also tested as part of the study, which may help refine the process for evaluating shock-related stress in these high-risk groups. The results demonstrated acute water insecurity, particularly in rural regions, and supported the preceding study's finding that there is a strong correlation between social capital and water security. Although families with larger herds of cattle tended to be more water insecure than households with smaller herds, livelihood diversity did not appear to have an impact on water security. Women's reports that the extra work of providing water for cattle raised on their homesteads makes them more vulnerable to corroborate this.

Mfinanga, Bishibura, and Mdoe (2024) assessed the effect of livestock access to water on the household income of pastoralists in Tanzania's semi-arid Monduli District. As part of the cross-sectional research design of the study, primary data from 367 randomly selected households were gathered using a semi-structured questionnaire. Using the Statistical Package for Social Sciences (SPSS) version 20, quantitative data were analyzed, and both descriptive statistics were found. The study examined the impact of livestock access to water on pastoralists' household income using a multinomial logistic regression model. The results show that, while retaining a low degree of water availability for livestock as the reference group, pastoralists' household income was impacted by household size and levels of water access for livestock, particularly medium and high. According to this research’s findings, household income increases with livestock's degree of access to water. The Tanzanian government and the Monduli District Council are advised by this study to

implement initiatives aimed at increasing pastoralists' revenue through bettering community access to water sources for their livestock.

A study was conducted in the Eastern Kenyan districts of Mwingi and Kitui by Opiyo, Mureithi, and Kinuthia (2011). For five months, semi-structured questionnaires were utilized to gather data. Using topographical maps to assess each administrative sub-location, watering points were created using cluster sampling. Three ethnic groups make use of the region's resources: the Akamba, Oroma, and Somali. The distances that animal herds migrated from their home regions were influenced by the distribution of water throughout the dry season found here. Tremendous variations in the number of families and wells, ranging from five to eight homes on average per well, was noted. The largest numbers of camels and goats were found in the region, and they also wandered farther and received less watering. However, diseases, predators, and periodic droughts resulted in animal losses; the highest rates of births (44.8%) and deaths (6.0%) were among goats. The seasonal fluctuations in cattle paths and the importance and extensive usage of the range by these cultures were likely influenced by the availability of water during the dry season. Common rights of access therefore hold sway, even though the Akamba "well owner" is in charge of managing and organizing shallow wells. The research area's water limitations and property rights concerns restrict the resources' ability to be exploited for cattle production. In order to lessen poverty, this study emphasizes the necessity of combining better livestock and water management in the ASALs.

2.2.2 Influence of Climate Resilient Infrastructure on Livelihoods Security of Pastoralists

Assefa, Chalchisa, Tegegn, Niguse, and Gutu (2023) examined how resilient pastoralists and agro-pastoralists are to climate change-related risks in the Borana zone of the Oromia region in southern Ethiopia. Focus groups, expert group discussions, and firsthand observations were employed in

the study to collect qualitative data; a household survey was used to collect quantitative data. The numeric data were evaluated using descriptive statistics, and the qualitative data were examined using content analysis. The findings indicate that the main threats posed by climate change to the livelihoods of pastoralists and agro-pastoralists in the research area are increased temperatures, more frequent droughts, and decreased rainfall. Indicators such as a decrease in species dynamics at 95%, livestock loss at 95%, agro-pastoral land degradation at 95%, food at 100%, and animal feed or pasture at 99% showed the biggest consequences of climate-induced hazards on pastoral and agro-pastoral livelihood systems.

The Borena zone's average score on the climate resilience index was determined to be 0.328, meaning that 32.8% of the respondents are resilient. Of these, 16.3% are pastoralists and 41.7% are agro-pastoralists.

All of the results, meanwhile, fall short of the minimal threshold's scale (0.5 or 50%), suggesting that the households' means of subsistence and resilience are inadequate. When compared to other important resilience building blocks, the pastoralists' and agropastoral' insufficient access to basic services and adaptive capacity accounted for the largest portion of Borena's low resilience. However, it was discovered that pastoralists had less resilience to the two livelihood systems than agro-pastoralists [0.407]. Adaptability was found to have a positive and statistically significant impact on the resilience of pastoralists' and agro-pastoralists' livelihoods, in addition to climate factors, but household asset endowments had a negative and statistically significant impact at $P < 0.05$. Therefore, policymakers should concentrate on strengthening the resilience of agro-pastoral and pastoral livelihood systems and reducing the impact of climate threats. Furthermore, programs that focus on increasing rangeland production, diversifying revenue streams, improving water

availability, and providing accurate and timely early warning systems are essential to helping pastoral and agro-pastoral people build resilient livelihoods.

Muluken, Andries, and Melka (2018) looked into how pastoralists in Ethiopia's Southern Afar region adapted to climatic changes. Primary data at the household level was gathered through focus groups and questionnaire surveys. Using stratified random sampling, a total of 250 pastoral homes were sampled. Principal component analysis and descriptive statistics were used to analyze the collected data. By clustering families based on livelihood groups, gender, and district, a two-step modeling approach was used to determine the resilience of households to climate shocks and pressures. The findings demonstrated that agropastoral households fared better against shocks related to climate change than pastoralist households did. In addition, people in the Gewane district exhibited greater resilience than people in the Amibara district. Compared to households led by men, those headed by women were less resilient. Pastoralists' resilience to climate change and variability has been greatly increased through increasing irrigation crop farming, providing farm inputs, improving animal assets and productivity, creating social safety nets, and granting access to markets, financing, extension services, and education.

In the Indian Himalayas, Ritika, Atishaya, Vivek, and Chitra (2024) assessed the capacity of pastoralists and smallholders to modify their means of subsistence in response to climate change. Assimilation ability, autopoiesis, and cognitive capacity—the three resilience traits—were utilized to construct an index of livelihood resilience, which was subsequently measured using the entropy-TOPSIS technique. Indicators from a household survey of 289 randomly chosen respondents from the three districts of Garhwal Himalayas were used to assess the resilience traits. The findings demonstrated that smallholders were more resilient than pastoralists in terms of their means of subsistence. After they were established, pastoralists had improved living circumstances and

simpler access to necessities. The study's main conclusions included that in order to increase communities' resilience to climate change, public policy should give top emphasis to social inclusion, cooperative, informal forest-level organization, environmental awareness and conservation, and information accessibility.

2.2.3 Influence of Diversification of Livelihoods on the Livelihoods Security of Pastoralists

Gargule (2018) examined the socioeconomic variables affecting the diversification of pastoral income using data from rural households in three pastoral settlements in Isiolo County, northern Kenya. The study's main focus was on the patterns and variables influencing participation in non-pastoral income-earning activities (NPIs), such as novel family strategies and their implications for pastoral livestock production, with an emphasis on household reliance on livestock revenue. The findings indicate that mobility status and household demographic characteristics influence the amount and severity of non-performing assets (NPIs) in household incomes. According to the study's conclusion, the rise in NPIs that coincides with the production of pastoral livestock indicates the increasing significance of livelihood security, which is obtained from controlling the risks associated with that production as well as maximizing incentives for non-livestock livelihoods. This finding implies that, at least not as the principal source of income, NPIs in the study area do not replace pastoral livelihood.

In Ethiopia's Arero district of the Borena Zone and Rayitu district of the Bale Zone, Baro, Mesfin, and Mebratu (2023) investigated household poverty levels in connection to the factors that affect the depth of poverty in pastoral households and the impacts of adopting a diversified lifestyle. A multistage sampling approach was utilized in the study to select 396 families from the districts of Rayitu and Arero. The cost of basic necessities (CBN) technique was used to choose the study locations. As a result, 10,881.26 Birr was found to be the adult's annual absolute poverty threshold.

A total of 34.6% of the sample homes were deemed to be destitute based on the federal poverty line. The Foster-Greer-Thorbecke index results showed that the incidence, gap, and severity of poverty were 34.6, 9.28, and 3.62, respectively.

The Tobit model and the Multinomial Endogenous Switching model were the two econometric models employed in the research. The size of the home, the age of the household head, and the distance to the closest market all considerably raised the pastoral households' degrees of poverty, according to the findings of the Tobit logistic regression. The degree of poverty in pastoral families was considerably reduced by the quantity of cattle and the number of extension contacts as determined by the tropical livestock unit. However, the results of the multinomial endogenous switching regression model demonstrated that crop production and the adoption of non-farm activities jointly had a significant and diminishing influence on the poverty levels of pastoral households. Therefore, in order to reduce the rate of poverty among pastoral households in semi-arid regions, policies that support the diversification of livelihoods within pastoral communities are essential.

In order to support settled crop farming and non-agricultural alternatives as a strategy for livelihood recovery, Muhereza (2019) sought to explain why it is problematic for the majority of development interventions being carried out in Karamoja. This encourages diversification of sources of income for households that were formerly solely pastoral. Although diversification is a good idea, not all types of diversification are always advantageous, according to this study, which draws conclusions from a number of studies as well as a thorough analysis of secondary literature. Through an analysis of the options accessible to the targeted Karamojong households, this research makes the case that although diversification opportunities within non-livestock and non-crop-based firms are important, the majority of Karamoja households had relatively few of these

Mount Kenya University

options. The prospects for crop-based enterprise diversification, such as growing a variety of crops and processing along crop-based value chains that include food processing and alcohol brewing, were extremely limited for crop-based firms. Pastoralism's diversification is still the most prevalent and sustainable practice, while being more challenging to maintain in the current environment.

A thorough analysis of literature on capital livelihood and livelihood diversification techniques was carried out by Nusrat, Anoma, and Ammar in 2023. In order to determine livelihood diversification techniques, the study first determines the importance of livelihood capital. Subsequently, it assesses how livelihood diversification tactics contribute to the decline in rural poverty in developing countries. According to research, the primary factors influencing the assets of livelihood diversification strategies are financial, natural, and human resources. On the relationship between physical and social capital and livelihood diversification, however, not much research has been done. Adoption of livelihood diversification strategies was influenced by a number of characteristics, including market accessibility, education, family size, land holding size, agricultural expertise, formal funding availability, and participation in village organizations. Diversifying one's income has helped to reduce poverty by enhancing food security and nutrition, raising income levels, ensuring sustainable crop production, and reducing climate susceptibility. This study shows that improving accessibility of livelihood resources is necessary to boost economic growth and reduce rural poverty in emerging economies.

In order to identify the elements that lead to tourism participation as a revenue stream unrelated to livestock pastures, Rahat (2019) looked at the strategies of on-pasture income diversification in Kyrgyz pastoralist culture. Features of individual households are evaluated, together with regional (rayon) features related to diversification and factors such as the purportedly high rates of pasture

productivity loss. The results show that families' levels of income diversification differ depending on factors including the number of animals possessed, geographic differences, and whether or not a household is in charge of looking after the animals of others. Moreover, the research yielded no statistically significant findings that would suggest a correlation between a high awareness of pasture degradation and choosing non-livestock careers like tourism.

2.3 Theoretical Framework

This study was anchored on the theories that explain objectives of this study.

2.3.1 Livelihoods Adaptation Theory on Diversification of Livelihood

Livelihood adaptation theory does not have a singular founder or originator. Rather, it has emerged through the integration of concepts from sustainable livelihoods frameworks and adaptation theory, influenced by various scholars and practitioners in development studies and environmental sciences. contribute to understanding livelihood adaptation theory. Scoones (1998) is one of the scholars who contributed to the development of this theory.

This theory explores how households and communities adjust their livelihood strategies in response to environmental and socioeconomic changes, including climate change impacts. It examines adaptive capacities, coping strategies, and barriers to livelihood diversification, emphasizing the role of local knowledge, institutions, and social networks in facilitating or hindering adaptation efforts. Livelihood adaptation theory, particularly in the context of diversification of livelihoods, focuses on how households and communities adjust their income-generating activities in response to changing environmental, economic, and social conditions, including climate change impacts.

This theory provides a framework for understanding how households and communities diversify their livelihood strategies to respond to any change in conditions, including climatic variation

impacts. It emphasizes the importance of flexibility, resilience, and sustainable development in promoting diversified livelihoods as a pathway to enhancing adaptive capacity and improving livelihood outcomes in a dynamic and uncertain environment.

2.3.2 Resilience Theory on Water and Climate Resilient Infrastructure

Resilience theory has roots in the work of several influential scholars. While there isn't a single founder, one of the key figures who contributed significantly to the development of resilience theory is Holling (1973). Resilience theory in water management focuses on building adaptable ability and fortitude of water systems towards climatic changes impacts. It emphasizes enhancing the ability of water resources and infrastructure to withstand disturbances, recover quickly, and maintain functionality under changing climatic conditions. This theory underscores the importance of flexible and adaptive management strategies that anticipate and respond to uncertain climate futures. Resilience theory, when applied to climate resilient infrastructure, focuses on designing and implementing infrastructure systems that can withstand and adapt to the effects of climatic changes.

This theory provides a conceptual framework for designing and implementing water management and climate resilient infrastructure that can adapt to uncertain and changing climate conditions. It emphasizes adaptive capacity, robustness, flexibility, and sustainability to enhance the resilience of infrastructure systems and support sustainable development goals in a climate-altered world.

2.4 Conceptual Framework

A conceptual framework is an organized depiction of important ideas and how they relate to one another that directs the planning, execution, and interpretation of a study. The independent variable in this research was techniques related to climate change. Climate resilient infrastructure, water management, and livelihood diversification was used as the constructs to quantify this. The

security of pastoralists' livelihoods will serve as the study's dependent variable. Figure 1 illustrates the range of parameters that was used to measure this, including natural capital, physical capital, human and social capital, food security, financial capital, and adaptive ability.

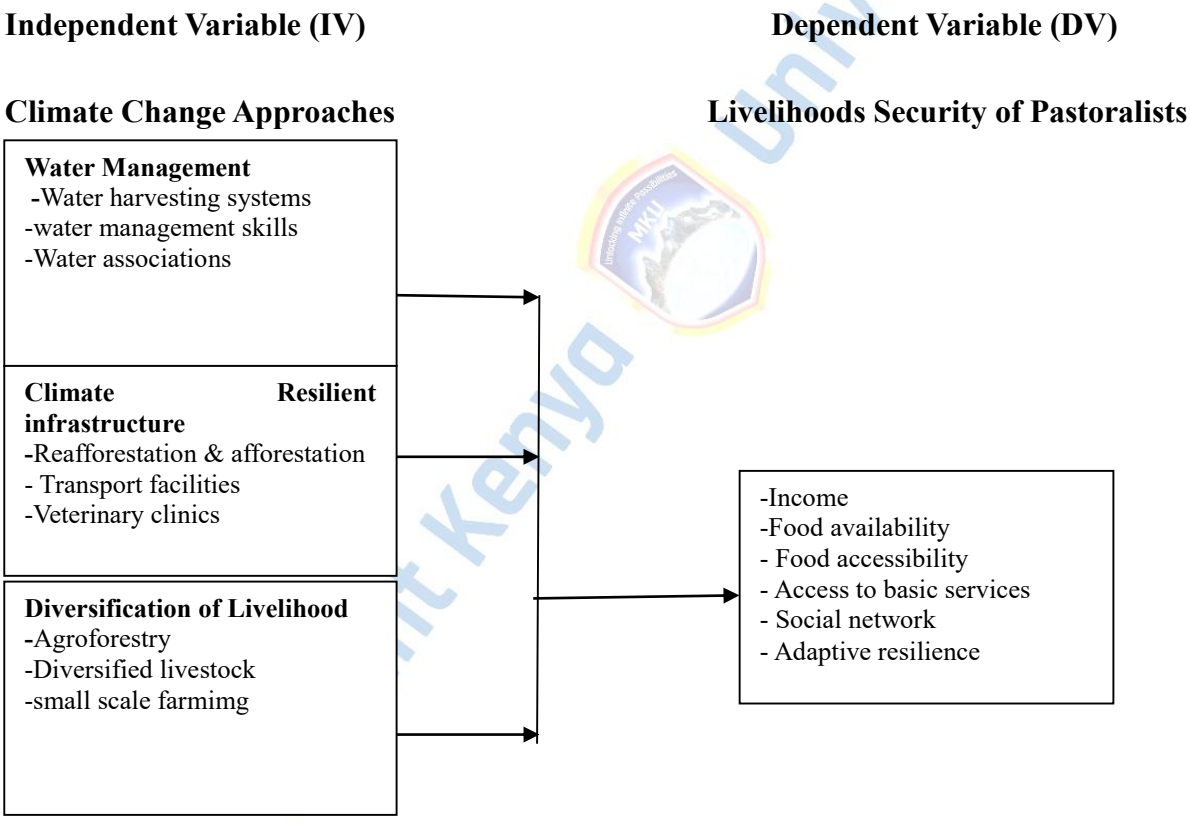


Figure 1 Conceptual Framework

Source: Researcher (2024)

Mount Kenya University

2.5 Research Gaps

A critical research gap in this context revolves around the lack of localized data on the efficacy of climate change adaptation strategies within Garissa Township. While general approaches like improved water management, climate-resilient infrastructure, and livelihood diversification are suggested, there's insufficient evidence on their specific impacts, acceptability, and scalability among pastoralist communities. Furthermore, the interplay between traditional practices and modern adaptation strategies remains underexplored. This study seeks to bridge this gap by providing detailed insights into how these approaches are perceived, experienced, and can be optimized to enhance the sustainability and resilience of pastoralist livelihoods against the adverse effects of climate change in this region. Through comprehensive field data and community engagement, the research aims to offer tailored recommendations that effectively address both environmental and socio-economic challenges.

2.6 Summary of Literature

Balfour, Obando, and Deepali (2020) investigated the disempowerment of pastoralist women due to limitations on their domestic water security. They found that women with multiple income sources and social capital are less susceptible to water stress. The study aimed to identify variables that improve resilience for pastoralist communities at risk of drought and present empirical data on water security factors. Results showed acute water insecurity, particularly in rural regions, and a strong correlation between social capital and water security. Livelihood diversity did not impact water security. Mfinanga, Bishibura, and Mdoe (2024) assessed the effect of livestock access to water on the household income of pastoralists in Tanzania's semi-arid Monduli District. The study found that household income increased with livestock's degree of access to water. Opiyo, Mureithi, and Kinuthia (2011) conducted a study in Eastern Kenyan districts of Mwingi and Kitui, focusing

on the distribution of water resources and the impact of diseases, predators, and droughts on animal herds. The study emphasizes the need for better livestock and water management to reduce poverty and improve resilience in pastoralist communities.

The study by Assefa, Chalchisa, Tegegn, Niguse, and Gutu (2023) found that climate change-related risks to pastoralists and agro-pastoralists in the Borana zone of southern Ethiopia are increased temperatures, more frequent droughts, and decreased rainfall. The Borena zone's average score on the climate resilience index was 0.328, with 32.8% of respondents being resilient. However, the results fall short of the minimal threshold, suggesting inadequate means of subsistence and resilience. Adaptability and household asset endowments were found to have a positive impact on resilience, but household asset endowments had a negative impact. Policymakers should focus on strengthening the resilience of agro-pastoral and pastoral livelihood systems and reducing the impact of climate threats. Programs focusing on increasing rangeland production, diversifying revenue streams, improving water availability, and providing accurate early warning systems are essential for helping pastoral and agro-pastoral people build resilient livelihoods. In the Indian Himalayas, Ritika, Atishaya, Vivek, and Chitra (2024) found that smallholders were more resilient than pastoralists in terms of their means of subsistence. To increase communities' resilience to climate change, public policy should prioritize social inclusion, cooperatives, informal forest-level organization, environmental awareness and conservation, and information accessibility.

Gargule (2018) studied the socioeconomic variables affecting the diversification of pastoral income in rural Kenya, focusing on patterns and variables influencing participation in non-pastoral income-earning activities (NPIs) and their implications for pastoral livestock production. The study found that mobility status and household demographic characteristics influence the amount

and severity of NPIs in household incomes. The rise in NPIs coincided with the production of pastoral livestock, indicating the increasing significance of livelihood security.

Baro, Mesfin, and Mebratu (2023) investigated household poverty levels in Ethiopia's Arero and Rayitu districts, finding that the Tobit logistic regression and multinomial endogenous switching model showed that the size of the home, the age of the household head, and the distance to the closest market significantly raised the degree of poverty in pastoral households. However, the multinomial endogenous switching regression model demonstrated that crop production and the adoption of non-farm activities jointly had a significant and diminishing influence on the poverty levels of pastoral households.

Mount Kenya University

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The chapter consists of research design, research approach, target population, sampling procedure and sample size, data collection methods, data analysis and research ethics.

3.2 Research Methodology

According to Creswell and Plano (2017), a research methodology can take the form of mixed, quantitative, or qualitative research methods. To test theories, spot trends, and measure the correlations between variables, quantitative research methods entail gathering and analyzing numerical data. This method is distinguished by the way it measures and generalizes findings through statistical analysis and structured research procedures. A qualitative research strategy is an investigative technique that uses non-numerical data—such as observations, interviews, and textual analysis—to gather and analyze information in order to better understand human behavior, experiences, and social phenomena. It aims to gain deep insights into people's thoughts, feelings, and motivations, as well as the meanings and interpretations they attach to their experiences. A mixed research approach, also known as mixed methods of research, is a methodology that combines both qualitative and quantitative research techniques within a single study to provide a more comprehensive understanding of a research problem.

Researchers can further investigate their study concerns by utilizing the advantages of both qualitative and quantitative data by combining these two methodologies. To evaluate how climate change approaches affect the security of livelihood for pastoralists, this study measured and collected both quantitative and qualitative data using mixed methods of research.

3.3 Research Design

According to Creswell (2014), a research design is a thorough plan or framework that outlines all of the procedures needed to carry out a research project, including methods and procedures for data collecting and analysis. This study used a correlational research design to ascertain the present relationship between approaches to climate change and the livelihood security of pastoralists.

This assisted the researcher in determining if the research variables are associated or not. In order to gain understanding of the pastoralists' opinions and perspectives regarding the research issues, the study employed a descriptive research design.

3.4 Location of the Study

The Garissa Township subcounty in Kenya's Garissa County was the site of this investigation. This location was specifically chosen since the region has been facing difficulties due to climatical variations, which has an impact on the livelihoods of the pastoral communities residing there. Garissa township faces significant climate change challenges affecting pastoral livelihoods. Located in a semi-arid region, it experiences frequent droughts and erratic rainfall patterns that threaten traditional pastoralism. Local communities struggle with water scarcity, degraded grazing lands, and forced adaptation of livestock practices, necessitating urgent mitigation strategies and livelihood diversification.

Mount Kenya University

3.5 Target Population

As indicated in Table 1, the target population for this study consisted of 7383 households that have been involved in pastoral activities in the Garissa Township sub county for the previous five years. The purposeful selection of these homes was based on their firsthand experience with the effects of climate change, which has equipped them with the knowledge needed to address study inquiries. The primary livestock in the area, kept by cattle, camels, sheep, and goats, has been purposefully taken into consideration in this study.

Table 1 Target Population

Livestock Category	
Cattle Keepers	
Sheep Keepers	

Mount Kenya University

Goat Kee pers	
Cam el Kee pers	
Total	

Source: KNBS (2019)

3.6 Sample size

In this study, a sample size of 379 was derived from a target population of 7383 using Yamane formula (1967) as shown below:

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

Where:

n = Sample size

N = Population Size

e = the level of precision desired/sampling error

n= $7383/1+7383(0.05)^2$

n= 379

The distribution of the sample was presented in Table 2.

Mount Kenya University

Table 2: Sample Size

Livestock Category	
Cattle Keepers	
Shepherds	

Mount Kenya University

pe

rs

G

oa

t

K

ee

pe

rs

C

a

m

el

K

ee

pe

rs

T

ot

al

Source: Researcher (2024)

Mount Kenya University

3.7 Sampling Procedure and Techniques

The stratified random sampling approach is methodologically sound for this pastoral community study. By categorizing households according to their primary livestock type (cattle, sheep, goats, or camels), the research acknowledges the heterogeneity of livelihood strategies within the population. This stratification ensures representation across all livestock-based livelihood systems, capturing the diversity of economic activities, risk management strategies, and cultural practices associated with different livestock specializations.

The proportional allocation from each stratum prevents overrepresentation of any single livestock group, which could otherwise skew results toward the experiences of more numerous or accessible populations. This approach aligns with Creswell's (2016) recommendations for maintaining research validity when studying heterogeneous populations.

The subsequent application of simple random sampling within each stratum eliminates selection bias and ensures that findings was generalizable to the broader population of each livestock group. This two-stage sampling process enhances both the representativeness and statistical power of the study, allowing for robust comparative analysis across different pastoral livelihood systems.

3.8 Data Collection Instruments

Semi-structured questionnaires given by the researcher to the respondents was used to garner primary data for this research. The questionnaire was selected as a convenient means of gathering data from a sizable research sample. Both closed-ended and open-ended items was included in the semi-structured questionnaire. The researchers was able to get quantifiable data by using closed-ended questions. The Likert scale used for these inquiries ranged from 1 to 5. unstructured questions was utilized in obtaining qualitative data from the respondents. Every family in the

Mount Kenya University

sample had a questionnaire filled out by the researcher and her research assistant. The study's objectives informed the structure of the questionnaire.

3.9 Piloting

The research equipment was put to the test through piloting. 38 responders, or 10% of the sample size, was included in this (Mugenda & Mugenda, 2003). Pastoral houses from Ijara South Sub County, which shares Garissa Township's climate change and pastoral activities, made up the study population for this project. Since they are not included in the study, the respondents that were used for this one did not take part in the final analysis. The researcher used the information from this approach to modify the research instruments so that they serve the intended objective.

3.9.1 Testing Validity

Validity is the extent to which a research instrument measures what it is intended to measure with accuracy (Creswell, 2014). In order to determine the extent to which the questionnaire measures the intended construct and to make sure it covers all relevant features of the construct being measured; content validity was employed. To guarantee that the questionnaire items are theoretically founded and support earlier research, a thorough study of the available literature was conducted. This improved the content validity of the questionnaire. Furthermore, a content validity assessment of the questionnaire was conducted by experts and supervisors.

Validity was increased by their input regarding item relevance, clarity, and appropriateness of the questionnaire items. The instruments' validity was tested using the Content Validity Index (CVI).

$$CVI = \frac{n}{N}$$

Where: n = number of items rated as relevant.
N = Total number of items.

The CVI was legitimate if it is higher than 0.70 that is the standard as a result the instrument was accurate.

3.9.2 Testing Reliability

Thus, a research instrument's reliability is its capacity to produce consistent results (Morling, 2022). It is vital to evaluate the reliability of survey instruments in research studies to guarantee that they consistently assess the specified constructs or variables. In ranges ranging from 0 to 1, Cronbach's Alpha Coefficient offers a general analysis of the tool. An instrument that has a coefficient value of 0.7 or higher is considered highly dependable. The same group of respondents will receive research instruments twice a week as part of this study (Test-Retest reliability). After that, a correlation between the two test results was used to determine the estimated coefficient of dependability. Subsequently, the questions underwent the required modifications to guarantee that the completed instruments furnish the intended data.

3.10 Data Collection Procedure

The researcher got certification from ERC committee before collecting primary data. The researcher then obtained from the postgraduate office the required and pertinent permission. Garissa County received an official letter of introduction asking for permission to conduct the study. Following the formal introduction, a schedule of subsequent meetings was established, together with details on when and how to provide the respondents with their questionnaires.

3.11 Data Analysis and Presentation

The methodical use of statistical techniques to assess, illustrate, and condense data is known as data analysis. The collected data was coded, sorted, and cleaned before data analysis. To evaluate quantitative data, both descriptive and inferential statistics was applied. Measures of dispersion, central tendency, frequencies, and percentages are all used in descriptive statistics. This made it easier for the researcher to evaluate the answers from every research goal. In order to determine

the nature and degree of the link between the independent and dependent variables, a simple liner regression analysis and the Pearson correlation coefficient was employed.

The extent to which changes in the independent variable explain changes in the dependent variable was analyzed using a multiple regression model. This was represented by the equation that follows:

$y = \alpha+\beta_1X_1+\beta_2X_2+\beta_3X_3+e$

Where:

y= Pastoralists' security of livelihood

X_1: Water management

X_2: Climate resilient infrastructure

X_3: Diversification of sources of income

e = Error of term

A significance level of 0.05 was used to test the null hypothesis. Thematic analysis was used to examine qualitative data. The researcher was able to find, examine, and present patterns—or themes—inside the qualitative data by using this method. The analyzed data was then shown using pertinent tables and figures.

3.12 Ethical consideration

Before beginning any activity, the researcher was allowed to work with the respondents with their informed consent. In order to obtain the respondents' agreement and desire to participate, the researcher made sure to fully explain to them the significance of accepting to engage in the study. As a result, the respondents won't feel compelled to answer the study questions. This was an elective action. In accordance with ethics, the researcher respected respondents' right to privacy and kept their information private at all times, even during employment.

In order to affect the respondents' expectations and attitude, the researcher made an effort to present herself with professionalism to them. In order to avoid using language that is discriminatory, the

researcher communicated with the respondent in a straightforward manner. The researcher obtained all necessary approvals before beginning the study.

CHAPTER FOUR

RESEARCH FINDINGS AND DISCUSSIONS

4.1 Introduction

This chapter presents the research findings and discussions. The chapter details the findings from the field with the order of a response rate, demographics and the findings per objective. The chapter also presents the regression analysis using the collected data. The purpose of the chapter presents the findings through showing the data analysis using tables and figures.

4.2 Response Rate

The study entailed a sample of 379 pastoralists in Garissa Township Sub-County, Kenya. The research administered 379 questionnaires but managed to collect 310 questionnaires. Of these,

Mount Kenya University

only 300 were duly filled and useable for data analysis. Thus a response rate of 70.2% as presented in Figure 2.

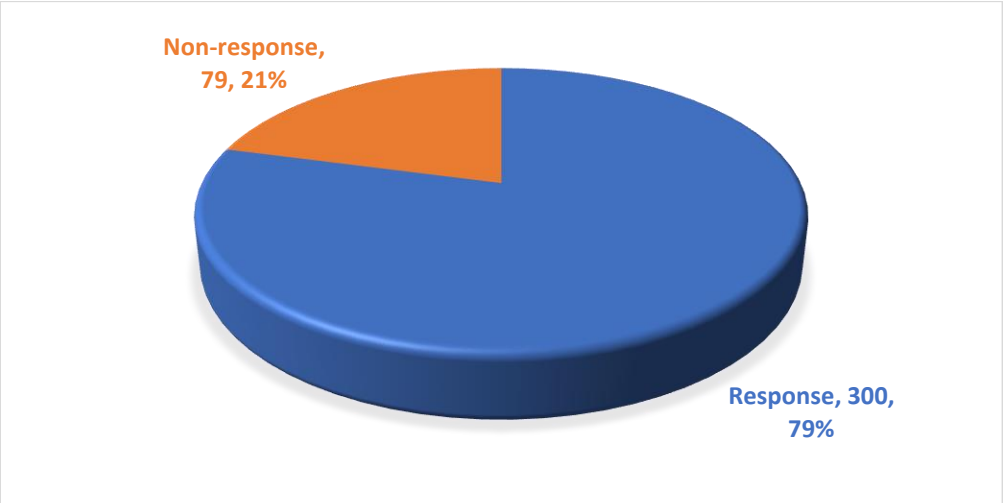


Figure 2 Response Rate

In social science research, response rates vary widely depending on the method of data collection, population characteristics, and study context. According to Babbie (2010), a response rate of 50% is generally considered adequate for analysis and reporting, 60% is good, and 70% or higher is very good. The 70.2% response rate in this study exceeds the "good" threshold and aligns with the "very good" category, suggesting that the data collected are sufficiently representative of the target population for drawing reliable conclusions about the influence of climate change mitigation approaches on livelihoods' security.

The original sample size of 379 was likely determined based on a power analysis or sampling formula (e.g., Yamane's formula or Cochran's formula) to ensure statistical significance for the population of pastoralists in Garissa Township Sub-County. With 300 usable responses, the study retains a robust sample size for conducting statistical analyses, such as the regression model relating livelihoods security to predictors like water management, climate-resilient infrastructure, and diversification. For a multiple regression with three predictors, a sample size of 300 exceeds

the rule of thumb of 10–20 observations per variable (e.g., 30–60 minimum), ensuring sufficient power to detect meaningful relationships and reducing the risk of Type II errors.

4.3 Demographics

ndents' characteristics are summarized as presented in Table 2.

Mount Kenya University

Table 2 Demographics

18–30 years	
31–40 years	

Table 2 shows the demographic profile of the respondents that provides valuable insights into the social context of pastoralism in Garissa Township Sub-County and its potential implications for livelihoods' security in the face of climate change mitigation approaches.

The Gender Distribution (70% Male, 30% Female) shows that the male-dominated sample aligns with traditional pastoralist communities in many semi-arid regions, where men typically take primary responsibility for livestock herding and decision-making. Women, while underrepresented in this sample, may play significant but less visible roles, such as managing household resources or engaging in supplementary income activities. The gender imbalance could imply that climate change mitigation strategies (e.g., water management or diversification) may need to be tailored to reach both men and women effectively, as their roles and vulnerabilities might differ.

Based on Age Distribution (40% aged 31–40, 35% above 40, 25% 18–30), the concentration of respondents in the 31–40 and above-40 age groups suggests a mature and experienced population, likely with deep knowledge of pastoralism and its challenges in a climate-stressed environment like Garissa. The smaller proportion of younger pastoralists (18–30 years) might indicate either a declining interest among youth in pastoralism—possibly due to climate-related risks or urban migration—or limited access to livestock ownership among younger individuals. This age profile suggests that mitigation approaches may need to account for the preferences and physical capacities of an older workforce while also engaging younger pastoralists to ensure sustainability.

Mount Kenya University

By Marital Status (70% Married, 20% Single, 6% Widowed, 4% Divorced/Separated), the high proportion of married respondents reflects a family-oriented community, where livelihoods' security likely extends beyond individual pastoralists to their dependents. This could amplify the stakes of climate change impacts, as droughts or resource scarcity might threaten not just the herders but entire households. Mitigation strategies like diversification of livelihoods could be particularly appealing to married respondents seeking to stabilize income for their families. The smaller percentages of widowed and divorced/separated individuals may indicate social vulnerabilities that could exacerbate insecurity in the face of climate shocks.

Regarding Duration of Pastoralism (55% 10+ years, 30% 5–9 years, 15% <4 years), the majority of respondents having over a decade of experience in pastoralism highlights a deep-rooted reliance on this livelihood, likely accompanied by traditional knowledge of coping with environmental variability. However, it also suggests that these pastoralists may be entrenched in practices that could be challenged by climate change, potentially making them resistant to or unfamiliar with new mitigation approaches like climate-resilient infrastructure or diversification. 15% with less than 4 years of experience might represent newcomers or younger individuals transitioning into pastoralism, who could be more adaptable to innovative strategies.

4.4 Livelihoods Security of Pastoralists in Garissa Township subcounty

Mount Kenya University

Table 3 Livelihoods Security of Pastoralists

Mount Kenya University

The findings, presented in Table 3, include mean scores and standard deviations for seven statements, offering insights into the perceived security of pastoralists in this semi-arid region. Below is a detailed description and analysis of these results.

Access to and Quality of Natural Resources (Mean = 2.6, SD = 1.2). The mean score of 2.6 indicates that respondents, on average, slightly disagree to are neutral about having adequate access to and quality of natural resources such as grazing lands, water sources, and biodiversity. The standard deviation of 1.2 suggests moderate variability in responses, reflecting differing experiences among pastoralists. This lukewarm perception likely stems from the critical role of water management in ensuring resource availability in a drought-prone area like Garissa, where overgrazing and water scarcity are persistent challenges.

For Access to Infrastructure (Mean = 2.4, SD = 1.1), with a mean of 2.4, respondents tend to disagree slightly that they have access to infrastructure such as housing, livestock shelters, roads, water storage, and veterinary services. The standard deviation of 1.1 indicates relatively consistent responses across the sample. This low score underscores the limited presence of climate-resilient infrastructure, which is vital for water management and livestock survival during extreme weather events.

About Skills, Knowledge, Health, and Education (Mean = 2.8, SD = 1.2), a mean score of 2.8 suggests that respondents are nearly neutral about possessing the skills, knowledge, health, and education needed to manage livestock and adapt to environmental changes. The standard deviation of 1.2 reflects some diversity in self-assessed capacity. This finding highlights a moderate level of adaptive capacity, potentially linked to traditional knowledge of water management, though formal education and health resources may be lacking.

Regarding Social Networks and Community Support (Mean = 3.1, SD = 1.3), the highest mean score of 3.1 indicates that respondents are neutral to slightly agree that social networks, community organizations, and traditional institutions provide support. The standard deviation of 1.3 suggests greater variability, possibly due to differences in community cohesion or access to support systems. This relatively higher score points to the importance of social capital in buffering the effects of poor water management and climate shocks.

About Access to Financial Resources (Mean = 2.3, SD = 1.1), with a mean of 2.3, respondents slightly disagree that they have access to financial resources like savings, credit, and insurance to manage risks. The standard Ascough standard deviation of 1.1 shows consistent perceptions of financial insecurity. This is the lowest score in the table, signaling a significant vulnerability in livelihoods security, as financial resources are crucial for investing in water management solutions like boreholes or rainwater harvesting systems.

Regarding Ability to Adjust Practices (Mean = 2.7, SD = 1.2), a mean of 2.7 indicates a near-neutral stance on the ability to adjust practices, processes, and structures to mitigate climate change impacts. The standard deviation of 1.2 reflects moderate variation, suggesting that while some pastoralists may adapt (e.g., through mobility or water conservation), others struggle, possibly due to resource constraints.

On Consistent Access to Food (Mean = 2.5, SD = 1.1), the mean score of 2.5 shows slight disagreement to neutrality regarding consistent access to sufficient, safe, and nutritious food. The standard deviation of 1.1 indicates relatively uniform responses. This finding ties closely to water management, as water availability directly affects livestock productivity and food security in pastoralist systems.

Mount Kenya University

The mean scores in Table 3, ranging from 2.3 to 3.1, collectively suggest that pastoralists in Garissa Township Sub-County perceive their livelihoods security as generally low to moderate. The consistently low scores (below 3.0) for most statements—except social networks—reflect significant challenges in accessing resources and adapting to climate change, with water management emerging as a critical linchpin. The slightly higher score for social networks (3.1) indicates that community support may serve as a key resilience factor, compensating somewhat for deficits in physical and financial resources. The standard deviations (1.1–1.3) suggest moderate heterogeneity, likely reflecting variations in geographic location, herd size, or access to external aid.

The low scores for natural resources (2.6) and infrastructure (2.4) align with the semi-arid context of Garissa, where water scarcity and poor infrastructure exacerbate vulnerability to climate change (Adan & Mburu, 2016). The financial resources score (2.3) highlights a critical gap, as lack of capital limits investments in water management technologies, a finding consistent with studies on pastoralist economies (Little et al., 2008). The neutral scores for adaptive capacity (2.7) and skills (2.8) suggest that while traditional knowledge exists, it may not fully equip pastoralists for intensifying climate pressures, echoing calls for capacity-building in climate adaptation (Ouma et al., 2017).

These findings resonate with existing research on pastoralist livelihoods in East Africa. For instance, McPeak and Little (2005) argue that water availability is a primary determinant of pastoralist resilience, and the mean score of 2.6 for natural resources supports this, indicating that inadequate water management undermines access to grazing and biodiversity. Similarly, the low infrastructure score (2.4) aligns with Nori et al. (2008), who note that underdeveloped

infrastructure in pastoralist regions hampers climate adaptation, particularly for water storage and livestock health.

The relatively higher score for social networks (3.1) corroborates studies emphasizing the role of social capital in pastoralist systems (e.g., Scoones, 1998), where communal resource-sharing and traditional institutions mitigate individual vulnerabilities. However, the low financial resources score (2.3) reflects a broader trend identified by Oba and Lusigi (2002), where limited access to credit and insurance restricts pastoralists' ability to invest in water management innovations, perpetuating a cycle of poverty and insecurity.

The food security score (2.5) ties directly to water management, as water scarcity reduces livestock yields and dietary diversity, a linkage well-documented in arid regions (Thornton et al., 2009). Overall, these results suggest that while social networks provide some buffer, the overarching constraints—poor water management, infrastructure deficits, and financial insecurity—limit livelihoods security, reinforcing the need for targeted climate change mitigation strategies.

The findings underscore the urgency of improving water management as a cornerstone of livelihoods security in Garissa. Investments in water infrastructure (e.g., boreholes, dams) and financial mechanisms (e.g., microcredit, insurance) could address the lowest-scoring domains. The moderate adaptive capacity (2.7) and skills (2.8) scores suggest potential for extension services to build on existing knowledge. Future research could explore why social networks score higher and how they can be leveraged to enhance water management initiatives.

4.5 Influence of Water Management on Livelihoods Security in Garissa Township subcounty

t

h

a

t

Table 4 Influence of Water Management on Livelihoods Security

Table 4, include mean scores and standard deviations, providing a quantitative snapshot of pastoralists' perceptions in this semi-arid region. Below is a detailed description and analysis of these findings.

Adequate Water Harvesting Facilities in Animal Sites (Mean = 2.3, SD = 1.1) With a mean score of 2.3, respondents slightly disagree that there are adequate water harvesting facilities (e.g., rainwater collection systems) at animal sites. The standard deviation of 1.1 indicates relatively consistent perceptions across the sample. This low score suggests limited infrastructure for capturing and storing water, a critical need in a drought-prone area like Garissa.

Adequate Boreholes in Place (Mean = 2.5, SD = 1.2); A mean of 2.5 reflects a slight disagreement to neutral stance on the adequacy of boreholes. The standard deviation of 1.2 shows moderate variability, possibly due to uneven distribution or functionality of boreholes across the sub-county.

This suggests that while some boreholes may exist, they are insufficient or unreliable for meeting livestock and household water needs.

For Adequate Water Purification Facilities (Mean = 2.1, SD = 1.0), the lowest mean score of 2.1 indicates that respondents generally disagree that adequate water purification facilities are available. The standard deviation of 1.0 suggests high agreement among respondents on this deficiency. This points to a significant gap in ensuring safe water, increasing risks of waterborne diseases for both humans and livestock.

Regarding Sufficient Water Sanitation Measures (Mean = 2.4, SD = 1.1), a mean of 2.4 shows slight disagreement regarding sufficient water sanitation measures to reduce contamination. The standard deviation of 1.1 reflects consistent responses. This finding highlights challenges in maintaining water quality, likely exacerbating health and productivity issues in pastoralist communities.

About Construction of Water Points (Mean = 2.6, SD = 1.2), with a mean of 2.6, respondents are nearly neutral about the presence of constructed water points like troughs, tanks, and pumps for reliable livestock water access. The standard deviation of 1.2 indicates moderate variation, suggesting that some areas may have better infrastructure than others. This score reflects partial progress but insufficient coverage or maintenance.

On Establishment and Strengthening of Water Associations (Mean = 2.8, SD = 1.3), the highest mean score of 2.8 indicates a near-neutral perception of whether water associations have been established and strengthened to manage resources collectively. The standard deviation of 1.3, the highest in the table, suggests greater variability, possibly reflecting differences in community organization or effectiveness of these associations. This relatively higher score hints at some level of collective action, though not fully robust.

For Training on Water Management Practices (Mean = 2.7, SD = 1.2), a mean of 2.7 shows a neutral stance on whether communities receive training on water management and sustainable use. The standard deviation of 1.2 indicates moderate diversity in responses, likely due to uneven access to training programs. This suggests that while some capacity-building efforts may exist, they are not widespread or impactful enough.

The mean scores in Table 4, ranging from 2.1 to 2.8, collectively suggest that pastoralists in Garissa Township Sub-County perceive water management as inadequate to moderately adequate in supporting their livelihoods security. All scores fall below the midpoint of 3.0, indicating a general dissatisfaction with water-related infrastructure, services, and support systems. The lowest score (2.1) for water purification facilities underscores a critical vulnerability, while the highest score (2.8) for water associations suggests that social organization offers some mitigation, albeit limited. The standard deviations (1.0–1.3) reflect moderate to high consistency in perceptions, with slightly more variability for organizational and training aspects, possibly due to localized differences in implementation.

These findings highlight water management as a weak link in livelihoods security, consistent with the semi-arid context of Garissa, where water scarcity and quality are perennial challenges. The low scores for physical infrastructure (e.g., harvesting facilities, boreholes, purification) indicate that investments in water systems lag behind the needs of pastoralists, threatening livestock survival and household resilience. The slightly higher scores for water associations (2.8) and training (2.7) suggest that human and social capital provide some buffer, but their impact is constrained by the lack of supporting infrastructure.

Mount Kenya University

Through an open-ended item, the respodnets were asked this question “In your opinion, what can be done to ensure proper water resource management in the pastoral communities? Two random respondents noted;

> Me, I think the government and the people helping us need to build more boreholes and make sure they don’t break down all the time. Here in Garissa, we wait too long for water when the rain fails, and the few boreholes we have are far or spoiled. They should also give us tanks to catch rain when it comes, because now we lose so much water. Another thing, they should teach us how to keep the water clean—I see my animals get sick from dirty water, and even my children sometimes. If we had a group to look after the water points, like a committee, we could make rules and stop fighting over it. That’s what I think can work (R 01).

R 02 wrote;

> For me, I say we need more help to manage water better in this place. The leaders should bring us dams or big tanks near where we graze, so we don’t walk far with the animals. Right now, the water we get is not enough, and sometimes it’s bad—my goats died last dry season because of that. They should also train us women, because we fetch water for the house, and we can learn how to save it or clean it. I hear about water groups in other places, so if we had one here, maybe we could share the work and fix things together. That’s my opinion on what can be done (R 02).

R 01, an older male with extensive pastoralism experience, emphasizes practical infrastructure solutions like boreholes and rainwater harvesting tanks, reflecting the low scores in Table 4 for "adequate boreholes" (2.5) and "water harvesting facilities" (2.3). His maintenance ("don’t break down all the time") addresses the reliability issue implied by the neutral score for water points (2.6). The call for training on water purification aligns with the low score for "water purification facilities" (2.1), showing awareness of health risks. His suggestion of a community committee ties to the slightly higher score for "water associations" (2.8), indicating a belief in collective management as a feasible step forward.

Mount Kenya University

R 02, a younger female with less experience, focuses on proximity and accessibility of water sources (dams or tanks), echoing the Table 4 finding that water infrastructure is inadequate (e.g., 2.4 for sanitation measures). Her mention of livestock losses due to poor water quality connects to the low purification score (2.1), highlighting its impact on livelihoods. Her request for training, especially for women, aligns with the neutral score for "training on water management practices" (2.7) and suggests a gender-sensitive approach not fully captured in the data. Her reference to water groups reinforces the potential of social organization (2.8), proposing it as a way to share responsibilities.

Both responses are grounded in the semi-arid realities of Garissa, where water scarcity and poor infrastructure (as seen in Table 4) threaten pastoralist livelihoods. R 01's emphasis on durability and community governance reflects a seasoned perspective, while R 02's focus on accessibility and women's involvement highlights household-level concerns. Together, they propose a mix of physical (infrastructure) and social (training, association) solutions, consistent with the study's broader findings and theoretical frameworks like Resilience Theory (infrastructure focus) and Livelihoods Adaptation Theory (community capacity).

These results align with and extend existing research on water management and pastoralist livelihoods in East Africa. The low scores for water harvesting (2.3) and boreholes (2.5) corroborate McPeak and Little (2005), who argue that inadequate water infrastructure is a primary constraint on pastoralist resilience in arid regions. In Garissa, where rainfall is erratic, the absence of sufficient harvesting facilities limits the ability to store water during wet periods, a challenge also noted by Oba (2013) in Kenyan drylands.

The particularly low score for water purification facilities (2.1) and sanitation measures (2.4) reflects a broader issue identified by Thornton et al. (2009), who link poor water quality in

pastoralist areas to reduced livestock productivity and human health risks. This finding suggests that climate change mitigation strategies must prioritize not just water quantity but also quality to enhance livelihoods security.

The moderate score for water points (2.6) aligns with Nori et al. (2008), who emphasize that while some water infrastructure exists in pastoralist regions, its distribution and maintenance are often inadequate. The neutral scores for water associations (2.8) and training (2.7) resonate with Scoones (1998), who highlights the role of social capital and knowledge in adapting to environmental stress. However, the modest ratings here indicate that these soft interventions are not yet fully effective, possibly due to limited resources or outreach, as noted by Ouma et al. (2017) in their study of Kenyan pastoralists.

Overall, the findings underscore a gap between the potential of water management to bolster livelihoods security and its current implementation in Garissa. This mirrors broader literature on climate adaptation in pastoral systems, where structural deficits often outweigh community-level efforts (Adan & Mburu, 2016).

The results suggest that water management interventions in Garissa Township Sub-County should prioritize expanding and maintaining physical infrastructure—such as boreholes, water harvesting systems, and purification facilities—to address the lowest-scoring areas. The moderate scores for associations and training indicate potential for scaling up community-based management and capacity-building, leveraging existing social structures. Policymakers could integrate these findings into climate resilience programs, ensuring that investments target both hardware (infrastructure) and software (training, governance).

For future research, exploring the variability in responses (e.g., why water associations score higher) could reveal the best practices in community organization. Additionally, correlating these

perceptions with objective water availability data could validate the Likert-scale findings and refine intervention strategies.

4.5.1 Theoretical Implications of the findings on Influence of Water Management on Livelihoods Security

The results in Table 4 indirectly reflect the challenges pastoralists face in leveraging water management to support livelihood diversification, a key adaptation strategy. The low mean scores for physical water infrastructure—such as water harvesting facilities (2.3), boreholes (2.5), and water points (2.6)—suggest that the natural and physical asset base required for diversification is weak. In Garissa, where water is a prerequisite for both livestock (the traditional livelihood) and alternative activities like small-scale irrigation farming, these deficiencies limit adaptation options. For instance, without reliable boreholes or water points, pastoralists cannot easily transition to agro-pastoralism, a common diversification strategy in semi-arid regions (Little et al., 2008).

The slightly higher score for water associations (2.8) aligns with the theory's emphasis on social capital as an asset for adaptation. Collective management of water resources could facilitate shared investments in diversification (e.g., communal irrigation schemes), but the modest rating indicates that this social asset is not fully developed or effective. Similarly, the neutral score for training on water management practices (2.7) suggests that human capital—knowledge and skills—is present but insufficient to drive widespread diversification. Pastoralists may understand sustainable water use conceptually yet lack the practical tools or resources to apply this knowledge to new livelihoods.

From the perspective of Livelihoods Adaptation Theory, the findings indicate that water management constraints hinder diversification, locking pastoralists into a vulnerable, livestock-dependent livelihood. Ellis (2000) argues that diversification requires enabling conditions, such as

secure access to water, which the low scores (2.1–2.6) for infrastructure and sanitation suggest are absent. This perpetuates a cycle of insecurity, as pastoralists cannot mitigate climate risks through alternative income sources. The theory implies that improving water management—e.g., through more boreholes or purification facilities—could unlock diversification potential, enhancing livelihoods security by providing the resource base for activities beyond pastoralism.

The results in Table 4 directly relate to Resilience Theory by highlighting the limited robustness of water-related infrastructure in Garissa Township Sub-County. The low mean scores for water harvesting facilities (2.3), boreholes (2.5), purification facilities (2.1), and sanitation measures (2.4) indicate that the physical infrastructure is not sufficiently resilient to support pastoralists during climate shocks. In a region prone to prolonged droughts, these deficiencies undermine the system's ability to absorb water scarcity, as evidenced by the slight disagreement that water points (2.6) provide reliable access for livestock. This suggests that the current infrastructure lacks the durability and coverage needed to maintain livelihoods security under climate stress.

The neutral scores for water associations (2.8) and training (2.7) reflect elements of adaptive capacity within Resilience Theory. Water associations represent a governance mechanism that could enhance resilience by fostering collective resource management, while training builds human capacity to adapt water use practices. However, their modest ratings suggest that these adaptive components are underdeveloped, limiting their effectiveness in strengthening system resilience. The standard deviations (1.0–1.3) indicate some variability, possibly reflecting localized resilience where certain communities have better access to infrastructure or training, but this is not widespread.

Mount Kenya University

From a Resilience Theory perspective, the findings reveal a fragile socio-ecological system in Garissa, where weak water management infrastructure reduces the capacity to withstand climate disturbances. Folke et al. (2004) argue that resilience depends on infrastructure that can store and deliver resources during crises, yet the scores below 3.0 suggest that Garissa's pastoralists lack this buffer. The low score for purification facilities (2.1) is particularly concerning, as contaminated water could amplify health shocks, further eroding resilience. The theory implies that enhancing climate-resilient infrastructure — e.g., drought-resistant boreholes or scalable water harvesting—could shift the system toward greater stability, enabling pastoralists to recover from and adapt to climate variability.

These results align with Thornton et al. (2009), who link resilient water infrastructure to livestock survival in East African pastoral systems, noting that its absence heightens vulnerability to drought. Similarly, Nori et al. (2008) emphasize that climate-resilient infrastructure is critical for maintaining pastoralist livelihoods, a goal unmet in Garissa given the low ratings. The modest scores for associations and training echo Adan and Mburu (2016), who suggest that while social and human capital contribute to resilience, their impact is curtailed without robust physical systems.

4.6 Influence of Climate Resilient Infrastructure on Livelihoods Security in Garissa Township subcounty

Table 5 Influence of Climate Resilient Infrastructure on Livelihoods Security

Mount Kenya University

Table 5 include mean scores and standard deviations, offering insights into the perceived adequacy of infrastructure in supporting pastoralists against climate challenges. Below is a detailed description and analysis of these findings. Adequate Robust Shelters for Livestock (Mean = 2.2, SD = 1.1) with a mean score of 2.2, respondents slightly disagree that there are adequate robust shelters to protect livestock from extreme weather conditions, such as droughts or floods. The standard deviation of 1.1 indicates moderate consistency in responses. This low score suggests a significant gap in infrastructure designed to shield livestock from climate shocks, a critical need in Garissa's semi-arid environment.

Transport Facilities for Livestock Movement (Mean = 2.4, SD = 1.2) with a mean of 2.4 reflects slight disagreement to a neutral stance on the establishment of transport facilities enabling pastoralists to move livestock to markets or safer areas during adverse weather. The standard deviation of 1.2 shows moderate variability, possibly due to uneven access to roads or transport services across the sub-county. This indicates limited mobility infrastructure, hindering adaptive strategies like relocation during droughts.

Solar and Wind Energy Systems (Mean = 2.1, SD = 1.0) had the mean score of 2.1, the second lowest in the table, suggesting that respondents generally disagree that solar and wind energy systems have been implemented to provide reliable, sustainable power. The standard deviation of

1.0 indicates high agreement on this deficiency. This points to a lack of renewable energy infrastructure, which could support water pumping or veterinary services in remote areas.

Veterinary Clinics and Mobile Units (Mean = 2.6, SD = 1.2) with a mean of 2.6, the highest in the table, respondents are nearly neutral about the establishment of veterinary clinics and mobile units for timely livestock healthcare. The standard deviation of 1.2 reflects moderate variation, suggesting some pastoralists may have better access than others. This score indicates partial progress in health infrastructure, though it remains insufficient for widespread impact.

Fodder Storage Facilities (Mean = 2.3, SD = 1.1) had a mean of 2.3 shows slight disagreement that facilities for storing fodder have been built to ensure a consistent supply during dry periods. The standard deviation of 1.1 suggests relatively uniform perceptions. This low score highlights a vulnerability in feed security, critical for livestock survival during Garissa's frequent droughts.

Reforestation and Afforestation Projects (Mean = 2.0, SD = 0.9) had the lowest mean score of 2.0 indicates general disagreement that reforestation and afforestation projects have been implemented to enhance biodiversity and provide additional fodder sources. The standard deviation of 0.9, the smallest in the table, reflects a strong consensus on this absence. This suggests minimal environmental infrastructure to support long-term resilience.

The mean scores in Table 5, ranging from 2.0 to 2.6, collectively indicate that pastoralists in Garissa Township Sub-County perceive climate-resilient infrastructure as largely inadequate for securing their livelihoods. All scores fall below the neutral midpoint of 3.0, reflecting dissatisfaction with the infrastructure's ability to mitigate climate risks. The lowest scores—reforestation/afforestation (2.0) and solar/wind energy (2.1)—highlight critical gaps in environmental and energy infrastructure, while the highest score for veterinary services (2.6) suggests slightly better, though still limited, progress in health support. The standard deviations

(0.9–1.2) show moderate consistency, with slight variability for transport and veterinary services, possibly due to geographic or resource disparities.

These findings underscore the vulnerability of pastoralists to climate change in Garissa, where infrastructure deficits exacerbate the impacts of extreme weather. The low scores for shelters (2.2) and fodder storage (2.3) indicate that livestock, the backbone of pastoralist livelihoods, lack protection and sustenance during droughts, aligning with the semi-arid region's climatic challenges. The modest rating for veterinary services (2.6) suggests some adaptive capacity, but the overall picture is one of fragility, with infrastructure failing to buffer against environmental shocks.

In an open-ended item, the respondents were asked "In your opinion, what can be done to ensure erratic climate changes don't disadvantage pastoralists?" The respondents wrote the following;

R 04 (Male, 38 years old, 12 years of pastoralism experience) wrote:

> Me, I say the government needs to help us build strong sheds for our animals, because when the sun is too hot or the floods come, my goats and cows suffer—many die. They should also fix the roads so we can move the animals to better places when the drought hits hard, not just stay here and lose everything. Another thing, we need more boreholes that work, not the ones that dry up or break, because water is life for us. If they give us training on how to keep fodder for the dry times, that will help too. Right now, this weather up and down is killing us, so they must act fast (R 04)

In another response R 06 (Female, 50 years old, 20 years of pastoralism experience) wrote;

> For me, I think we need big changes to stop this crazy weather from hurting us pastoralists. They should plant trees around here—there's too much bare land, and it makes the heat worse, no grass for my animals. Also, we need tanks to store water when it rains, because now it just runs off and then we're dry again. The leaders should bring vets closer to us, not far away, so our animals don't die from sickness when the weather changes. And maybe give us some money or loans to start small businesses, so we don't only depend on animals when the climate goes bad. That's what I see can help us (R 06).

R 04, a middle-aged male with over a decade of experience, focuses on practical infrastructure and mobility solutions, reflecting the low scores in Table 5 for "robust shelters" (2.2) and "transport facilities" (2.4). His call for strong sheds and better roads directly addresses the lack of climate-resilient infrastructure to protect livestock and enable relocation during extreme weather, key vulnerabilities in Garissa. The mention of reliable boreholes ties to Table 4's findings (e.g., 2.5 for "adequate boreholes"), emphasizing water's role in surviving erratic climate shifts. His suggestion of fodder storage training aligns with Table 5's low score (2.3) for "fodder storage facilities," showing awareness of feed insecurity as a climate-related disadvantage.

R 06, an older female with extensive experience, offers a mix of ecological, infrastructural, and economic solutions, drawing on a broader view of livelihoods security. Her call for reforestation reflects Table 5's lowest score (2.0) for "reforestation and afforestation projects," recognizing how environmental degradation exacerbates climate impacts like heat and fodder scarcity. The request for water storage tanks connects to Table 4's "water harvesting facilities" (2.3), addressing the challenge of erratic rainfall. Her emphasis on accessible veterinary services mirrors Table 5's modest score (2.6) for "veterinary clinics," while the suggestion of loans for small businesses hints at diversification, a strategy constrained by infrastructure deficits in both tables.

Both responses are grounded in Garissa's semi-arid, climate-stressed context, where erratic weather—droughts, floods, and heat—threatens pastoralist livelihoods. R 04's focus on immediate, livestock-centric solutions reflects a male pastoralist's operational concerns, consistent with the study's 70% male sample and Table 5's infrastructure gaps. R 06's broader perspective, including ecological restoration and economic diversification, aligns with her longer experience and possibly a female viewpoint on household resilience, echoing the need for adaptive capacity

noted in the study's theoretical frameworks (Livelihoods Adaptation Theory and Resilience Theory). Together, they propose a blend of resilience-building infrastructure (shelters, water tanks, vets) and adaptive strategies (training, diversification), directly addressing the disadvantages of climate variability.

Botn the quantitative and qualitative results resonate with and extend existing research on climate-resilient infrastructure and pastoralist livelihoods in East Africa, particularly within the framework of Resilience Theory (Holling, 1973; Folke et al., 2004), which emphasizes robust systems to absorb disturbances.

The low score for robust shelters (2.2) aligns with Thornton et al. (2009), who note that inadequate livestock protection infrastructure in arid regions increases mortality during extreme weather, undermining resilience. Similarly, the limited transport facilities (2.4) echo Nori et al. (2008), who argue that poor mobility infrastructure restricts pastoralists' ability to adapt by relocating herds, a key resilience strategy in variable climates. The near-absence of solar and wind energy systems (2.1) supports Adan and Mburu (2016), who highlight the underutilization of renewable energy in Kenyan pastoral areas, despite its potential to power water pumps and veterinary facilities, enhancing system stability.

The slightly higher score for veterinary clinics and mobile units (2.6) aligns with Ouma et al. (2017), who emphasize that health infrastructure bolsters resilience by reducing livestock losses, though the modest rating here suggests incomplete coverage, consistent with their findings on uneven service distribution. The low score for fodder storage (2.3) corroborates McPeak and Little (2005), who link feed insecurity to drought vulnerability in East African pastoral systems, noting that storage facilities are critical for maintaining livelihoods during dry spells.

Mount Kenya University

The starkly low score for reforestation and afforestation (2.0) reflects a broader trend identified by Oba (2013), who argues that environmental degradation in pastoral regions—exacerbated by limited reforestation—reduces biodiversity and fodder availability, weakening long-term resilience. This finding underscores a missed opportunity to integrate ecological infrastructure into climate adaptation, as advocated by Scoones (1998) in the Sustainable Livelihoods Framework, which connects environmental assets to security.

Overall, the findings suggest that Garissa's pastoralists operate in a socio-ecological system with low resilience, as defined by Folke et al. (2004), due to inadequate climate-resilient infrastructure. The literature implies that without robust shelters, transport, energy, and ecological measures, pastoralists cannot effectively absorb or adapt to climate shocks, perpetuating insecurity.

The results call for targeted investments in climate-resilient infrastructure to enhance livelihoods security in Garissa. Prioritizing robust shelters, fodder storage, and veterinary services could address immediate vulnerabilities, while transport and renewable energy systems would improve adaptive capacity. Reforestation projects, scoring lowest, warrant urgent attention to restore ecological resilience and diversify fodder sources. Policymakers could draw on successful models, such as mobile veterinary units in northern Kenya (Ouma et al., 2017), scaling them to Garissa.

Future research could explore why veterinary services score higher, identifying best practices for replication, and investigate barriers to reforestation, such as land tenure or funding. Linking these perceptions to objective infrastructure data (e.g., number of shelters) could further validate the findings and refine intervention strategies.

Mount Kenya University

4.6.1 Theoretical Implications of the findings on Influence of Climate Resilient Infrastructure on Livelihoods Security

The consistently low mean scores in Table 5 (2.0–2.6) for climate-resilient infrastructure—such as shelters (2.2), transport facilities (2.4), fodder storage (2.3), and reforestation (2.0)—suggest that pastoralists in Garissa lack the physical asset base necessary for diversification. For instance, the absence of robust shelters and fodder storage limits livestock survival during droughts, reducing the resources (e.g., healthy herds) pastoralists could leverage to transition into alternative livelihoods like agro-pastoralism or livestock trading. Similarly, the low score for transport facilities (2.4) indicates restricted market access, hindering income diversification through sales—a strategy Ellis (2000) identifies as critical for adaptation in pastoral systems.

The minimal presence of solar and wind energy systems (2.1) further constrains diversification by limiting power for small enterprises (e.g., milk processing or trade), while the low score for reforestation (2.0) suggests missed opportunities to diversify into fodder production or agroforestry. Even the relatively higher score for veterinary services (2.6) remains below neutral, implying that livestock health—an asset for diversification into commercial herding—is not adequately supported.

These findings imply that Livelihoods Adaptation Theory's assumption of asset availability as a driver of diversification does not fully hold in Garissa. The theory posits that access to infrastructure enables households to adapt by reallocating resources across livelihoods, but the data reveal a structural bottleneck: without climate-resilient infrastructure, pastoralists remain locked in a single, climate-sensitive livelihood (pastoralism). This challenges the theory's optimism about adaptive capacity in resource-scarce contexts, suggesting that external

Mount Kenya University

interventions (e.g., infrastructure development) are prerequisites for diversification, rather than an outcome of endogenous asset use, as Scoones (1998) might suggest.

The results align with Little et al. (2008), who argue that diversification in East African pastoralism requires secure physical assets yet extend this by showing how climate-specific infrastructure deficits (e.g., fodder storage, transport) amplify vulnerability. This implies a need to refine the theory to account for climate change as a multiplier of asset scarcity, limiting adaptive pathways.

Resilience Theory, applied to socio-ecological systems (Holling, 1973; Folke et al., 2004), defines resilience as the capacity to absorb disturbances, adapt, and maintain function amid shocks like climate change. Climate-resilient infrastructure—such as shelters, veterinary services, and fodder storage—is central to this, providing robustness to withstand environmental stress and adaptability to adjust practices. The theory emphasizes system stability through interconnected components (e.g., infrastructure, ecology, human capacity).

The low scores across Table 5 (2.0–2.6) indicate that Garissa's pastoralist system lacks the resilient infrastructure needed to absorb climate shocks or adapt effectively. The slight disagreement on robust shelters (2.2) and fodder storage (2.3) suggests that livestock—the core of the system—are exposed to extreme weather and feed shortages, undermining resilience as defined by Holling (1973). The low score for transport facilities (2.4) limits mobility, a traditional adaptive mechanism, while the near-absence of solar/wind energy (2.1) and reforestation (2.0) reflects a fragile ecological and energy base, reducing long-term system stability.

The veterinary services score (2.6), though the highest, remains below neutral, indicating that even this adaptive component is insufficient to buffer disease shocks, a key resilience factor (Folke et al., 2004). The standard deviations (0.9–1.2) suggest some localized variation, but the overall picture is one of a brittle system, unable to maintain livelihoods security under climate pressure.

These findings support Resilience Theory's emphasis on infrastructure as a cornerstone of stability but highlight a disconnect between theoretical ideals and empirical reality. The theory assumes that resilient systems can adapt through robust infrastructure, yet Garissa's low scores suggest that without significant investment, the system remains in a low-resilience state, prone to collapse rather than recovery. This challenges the theory's adaptability premise, implying that resilience is not an inherent capacity but contingent on external inputs (e.g., infrastructure development) in degraded environments like Garissa. The absence of reforestation (2.0) further questions the theory's ecological focus, as the system lacks the biodiversity needed for self-reinforcing resilience.

The results align with Thornton et al. (2009), who link resilient infrastructure to livestock survival, but extend this by showing how comprehensive deficits (shelters, energy, ecology) compound vulnerability. This suggests a need to refine Resilience Theory to address cumulative infrastructure gaps in climate-stressed pastoral systems, as noted by Nori et al. (2008), who call for integrated approaches to bolster resilience.

Both theories underscore infrastructure's role in livelihoods security, but their implications diverge in focus. Livelihoods Adaptation Theory interprets the Table 5 findings as a barrier to diversification, suggesting that pastoralists cannot shift livelihoods without assets like transport or fodder storage, challenging the theory's assumption of endogenous adaptation. Resilience Theory views the same findings as evidence of system fragility, implying that without robust infrastructure, the pastoralist socio-ecological system cannot absorb climate shocks, questioning the theory's adaptability premise in resource-poor settings.

Together, the findings suggest that climate change amplifies the dependence on external infrastructure, pushing both theories toward a more interventionist stance. For Livelihoods

Adaptation Theory, this means diversification is not a natural outcome but requires enabling conditions (e.g., shelters, veterinary services). For Resilience Theory, it implies that resilience is not self-sustaining without deliberate strengthening of infrastructure and ecological components (e.g., reforestation). This dual lens highlights a critical theoretical gap: in climate-vulnerable contexts like Garissa, adaptation and resilience are interdependent, requiring integrated strategies beyond what either theory fully anticipates.

4.7 Influence of Diversification of Livelihood on Livelihoods Security in Garissa Township subcounty

t

Table 6 Influence of Diversification of Livelihood on Livelihoods Security in Garissa Township subcounty

h

e		
i		
n		
f		
l		
u		
e		
n		

c

The results, presented in Table 6, include mean scores and standard deviations, providing insights into the extent and perception of diversification among pastoralists in this semi-arid region. Below

o

f

Mount Kenya University

is a detailed description and analysis of these findings. About adoption of Small-Scale Crop Farming (Mean = 2.5, SD = 1.2), with a mean score of 2.5, respondents slightly disagree to are neutral about adopting small-scale crop farming, particularly drought-resistant and fast-maturing crops. The standard deviation of 1.2 indicates moderate variability, suggesting differing levels of engagement or success. This score reflects limited uptake of crop farming as a diversification strategy, likely due to water scarcity and poor infrastructure in Garissa.

Regarding Integration of Trees and Shrubs into Farming Systems (Mean = 2.3, SD = 1.1), a mean of 2.3 shows slight disagreement that trees and shrubs have been integrated into farming systems for additional income and environmental benefits. The standard deviation of 1.1 suggests relatively consistent perceptions. This low score indicates minimal agroforestry adoption, a potential diversification avenue constrained by environmental and resource challenges.

About Raising Different Types of Livestock (Mean = 3.2, SD = 1.3), the highest mean score of 3.2, the only one above neutral, indicates that respondents are neutral to slightly agree that they raise different types of livestock (e.g., poultry, goats, camels) more resilient to climate variability. The standard deviation of 1.3, the highest in the table, reflects significant variation, possibly due to differences in herd size or access to resilient breeds. This suggests that livestock diversification is the most adopted strategy among pastoralists.

On Involvement in Small-Scale Retail and Trade (Mean = 2.7, SD = 1.2), a mean of 2.7 shows a near-neutral stance on involvement in small-scale retail and trade businesses for extra income. The standard deviation of 1.2 indicates moderate variability, likely reflecting uneven access to markets or capital. This score suggests some engagement in non-pastoral income sources, though not widespread.

Mount Kenya University

Regarding Vocational Training in Trades (Mean = 2.1, SD = 1.0), with a mean of 2.1, the lowest in the table, respondents generally disagree that they have been provided with vocational training in carpentry, masonry, tailoring, or other trades. The standard deviation of 1.0 shows high consistency in this perception. This indicates a significant gap in human capital development for diversification beyond pastoralism.

Access to Credit and Savings Facilities (Mean = 2.4, SD = 1.1) shows a mean of 2.4 that reflects slight disagreement that respondents obtain credit and savings facilities from community savings groups. The standard deviation of 1.1 suggests uniform perceptions of limited financial resources. This score highlights a barrier to funding diversification efforts, such as starting businesses or investing in crops.

The mean scores in Table 6, ranging from 2.1 to 3.2, suggest that diversification of livelihood among pastoralists in Garissa Township Sub-County is limited, with only livestock diversification (3.2) reaching or exceeding neutrality. Most scores fall below 3.0, indicating a general perception that diversification strategies are not adequately adopted or supported, undermining sustainable livelihoods security. The highest score for raising different livestock types (3.2) points to a preference for diversifying within pastoralism, likely due to familiarity and lower resource demands compared to external ventures. The lowest score for vocational training (2.1) underscores a critical gap in skills development, while moderate scores for crop farming (2.5), trade (2.7), and credit (2.4) suggest partial but insufficient engagement in non-pastoral options.

The standard deviations (1.0–1.3) reflect moderate to high variability, particularly for livestock diversification (1.3), indicating that some pastoralists may successfully diversify while others lag, possibly due to differences in wealth, location, or access to support. The findings highlight a reliance on pastoralism, with limited structural support (e.g., training, credit) for broader

diversification, reflecting the semi-arid context of Garissa where climate and resource constraints shape livelihood options.

4.7.1 Implications in Relation to Literature

These results align with and extend research on livelihood diversification in pastoralist systems, particularly within the framework of Livelihoods Adaptation Theory (Scoones, 1998; Ellis, 2000), which emphasizes diversification as a strategy to enhance security under environmental stress.

The modest score for small-scale crop farming (2.5) supports Mahmoud (2010), who found that agro-pastoralism in Kenya is constrained by water availability and infrastructure—issues evident in Garissa (e.g., Table 4's low water management scores). The low score for trees and shrubs (2.3) aligns with Oba (2013), who notes that agroforestry in arid regions requires significant investment in water and land management, resources scarce in Garissa as per Table 4 and Table 5 findings. Both suggest that diversification into crop-based systems is limited by environmental and infrastructural deficits.

The higher score for livestock diversification (3.2) corroborates Little et al. (2008), who argue that pastoralists often diversify within their traditional domain (e.g., adding camels or goats) due to familiarity and lower risk compared to external ventures. This finding supports Livelihoods Adaptation Theory's emphasis on leveraging existing assets (e.g., livestock knowledge), though the variability (SD = 1.3) suggests unequal access to resilient breeds or markets, a nuance Ellis (2000) highlights in resource-poor contexts.

The near-neutral score for retail and trade (2.7) aligns with Scoones (1998), who notes that non-farm income can buffer climate shocks, but the modest rating here reflects barriers like poor transport (Table 5, 2.4) and limited credit (2.4), consistent with Little et al. (2008) on market access challenges. The low score for vocational training (2.1) echoes Ouma et al. (2017), who stress that

human capital deficits hinder diversification into skilled trades, a critical gap in Garissa where training is not prioritized (cf. Table 4's 2.7 for water management training).

The limited access to credit and savings (2.4) supports Ellis (2000), who identifies financial capital as a prerequisite for diversification, yet mirrors Oba and Lusigi (2002), who note that pastoralists in arid regions often lack formal financial systems, relying instead on informal networks that may be insufficient. This constrains investments in new livelihoods, perpetuating dependence on pastoralism.

Overall, the findings suggest that while diversification offers a pathway to sustainable livelihoods security, as per Livelihoods Adaptation Theory, its realization in Garissa is stymied by inadequate assets—physical (infrastructure), human (training), and financial (credit). This reinforces the theory's premise that adaptation requires enabling conditions but highlights a context-specific challenge: climate and resource scarcity amplify asset deficits, limiting diversification's potential.

The results imply a need for policies to strengthen diversification by addressing asset gaps. Enhancing water management (Table 4) and climate-resilient infrastructure (Table 5) could support crop farming and agroforestry, while vocational training programs and credit facilities could boost trade and skilled livelihoods. The success of livestock diversification (3.2) suggests promoting resilient breeds (e.g., camels) as a scalable model.

Future research could explore why livestock diversification scores higher, identifying factors like herd size or market access, and test interventions (e.g., training, microfinance) to bridge the gaps in non-pastoral diversification. Linking these perceptions to actual diversification outcomes (e.g., income data) could further validate the findings.

4.8 Regression Analysis

Mount Kenya University

Table 7 Regression Analysis coefficients

	Coefficient (β)				
Intercept (β_0)					
Water Management (β_1)					
Infra (β_2)					
Diversification (β_3)					

Mount Kenya University

Diversification of Livelihood (β_3 = 5.60, p = 0.000): Each additional income source increases

T

h
s aligns with the Likert-scale findings in Table 4 (e.g., mean scores of 2.1–2.8), where inadequate

e

c

o

e

fThe coefficient for Climate Resilient Infrastructure (CRI) is $\beta_2 = 2.10$, with a t-value of 3.00 and a

f

i

Decision: Reject H02. There is a significant positive relationship between climate-resilient

cinfrastructure and livelihoods security. This is consistent with Table 5's findings (e.g., mean scores

iof 2.0–2.6), where low infrastructure ratings reflect vulnerability, and suggests that enhancing

e

n

t

The coefficient for Diversification of Livelihood (DL) is $\beta_3 = 5.60$, with a t-value of 4.67 and a p-

against the null hypothesis. This effect is the strongest among the predictors, highlighting
f
diversification's critical role.
o
. This corroborates Table 6's findings (e.g., 3.2 for livestock diversification vs. 2.1–2.7 for other
r

W

a

t

e

uffers against climate shocks. The rejection of all null hypotheses suggests that these factors are interlinked, with water and infrastructure enabling diversification, a synergy critical for Garissa's resilient infrastructure, and promoting diverse livelihoods—to ensure sustainable security.

Mount Kenya University

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

5.2 Summary of Findings

gn with McPeak and Little (2005) on infrastructure constraints and Thornton et al. (2009) on water

quality's impact on productivity, reinforcing Resilience Theory's focus on robust systems (Folke et al., 2004) and Livelihoods Adaptation Theory's community capacity (Scoones, 1998). They r m i n ., 2004), showing a fragile system unable to absorb climate shocks due to poor infrastructure g (Thornton et al., 2009; Nori et al., 2008). Low scores for shelters and fodder echo McPeak and Little (2005), while reforestation's absence supports Oba (2013). Veterinary progress (Ouma et al., c 2017) is limited. Policies should prioritize shelters, fodder storage, and ecological restoration, with l research exploring veterinary success and barriers to reforestation to enhance resilience in i G m a a r Mean scores (2.1–3.2) and standard deviations (1.0–1.3) reveal limited diversification, with only t i e s s These results align with Livelihoods Adaptation Theory (Scoones, 1998; Ellis, 2000), emphasizing r a diversification's role in security, but underscore barriers—water, infrastructure, training, and c ' credit—limiting its adoption in Garissa's semi-arid context. Livestock diversification (Little et al., s i l i

5.3 Conclusion

n c e

Mount Kenya University

cores for harvesting facilities (2.3), boreholes (2.5), and purification (2.1), exacerbating pastoralists' vulnerability in this drought-prone region. Despite some strengths in water confirms water management's critical role in livelihoods security. Enhancing boreholes,

port (2.4) persist. Regression analysis ($p = 0.003$) underscores infrastructure's significance. Strengthening shelters, fodder systems, and ecological restoration, while leveraging veterinary gains, is vital for resilience, supporting Resilience Theory's emphasis on robust systems in Garissa's semi-arid context.

ification beyond pastoralism, ensuring sustainable livelihoods for Garissa's pastoralists amid

5.4 Recommendations

Mount Kenya University

Mount Kenya University

REFERENCES

Adan, M., & Mburu, J. (2016). Climate change adaptation strategies by pastoralists in arid and semi-arid lands of Kenya. Journal of Environmental Management, 182, 123–130.

Ahmad, D., & Afzal, M. (2021). Impact of climate change on pastoralists' resilience and sustainable mitigation in Punjab, Pakistan. Environment, Development and Sustainability, 23(8), 11406-11426.

Assefa, T. D., Chalchisa, F., Tegegn, D., Niguse, B. D. and Gutu, T. (2023). Pastoralists' and agro-pastoralists' livelihood resilience to climate change-induced risks in the Borana zone, south Ethiopia: Using resilience index measurement approach. Article number: 4 (2023) Springers open

Ayele, T., Dedecha, D., & Duba, D. (2020). The impact of climate change on pastoralist livelihoods in Ethiopia: A review. Journal of Resources Development and Management, 63(1-14).

Babbie, E. (2010). The Practice of Social Research. Wadsworth Cengage Learning.

Balfour, N., Obando and Deepali (2020). Dimensions of water insecurity in pastoralist households in Kenya. Waterlines Vol. 39 No. 1

Baro, B., Mesfin, T. and Mebratu, A. (2023). The impact of livelihood diversification as a climate change adaptation strategy on poverty level of pastoral households in southeastern and southern Ethiopia. Cogent Social Sciences Volume 9, 2023 - Issue 2.

Creswell, J. W. (2014). Research Design: Qualitative, Quantitative and Mixed Methods Approaches (4th ed.). Thousand Oaks, CA: Sage.

Creswell, J. W., & Plano Clark, V. L. (2017). Designing and Conducting Mixed Methods Research. Sage Publications.

Ellis, F. (2000). Rural Livelihoods and Diversity in Developing Countries. Oxford University Press.

FAO (2021). "The impact of climate change on pastoralism in Garissa County, Kenya." Retrieved from FAO.org.

Folke, C., Carpenter, S., Elmqvist, T., Gunderson, L., Holling, C. S., & Walker, B. (2004). Resilience and sustainable development: Building adaptive capacity in a world of transformations. Annual Review of Ecology, Evolution, and Systematics, 35, 557–581.

Gargule, A. A. (2018). Managing livelihood risks: Income diversification and the livelihood strategies of households in pastoral settlements in Isiolo County, Kenya. SPRINGER OPEN, Article number: 20

Ghai, R. (2021). Understanding 'culture'of pastoralism and 'modern development'in Thar: Muslim pastoralists of north-west Rajasthan, India. Pastoralism, 11, 1-19.

Holechek, J. L., Geli, H. M., Cibils, A. F., & Sawalhah, M. N. (2020). Climate change, rangelands, and sustainability of ranching in the Western United States. Sustainability, 12(12), 4942.

Holling, C. S. (1973). "Resilience and stability of ecological systems." Annual Review of Ecology and Systematics, 4, 1-23.

Kerven, C., Robinson, S., & Behnke, R. (2021). Pastoralism at scale on the Kazakh rangelands: From clans to workers to ranchers. Frontiers in Sustainable Food Systems, 4, 590401.

Little, P. D., McPeak, J., Barrett, C. B., & Pattison, J. (2008). Challenging orthodoxies: Understanding poverty in pastoral areas of East Africa. Development and Change, 39(4), 587–611.

Lolemtum, J. T. (2023). *Impacts of Climate Change on Sustainable Pastoralist Livelihoodsof Pokot Community in West Pokot County, Kenya* (Doctoral dissertation, University of Nairobi).

Mahmoud, H. A. (2010). Livestock trade in the Kenyan, Somali and Ethiopian borderlands. Chatham House Briefing Paper.

Manduzai, A. K., & Volpato, G. (2023). Niches, Interstitiality and Impoverishment. Pastoralism Among Afghan Kochi Refugees in Mansehra, Northwest Pakistan. Human Ecology, 51(2), 265-277.

Mathwich, N. M. (2021). Colonialism and Historical Ecology: Livestock management as a case study in the American Southwest. In Routledge Handbook of the Archaeology of Indigenous-Colonial Interaction in the Americas (pp. 79-93). Routledge.

McPeak, J., & Little, P. D. (2005). Pastoral Livestock Marketing in Eastern Africa: Research and Policy Challenges. ITDG Publishing.

Mfinanga, F.A., Bishibura, S. E. & Mdoe, C. (2024). Influence of water access for livestock on pastoralists household income in semi-arid areas of Monduli district in Tanzania. Journal of Oasis Agriculture and Sustainable Development

Muhereza, F. E. (2019). Livestock-Centered Diversification and Livelihood Recovery in Post-Disarmament Karamoja. Paper submitted to the KRSU regional conference on 'Pathways to Resilience in Karamoja. Recent Research and Policy Options', 21-23 May 2019, Moroto, Uganda

Muluken, M., Andries, J. Melka, Y. (2018) Understanding resilience of pastoralists to climate change and variability in the Southern Afar Region, Ethiopia. Climate Risk Management, Volume 20, Pages 64-77

Ndiritu, S. W. (2021). Drought responses and adaptation strategies to climate change by pastoralists in the semi-arid area, Laikipia County, Kenya. Mitigation and adaptation strategies for Global Change, 26, 1-18.

Ndiritu, S. W., & Muricho, G. (2021). Impact of climate change adaptation on food security: evidence from semi-arid lands, Kenya. Climatic Change, 167(1), 24.

Nori, M., Taylor, M., & Sensi, A. (2008). Browsing on fences: Pastoral land rights, livelihoods and adaptation to climate change. IIED Issue Paper, 148.

Nusrat, H., Anoma, A., Ammar, A.A. (2023). The influence and impact of livelihood capitals on livelihood diversification strategies in developing countries: a systematic literature review. Springer Link. Environmental Science and Pollution Research 30(27):1-17

Oba, G. (2013). The Sustainability of Pastoral Production in Africa. Springer.

Oba, G., & Lusigi, W. J. (2002). An overview of drought strategies and land use in African pastoral systems. Land Use Policy, 19(2), 151–161.

Opiyo, F., Mureithi, S.M., and Kinuthia, N. N. (2011). The Influence of Water Availability on Pastoralist's Resource Use in Mwingi and Kitui Districts in Kenya. July 2011Journal of Human Ecology 35(1)

Ouma, R., Mude, A., & Van de Steeg, J. (2017). Index-based livestock insurance for Kenyan pastoralists: An innovation in climate risk management. Climate Risk Management, 18, 11–20.

Rahat, S. (2019) Income diversification strategies among pastoralists in Central Asia: Findings from Kyrgyzstan Pastoralism volume 9, Article number: 14.

Ritika, K., Atishaya, S., Vivek, S.B., and Chitra, K. (2024). Household livelihood resilience of pastoralists and smallholders to climate change in Western Himalaya, India. Heliyon 10(1–2)

Scoones, I. (1998). "Sustainable rural livelihoods: A framework for analysis." IDS Working Paper, 72, 1-22.

Scoones, I. (2021). Pastoralists and peasants: perspectives on agrarian change. The Journal of Peasant Studies, 48(1), 1-47.

Srivastav, A. L., Dhyani, R., Ranjan, M., Madhav, S., & Sillanpää, M. (2021). Climate-resilient strategies for sustainable management of water resources and agriculture. Environmental Science and Pollution Research, 28(31), 41576-41595.

Thornton, P. K., Van de Steeg, J., Notenbaert, A., & Herrero, M. (2009). The impacts of climate change on livestock and livestock systems in developing countries: A review of what we know and what we need to know. Agricultural Systems, 101(3), 113–127.

Thornton, P. K., Van de Steeg, J., Notenbaert, A., & Herrero, M. (2009). The impacts of climate change on livestock and livestock systems in developing countries: A review of what we know and what we need to know. Agricultural Systems, 101(3), 113–127.

Tugjamba, N., Walkerden, G., & Miller, F. (2023). Adapting nomadic pastoralism to climate change. Climatic Change, 176(4), 28.

UNDP (2021). "Pastoralism and Resilience in Garissa County, Kenya." Retrieved from UNDP.org.

Mount Kenya University

APPENDICES

Appendix 1: Research Participation Consent Form

Dear respondent,

Date……..

Prior to participating in this study, you are requested to read, understand and sign up the procedure of participation.

Purpose of the Study

The purpose of the study is to investigate the impact of climate change mitigation approaches on livelihoods security of pastoralists in Garissa Township subcounty, Kenya.

Voluntary participation

Your consent to participate in the study was voluntary. There is no repercussion of any effect of your turn down to participate in the study.

Use of the collected data

The collected data was used solely for academic purposes.

Confidentiality

The information shared in the study was confidential and no other entity will access it.

Furthermore, no dentification was given in the tools used in the study.

Rewards

There are no rewards for participating in the study.

Withdrawal from Participation

Any research participant is free and allowed to withdraw from participation without necessarily giving an explanation.

Attestation and declaration

Mount Kenya University

I have read and understood the purpose and context of participating in the study. I have had an opportunity to ask question related to the study and answered to satisfaction.

I willingly sign up to show my consent for participation.

Participant name……..……

Signature…….

Date…….

Mount Kenya University

Appendix II: Semi-Structured Questionnaire

Dear respondent,

I am a student of Mount Kenya University, pursuing a master's in Development Studies. This study aims to investigate the impact of climate change approaches on livelihoods security of pastoralists in Garissa Township Subcounty in Kenya. Your contribution to this research was

very important. I therefore humbly request you to spare for me sometime to fill this questionnaire. This is purely academic research and your response was treated with utmost confidentiality. Please kindly fill the gaps and where necessary tick the best option in the boxes provided.

Instructions

A Tick the appropriate box ( ) for your responses

b) Please DO NOT write your name anywhere in the questionnaire.

PART A: **Demographic Information**

1. What is your gender? Male☐ Female ☐

2. How old are you? 18- 30 years ☐ 31- 40years☐ above 40 years☐

3. What is your marital status?

   Single/never married☐ Married ☐Widowed ☐ Divorced/Separated ☐

4. For how long have you practiced pastoralism? Less than 4☐ 5 to 9 year's ☐ 10 years and above

PART B: Influence of water management on livelihoods security of pastoralists

5. Please tick the number that best reflects your opinion responses on the influence of water management on livelihoods security of pastoralists

1= Strongly Disagree 2= Disagree 3= Not sure 4= Agree 5 = Strongly Agree

Statement	1	2	3	4	5
There are adequate water harvesting facilities in the animal sites There are adequate boreholes in place					
There are adequate water purification facilities					
There are sufficient water sanitation measures in place to reduce water contamination					

Mount Kenya University

Water points have been constructed such as troughs, tanks, and pumps to provide reliable access to water for livestock					
Water associations have been established and strengthened to manage and maintain water resources collectively					
Communities are provided with training on water management practices and the importance of sustainable water use.					

6. In your opinion, what can be done to ensure proper water resource management in the pastoral communities?

……

……

……

……

……

……

PART C: Influence of climate resilient infrastructure on livelihoods security of pastoralists

7. Please tick the number that best reflects your opinion responses on the influence of climate resilient infrastructure on livelihoods security of pastoralists

1= Strongly Disagree 2= Disagree 3= Not sure 4= Agree 5 = Strongly Agree

Statement	1	2	3	4	5
There are adequate robust shelters constructed to protect livestock from extreme weather conditions, such as heatwaves, cold spells, and storms					
Transport facilities been established that enable pastoralists to move livestock to markets or safer areas during adverse weather conditions					

Mount Kenya University

Solar and wind energy systems have been implemented to provide a reliable and sustainable power supply for water pumps, lighting, and other needs					
veterinary clinics and mobile units have been established to provide timely healthcare for livestock.					
Facilities for storing fodder have been built to ensure a consistent supply during dry periods.					
Reforestation and afforestation projects to enhance biodiversity and provide additional sources of fodder					

8. In your opinion, what can be done to ensure erratic climate changes don't disadvantage pastoralists?

……

……

……

……

……

……

PART D: Influence of diversification of livelihood on livelihoods security of pastoralists

9. Please tick the number that best reflects your opinion responses on the influence of water management on livelihoods security of pastoralists

1= Strongly Disagree 2= Disagree 3= Not sure 4= Agree 5 = Strongly Agree

Statement	1	2	3	4	5
Small-scale crop farming, particularly drought-resistant and fast-maturing crops has been adopted					
Trees and shrubs have been integrated into farming systems for additional income and environmental benefits					

Mount Kenya University

I raise different types of livestock, such as poultry, goats, and camels, which might be more resilient to climate variability					
I am involved in small-scale retail and trade businesses to get extra income					
I have been provided with vocational training in carpentry, masonry, tailoring, and other trades					
I obtain credit and savings facilities from the community savings groups					

9. In your opinion, what measures can be put in place to expose pastoralists to more alternatives of obtaining income apart from pastoralism

……

……

……

……

……

…….

PART E: Livelihoods security of pastoralists

11. Please tick the number that best reflects your opinion responses on livelihoods security of pastoralists

1= Strongly Disagree 2= Disagree 3= Not sure 4= Agree 5 = Strongly Agree Influence of

Statement	1	2	3	4	5
I have access to and quality of natural resources such as grazing lands, water sources, and biodiversity which are critical for livestock rearing					
I have access to infrastructure such as housing, livestock shelters, roads, water storage, and veterinary services that support pastoral livelihoods					

Mount Kenya University

I have skills, knowledge, health, and education that enable me to manage my livestock and adapt to changing environmental conditions					
There are social networks, community organizations, and traditional institutions that provide support, share resources, and facilitate collective action					
I have access to financial resources such as savings, credit, and insurance that help me manage risks and invest in adaptive strategies					
I am able to adjust practices, processes, and structures to mitigate the impacts of climate change, including the adoption of sustainable grazing practices					
I have consistent access to sufficient, safe, and nutritious food, which is directly influenced by the health and productivity of livestock.					

12. In your opinion, what can be done to make livelihoods sustainable for the pastoralists?

……

……

……

……

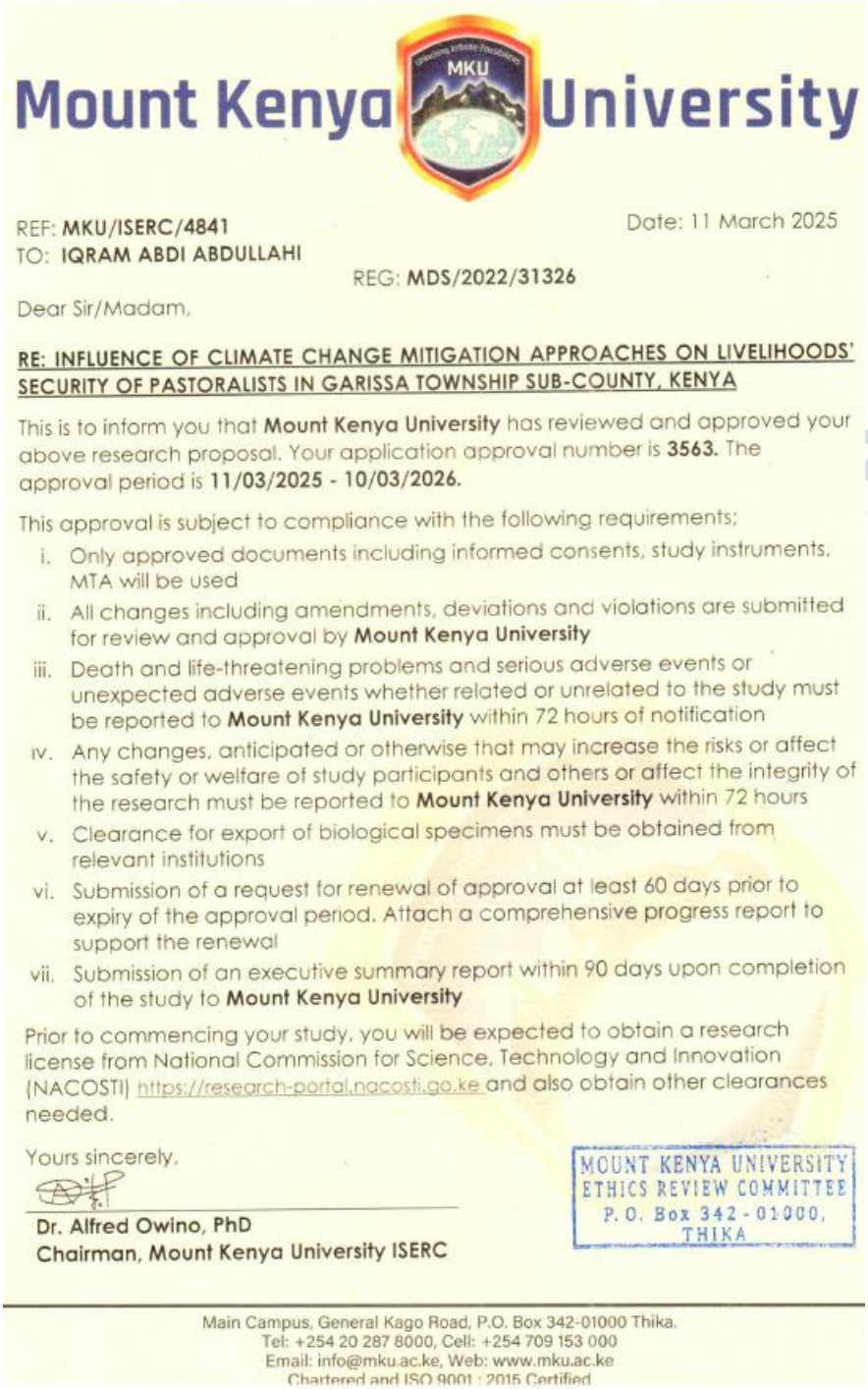
……

……

Thank you very much for your cooperation

Mount Kenya University

Appendix: III: Ethical Review Clearance



Mount Kenya University

REF: MKU/ISERC/4841
TO: IQRAM ABDI ABDULLAHI

Date: 11 March 2025

REG: MDS/2022/31326

Dear Sir/Madam,

RE: INFLUENCE OF CLIMATE CHANGE MITIGATION APPROACHES ON LIVELIHOODS' SECURITY OF PASTORALISTS IN GARISSA TOWNSHIP SUB-COUNTY, KENYA

This is to inform you that **Mount Kenya University** has reviewed and approved your above research proposal. Your application approval number is **3563.** The approval period is **11/03/2025 - 10/03/2026.**

This approval is subject to compliance with the following requirements:

i. Only approved documents including informed consents, study instruments, MTA will be used
ii. All changes including amendments, deviations and violations are submitted for review and approval by **Mount Kenya University**
iii. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to **Mount Kenya University** within 72 hours of notification
iv. Any changes, anticipated or otherwise that may increase the risks or affect the safety or welfare of study participants and others or affect the integrity of the research must be reported to **Mount Kenya University** within 72 hours
v. Clearance for export of biological specimens must be obtained from relevant institutions
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal
vii. Submission of an executive summary report within 90 days upon completion of the study to **Mount Kenya University**

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://research-portal.nacosti.go.ke and also obtain other clearances needed.

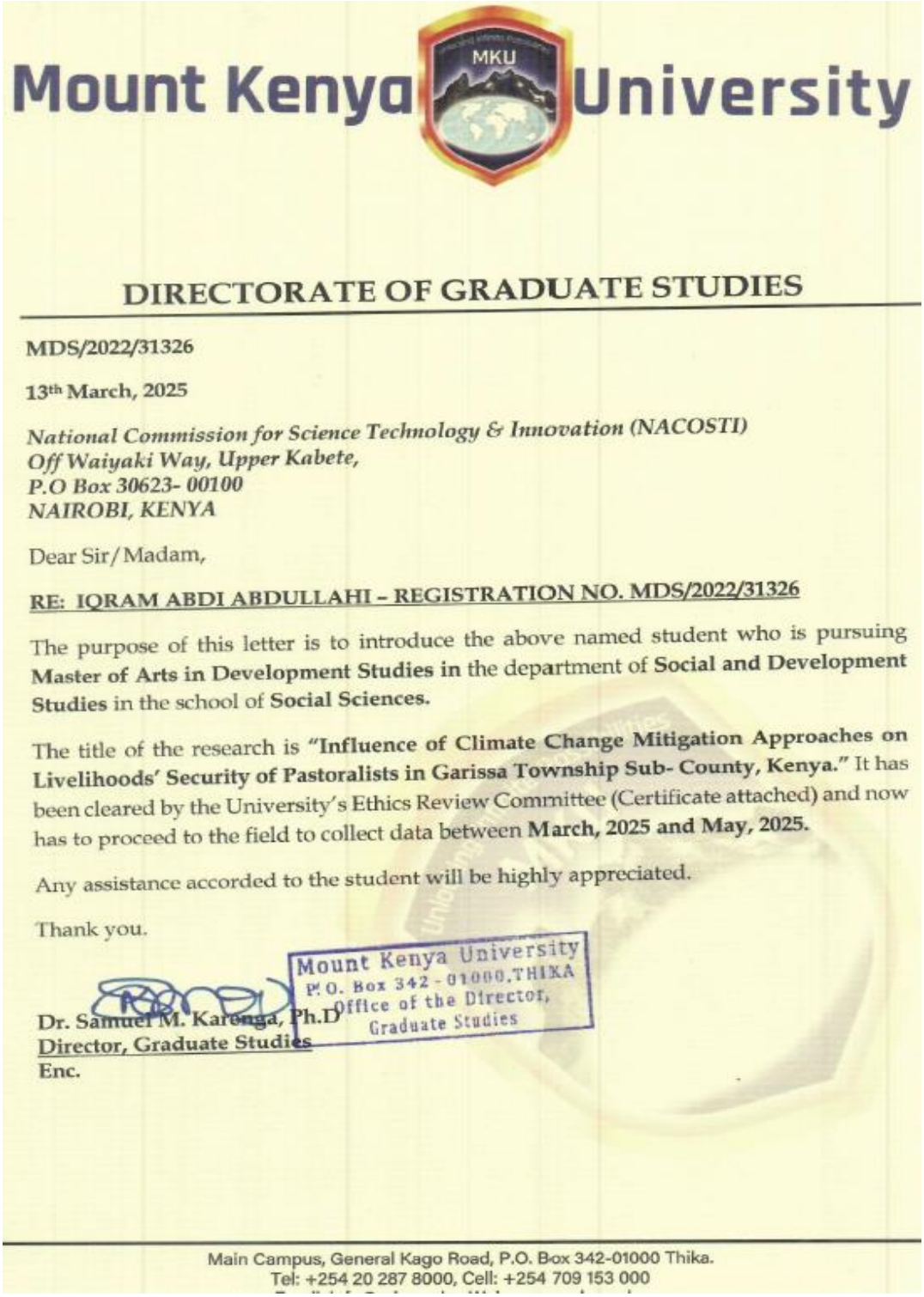
Yours sincerely,

Dr. Alfred Owino, PhD
Chairman, Mount Kenya University ISERC

MOUNT KENYA UNIVERSITY
ETHICS REVIEW COMMITTEE
P. O. Box 342 - 01000,
THIKA

Main Campus, General Kago Road, P.O. Box 342-01000 Thika.
Tel: +254 20 287 8000, Cell: +254 709 153 000
Email: info@mku.ac.ke, Web: www.mku.ac.ke
Chartered and ISO 9001 : 2015 Certified

Appendix: IV: Postgraduate Introduction Letter



Mount Kenya University

DIRECTORATE OF GRADUATE STUDIES

MDS/2022/31326

13th March, 2025

National Commission for Science Technology & Innovation (NACOSTI)
Off Waiyaki Way, Upper Kabete,
P.O Box 30623- 00100
NAIROBI, KENYA

Dear Sir/Madam,

RE: IQRAM ABDI ABDULLAHI – REGISTRATION NO. MDS/2022/31326

The purpose of this letter is to introduce the above named student who is pursuing **Master of Arts in Development Studies in** the department of **Social and Development Studies** in the school of **Social Sciences.**

The title of the research is **"Influence of Climate Change Mitigation Approaches on Livelihoods' Security of Pastoralists in Garissa Township Sub- County, Kenya."** It has been cleared by the University's Ethics Review Committee (Certificate attached) and now has to proceed to the field to collect data between **March, 2025 and May, 2025.**

Any assistance accorded to the student will be highly appreciated.

Thank you.

Mount Kenya University
P. O. Box 342 - 01000, THIKA
Office of the Director,
Graduate Studies

Dr. Samuel M. Karonga, Ph.D
Director, Graduate Studies
Enc.

Main Campus, General Kago Road, P.O. Box 342-01000 Thika.
Tel: +254 20 287 8000, Cell: +254 709 153 000

Appendix V: NACOSTI Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 718860

Date of Issue: 26/March/2025

RESEARCH LICENSE

This is to Certify that Ms.. IQRAM ABDI of Mount Kenya University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Garissa on the topic: INFLUENCE OF CLIMATE CHANGE MITIGATION APPROACHES ON LIVELIHOODS' SECURITY OF PASTORALISTS IN GARISSA TOWNSHIP SUB-COUNTY, KENYA for the period ending : 26/March/2026.

License No: NACOSTI/P/25/417209

718860

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

See overleaf for conditions

Appendix VI: Map of Garissa subcounty

Mount Kenya

Appendix VII: Field Authorization

MINISTRY OF EDUCATION

STATE DEPARTMENT OF BASIC EDUCATION

Telegram: "SCHOOLING" Garissa
Telephone: 046-210-2458, Garissa.
Fax: 046-210-2002
Email: coegarissacounty@gmail.com
When replying please quote

COUNTY DIRECTOR OF EDUCATION
GARISSA
P.O. Box P.O. 70200
GARISSA

REF: NEP/ED/6.26/VOL.IV (146)

DATE 29th March 2025

IQRAM ABDI
MOUNT KENYA UNIVERSITY
GARISSA.

RE: RESEARCH AUTHORIZATION.

Refer to your letter Ref. No. **NACOSTI/P/25/417209** dated 26th March 2025 from Director General/CDE on application for authority to carry out research on "**Influence of climate change mitigation approaches on livelihoods' security of pastoralists in Garissa Township sub-county, Kenya**" for the period ending 27th March 2026.

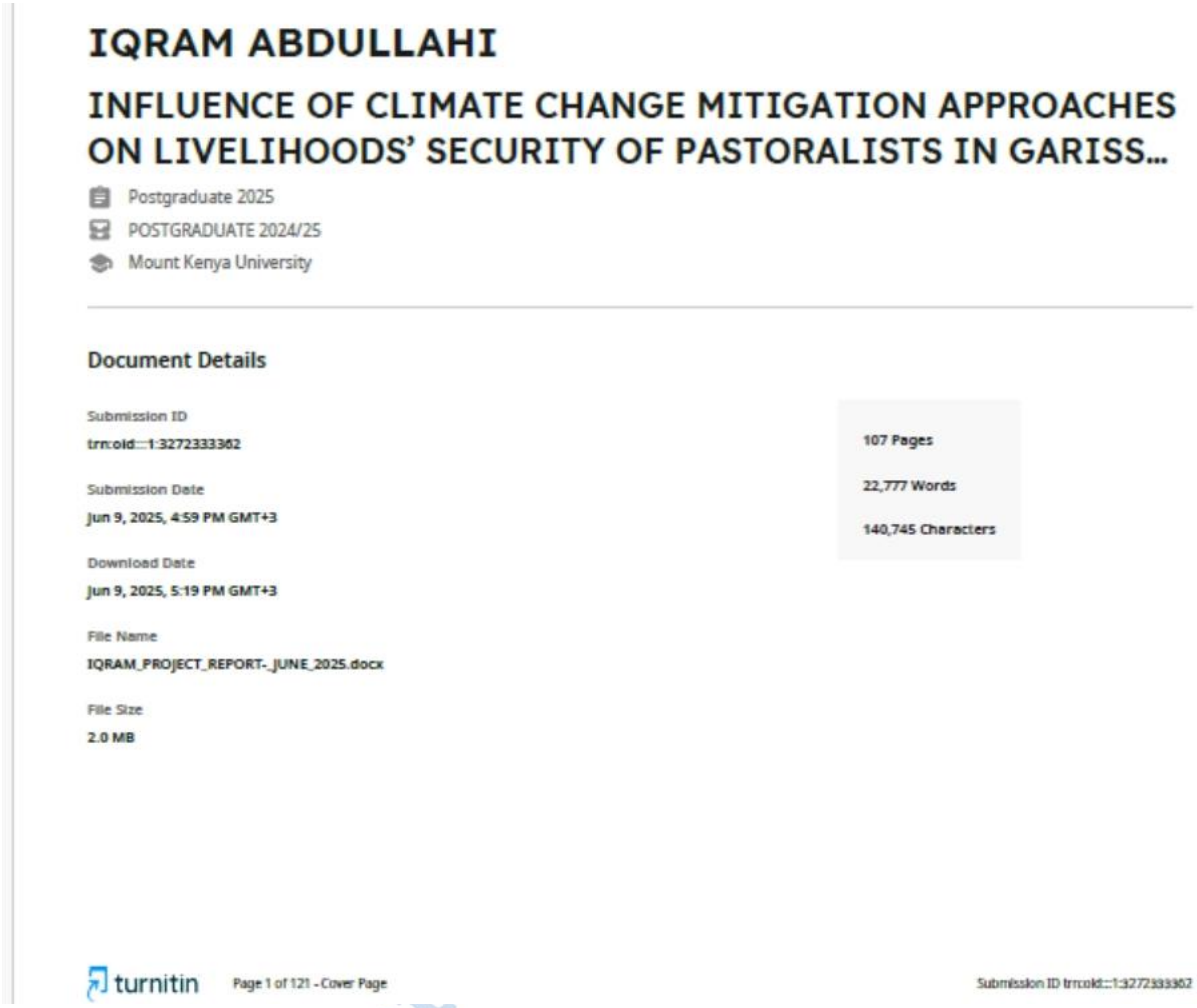
We are pleased to inform you that you have been authorised and given consent for your research outcome.

ABDIHAMID MAALIM
COUNTY DIRECTOR OF EDUCATION
GARISSA.

Ce:

-Regional Director of Education -**North Eastern Region.**

Appendix IX: Turnitin report



IQRAM ABDULLAHI

INFLUENCE OF CLIMATE CHANGE MITIGATION APPROACHES ON LIVELIHOODS' SECURITY OF PASTORALISTS IN GARISS...

Postgraduate 2025

POSTGRADUATE 2024/25

Mount Kenya University

Document Details

Submission ID
trn:oid:::1:3272333362

Submission Date
Jun 9, 2025, 4:59 PM GMT+3

Download Date
Jun 9, 2025, 5:19 PM GMT+3

File Name
IQRAM_PROJECT_REPORT-_JUNE_2025.docx

File Size
2.0 MB

107 Pages

22,777 Words

140,745 Characters

turnitin Page 1 of 121 - Cover Page Submission ID trn:oid:::1:3272333362

Mount