

Adaptation to climate change among pastoralist communities of Somali Region, Ethiopia

By

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Exact wording of the title of the thesis as appearing on the electronic copy submitted for examination: Climate Change Impacts, Adaptation Strategies and Institutional Interventions among Pastoralist Communities of the Somali Region, Ethiopia.

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DEDICATION

This thesis is devoted to the affectionate recall of my brother, **Aden Hussein Yussuf and My Uncle Adow Hish Muhumed**, those who passed away abruptly and unexpectedly during my dissertation work in different times. Almighty Allah grants them their soul eternal peacetime, Ameen. My respected Families, you are at all times in my mind for the unwavering assistance and encouragement you showed me throughout my entire educational journey. I always pray to Almighty Allah after my compulsory prayers to reward you with Jannatul Firdaus (the highest paradise).

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ABSTRACT

This study has general aim of investigating, Adaptation to climate change among pastoralist communities of Somali Region, Ethiopia. It deals with impacts of climate change, adaptation strategies of pastoralist communities and the extent to which institutional interventions complement pastoralists' indigenous adaptation mechanisms. The study is framed by three complementary theoretical perspectives Afrocentricity, the Capability Approach, and the Sustainable Livelihoods Framework (SLF) which together position pastoralists as active agents whose indigenous knowledge, capabilities, and livelihood assets shape their adaptive responses to climate risks. Guided by a pragmatist research philosophy, the study employed mixed-methods with descriptive research design. The study population comprised the pastoral communities of the Somali Region, which contains 5,748,998 of people from which 384 sample size were selected through a multi-stage sampling procedure across six purposively selected districts. Data were collected using a structured household survey, focus group discussions, key informant interviews, and field observations, and were analysed using descriptive statistics, a binary logistic regression model, and thematic analysis of the qualitative data.

The findings show that recurrent drought, erratic rainfall, and water scarcity are the dominant climatic stressors in the region, driving livestock losses, resource-based conflict, and food insecurity. Most households practised some form of adaptation, principally migration, livestock diversification and sales, and careful management of available resources although many of these responses remained short-term and reactive. The binary logistic regression identified the household head's age, education, income diversification, and prior adaptive experience as significant determinants of adaptive capacity. While 60.9% of households reported receiving institutional support, only 15.4% considered the interventions supportive, and access to credit, safety nets, and extension services remained limited. Qualitative evidence revealed weak coordination between formal interventions and indigenous knowledge systems, despite strong community reliance on traditional practices such as resource sharing and herd mobility. The study concludes that climate change in the Somali Region is not only an ecological hazard but also a socio-economic and institutional challenge. Building durable resilience therefore requires long-term, participatory approaches that integrate indigenous and scientific knowledge, strengthen institutional support, diversify livelihoods, and improve pastoralists' access to climate information and financial resources.

Keywords: *Climate Change, Pastoralism, Indigenous Knowledge, Adaptation, Institutional Support, Resilience, Somali Region, Ethiopia*

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LIST OF ACRONYMS

°C	Degrees Celsius
DFID	Department for International Development's
EPRDF	Ethiopian People's Revolutionary Democratic Front
EMA	Environmental Management Agency
FAO	Food and Agriculture Organization
GDP	Growth Domestic Products
GHG	Green House Gas
IWGIA	International Work Group for Indigenous Affairs
IKS	Indigenous Knowledge Systems
IPCC	Intergovernmental Panel on Climate Change
M&E	Monitoring and evaluation
MRGI	Minority Rights Group International
NCCO	National Climate Change Office
NGO	Non-Governmental Organizations
SHG	Self Help Group
SK	Scientific Knowledge
SLF/A	Sustainable Livelihood Framework/Approach
SRS	Somali Regional State
UK	United Kingdom
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
WFP	World Food Programme
WMO	World Meteorological Organization
WWAP	World Water Assessment Programme
NOAA	National Oceanic and Atmospheric Administration
GTP	Plan for Growth and Transformation
SLM	Sustainable land management
CIIEWS	Climate Information and Early Warning Systems

Chapter One: General Introduction

Introduction

The introduction section arranges the fundamental elements of the hypothesis. It opens with the background of the study, situating the topic of adaptation to climate change among pastoralist communities in the Somali Region of Ethiopia within the broader global, African, Sub-Saharan, and Ethiopia regional contexts. The problem statement identifies the main research gap, outlining the key issues that warrant deeper investigation and explaining the academic and policy importance of addressing them. The study's rationale was presented, clarifying the underlying reasons for undertaking the research and emphasizing its relevance to existing scholarship, as well as its potential contributions to knowledge, policy, and practice. It also underscores how the study engages with ongoing debates and unresolved questions in the arena.

The determination and specific objectives of the investigation was subsequently introduced by defining what the study seeks to accomplish and guide the ultimate goal of the study. The research questions and hypotheses was formulated to steer data collection and analysis, ensuring a systematic and targeted approach to inquiry. Finally, the bonders and delimitations of the research was included. The scope outlines the research boundaries covering the population, variables, timeframe, and geographic area while the limitations recognize factors that may affect the generalization or interpretation of the results. In conclusion, this chapter establishes the conceptual and methodological basis of the research. By offering the contextual challenges, rationale, objectives, research questions, and boundaries, it provides a coherent framework for the subsequent chapters and directs the reader toward understanding the research goal and significance.

1.1. Background of the Study

Climate change manifests serious challenge to pastoralist communities and environment in the tropical counties. However, climate change is a global threat to human society, there are many reasons to believe that the most affected are the poor and rural communities in the tropical counties whose livelihoods depend on agriculture production and pastoralist activities. The World Meteorological Organization confirmed that 2024 was the warmest year on record, with an average global temperature of 1.55°C above pre-industrial levels, and the extraordinary level of warming has fuelled a cascade of extreme weather events worldwide, including intensified heatwaves, wildfires, droughts, heavy rainfall, and floods (WMO, 2025). Climate change disrupts the education systems of pastoralist children, because the children are unable to attend school during the dry season by assisting their parents in securing water, rearing livestock, and performing other labour tasks. Furthermore, revenue sources like agriculture and pastoralism are adversely affected. Health

and administrative services also suffer: when natural disasters like droughts and floods occur, they give rise to diseases caused by malnutrition and famine, which can also impair the functioning of administrative systems (Von Kotze and Holloway, 1996, p.32). The combination of the adverse effects of climate change and governments' incapacity has reduced agricultural output and crop production, which has exacerbated chronic hunger and malnutrition, food insecurity, and prevalent undernourishment among poor rural communities (Muyambo et al., 2020). The natural hazards and climate change, scholars contend that climate-induced stressors disrupt food production systems, destabilise supply chains, and lead to rising food prices, restricted market access, and increased financial strain on both producers and consumers (Mirzaei et al., 2025). Consequently, those relying on agriculture and pastoralism may experience significantly lower production outputs, which deepens poverty and increases vulnerability among affected populations, particularly smallholder farmers.

In developing countries, and Africa in specific, climate change has connected to societal instabilities such as grassland conflicts, insecurity, internal displacement of communities, and cross-border migration (Barnett, 2005). This scarcity of natural resources like animal feed, leads to conflicts among pastoralist communities resulting in violence and displacement. This conflict occurs over scarce resources among marginalised communities and political instabilities in Africa are the feature of climate change (Baptista, et al, 2022). For instance, increasing famine and unemployment force people to migrate to seek economic opportunities elsewhere. Africa is widely recognised as the most vulnerable continent to the impacts of climate change, facing a range of environmental and climate-related challenges that pose significant threats to its economic and social development, including food insecurity, water scarcity, and displacement (Saber et al., 2025). The continent's exposure to extreme weather events is further compounded by a high dependence on rain-fed agriculture, rapidly growing populations, under-resourced infrastructure, and limited adaptive capacity, with over 60% of the continent lacking adequate weather and climate observation systems (WMO, 2025). East Africa is trending toward sustained acidification, particularly in the Horn, whereas West Africa faces a future of increased hydrological variability characterised by sharp swings between intense droughts and floods within a single season (Lim Kam Sian et al., 2026). Intensified climate variability including hotter extremes, erratic rainfall, and a surge in severe weather events threatens fisheries, water resources, public health, and overall socio-economic stability, with these uncertainties linked to reduced crop yields, disrupted supply chains, and heightened food insecurity imperilling millions of rural households. Addressing these challenges requires synthesising indigenous knowledge with modern scientific insights to develop comprehensive

adaptation strategies, with evidence showing that context-specific measures and locally driven initiatives are vital for enhancing resilience in under-resourced communities (Cho et al., 2025). Studies across ten African mountain regions confirm that while adaptation responses are mostly incremental, certain attributes notably social capital can enable more transformational adaptation, underscoring the importance of community-level assets in building long-term climate resilience (Ngigi & Muange, 2025).

Climate change variability encompasses the fluctuations in temperature, precipitation, and extreme weather events occurring across short and long time scales that have intensified significantly due to anthropogenic greenhouse gas emissions (Reidmiller, et al., 2024). As a developing country, Ethiopia is not immune to climate change. The Ethiopian livestock population is significant, including 57 million cattle, 5 million camels, 30 million sheep, 23 million goats, and 57 million poultry (Ali, 2021). However, climate-related instability has caused agricultural production, both crop and animal, to trend downward, reducing per capita grain and milk consumption nationally (Nandeeswara and Bealu, 2015). Agricultural invention continuous the primary income strategy for pastoral societies in Ethiopia, contributing 15% to GDP, employing 80% of smallholder farmers, and supporting 175 million individuals (FAO, 2016). Despite its importance, farming production is severely affected by climate-induced challenges such as crop diseases, overflows, pests, and severe droughts, which cause food insecurity, displacement, and conflict. A study among pastoralists (Chinasho, 2017) found that the adverse effects of high temperatures and unpredictable weather patterns is pronounced in dryland areas compared to humid regions within the country. These climate-related changes is characterizing by high concentration, regularity, and severity, posing significant challenges to Ethiopian pastoralist societies, particularly those in lowland areas.

In the Somali Region, where pastoralist communities form a significant part of the population, sustaining traditional livelihoods has become increasingly challenging as a result of insufficient seasonal rainfall. The region has experienced persistent drought for several years, with the most severe starting in 2016 and continuing to the present. Thus, drought is the primary climate variability factor affecting pastoral communities in the Somali region and other parts of the country. The amount of rainfall fluctuates from one season to another, leading to various issues that influence the pastoral way of life. This prolonged period of insufficient rainfall significantly reduces animal productivity (Mahad, 2020). Pastoralists are highly vulnerable to climate variability, which undermines household food security and livelihood activities. Many households have yet to recover, and over 350,000 people have been displaced due to drought-related causes (Maria, 2019).

In response to environmental variation and its effects on rural communities and pastoralists, the Ethiopian government has developed strategies for adaptation. The National Adaptation Programme of Action (NMA, 2007) documented that the most vulnerable segments of the population are smallholder rain-fed farmers and pastoralists, and provided guidelines to assist these communities in adjusting to the changes brought about by climate change. Unlike industrialised countries, which are mandated to reduce greenhouse gas emissions, Ethiopia's primary strategy is to adapt to and mitigate the impacts of climate variability through proactive national plans and realistic mitigation and adaptation efforts. However, balancing limited water resources with increasing agricultural demands remains a significant challenge, particularly in dryland regions. Therefore, Ethiopia plays a significant role in setting and implementing the Sustainable Development Goals (SDGs) at both grassroots and managerial levels guided by the principles of all 17 SDGs, but still it remains high demand for an effective pastoral adaptation strategy to climate change. Based on the aforementioned SDGs barriers, it is evident that both institutional and indigenous knowledge systems are valuable in justifying the possessions of climate change on communities dependent on agriculture and pastoralism. Therefore, this study seeks to explore and examine the development challenges faced by pastoralists in the Somali region in responding and adapting to climate change.

Moreover, climate change adaptation consists of a set of activities that range from addressing the drivers of vulnerability to building response capacity for managing climate risk and confronting climate change. Addressing this issue requires a clear understanding of how human activities, particularly agricultural practices, shape the association between water accessibility and carbon cycling. Pastoralists, who are among the most climate-sensitive groups, continue to face harsh and worsening environmental conditions. This means that they need for more effective, context-specific approaches that address both resource constraints and community knowledge gap (Khattak et al., 2025). The developing countries, including Ethiopia, historical records indicate that climatic shocks, such as droughts, were not new phenomena. Pastoral communities have therefore long experienced such shocks and have historically relied on indigenous knowledge to adapt to climate change. Numerous studies have demonstrated that indigenous knowledge systems have been useful in mitigating the consequence of climate disparity on rural societies. Thwarting and mitigating the impacts of climate-related disasters requires a combined intervention that integrates both scientific and indigenous approaches, by combining local knowledge with scientific understanding offers a practical way to improve climate change adaptation and strengthen community resilience (Mwalwimba et al., 2024).

Study conducted in north-eastern Brazil, noted that local people possess strong indigenous knowledge schemes for adversity management, rain prediction, and adaptation plans (Kamara 2007, Pennesi, 2007). This makes pastoralists further resistant to environmental change and outdoor shocks. Nevertheless, the effect of recent disasters has been so severe that indigenous knowledge has been unable to response it, as the challenges have exceeded its capacity (IKS). In such issue, institutional interference becomes vital. Moreover, in Ethiopia, climate change has severely affected the livelihood options of pastoralists, as current estimates show that 20.4 million people require food assistance (WFP, 2022). The drivers for this need include crop disease, instability, internal displacement due to conflict, and prolonged severe drought.

The study area is one of the most drought-prone and vulnerable parts of the country due to similar agro-ecological characteristics, same livelihood profile of the communities, and highly inconsistent rainfall and high temperatures. In addition to that, the area's rainfall pattern is very fluctuating from season to season, which causes food insecurity problems. Pastoral populations rely heavily on adaptation strategies to sustain their livelihoods in this harsh ecosystem. The knowledge, skills, and attitudes toward climate change and adaptation differ from one pastoralist community to the next. In the study, community-based coping reactions to climate effect and change is not well acknowledged due to unknown reasons. Distinguishing between local adaptive capacity and government response to climate change is essential for designing suitable adaptation strategies. Specifically, this study contributes by inspecting the extent of climate change's impact on pastoralist communities by inspecting the existing pastoralist adaptation mechanisms. Moreover, this study was explored existing institutional interventions and whether they complement pastoralist adaptation mechanisms by suggesting ways through which pastoralists can successfully handle the influence of climate change.

1.2. Problem Statement

This study aims to find gaps in how climate change has influenced pastoralist communities and suggest ways to improve it through adaptation and coping techniques. It intends to engage different participants, such as policymakers, researchers, the private actors, climate experts, and government officials to certify that climate change adjustment measures are taken at community and government level intervention. Moreover, this study was evaluated the effectiveness of such measures and their complementarity with pastoralists' adaptation and coping mechanisms, thereby promoting resilience and sustainability among pastoralist communities facing climate change. In this section, the researcher was presented the problem statement regarding to the five-stage approach by formulating the research gap as follows:

Stage 1: The Ideal Situation

Climate change poses serious challenges to human existence, while climate change remains a global threat it is worth mentioning that vulnerable societies like those in emerging nations are at a higher hazard to climate change. Regarding to (Mason, et al, 2015) developing countries face a greater degree of defencelessness to ecological deforestation than developed counterparts do. It is essential to note that the exposure of developing countries to environmental shift is an outcome of combined aspects, containing lack of good governance, limited of economic and human skills, lack of technology and political will (Sova et al., 2017). In an ideal situation, these communities would be supported by responsive institutional frameworks government policies, development programmes, and early warning systems that complement rather than undermine their existing adaptive strategies. Globally, climate change adaptation frameworks, including the Paris Agreement (2015) and the Sendai Framework for Disaster Risk Reduction (2015–2030), call for inclusive, community-centred approaches that integrate local knowledge with scientific evidence to build resilience among the most climate-vulnerable populations. This means that in normative context that pastoralist communities in Ethiopia's Somali Region face challenges in getting coherent, well-resourced, and culturally appropriate adaptation interventions that protect their livelihoods and strengthen their long-term resilience.

Stage 2: The Actual Situation

In developing countries, climate change has caused indescribable human suffering including hunger and starvation, mass displacements, conflicts and political instabilities (Maino & Emrullahu, 2022). Climate change understood here as the long-term shifts in temperature and precipitation patterns attributable to anthropogenic greenhouse gas emissions has intensified the frequency and severity of droughts, eroded rangeland productivity, and disrupted the seasonal rainfall patterns on which pastoral livelihoods depend (IPCC, 2022). It is important to distinguish climate change from climate variability, which refers to short-term fluctuations in climatic conditions around a long-term mean; while pastoralists have historically adapted to variability, the accelerating pace of climate change now exceeds the capacity of traditional adaptive strategies to absorb (Deressa & Kassie, 2024). Furthermore, methodologically, the existing research relies on single-method designs, binary outcomes, and cross-sectional snapshots that miss the complexity of adaptive multi-dimension responses. Similarly, a conceptual distinction must be drawn between adaptation the deliberate, longer-term adjustments to reduce vulnerability to climatic shifts and coping, which refers to short-term responses that manage immediate climatic stress without necessarily reducing underlying vulnerability (Abebaw, 2025). In practice, pastoralists in the Somali Region are increasingly forced into reactive coping responses distress livestock sales, displacement, and dependence on food aid rather than proactive

adaptation, reflecting a deepening erosion of adaptive capacity (Mahad, 2020). Current estimates suggest that 20.4 million people in Ethiopia require food assistance because of climate-related shocks (WFP, 2022), with pastoral communities in the Somali Region among the most acutely affected.

Stage 3: The Evidenced Research Gap

Despite the scale and urgency of this crisis, significant gaps remain in the scholarly literature. Empirically, the Somali Region is markedly under-represented in climate change adaptation research; the majority of comparable studies have focused on the Afar Region, Oromia, or the Ethiopian highlands, leaving the specific dynamics of pastoral adaptation in the Somali Region largely undocumented (Ahmed et al., 2023). Methodologically, existing studies have predominantly relied on single-method quantitative designs, binary operationalisations of adaptation outcomes, and cross-sectional snapshots that fail to capture the complexity and diversity of adaptive responses among pastoral households (Deressa & Kassie, 2024). Theoretically, few studies have integrated Afrocentric perspectives, the Capability Approach, and the Sustainable Livelihoods Framework in a unified analytical architecture to examine pastoral adaptation a gap that limits the depth of theoretical interpretation available in the field. Practically, while institutional interventions such as the Productive Safety Net Programme (PSNP) and Pastoral Community Development Project (PCDP) have been operating in the region, the extent to which they genuinely complement pastoralists' indigenous adaptation mechanisms remains poorly understood and empirically understudied (Khattak et al., 2025). In short, what is known is that pastoralists in Ethiopia face intensifying climate stress; what is inadequately known is how pastoral communities in the Somali Region specifically are adapting, what determines the effectiveness of their adaptation strategies, and whether institutional interventions are meaningfully complementing or inadvertently displacing community-driven adaptive responses.

Stage 4: Implications and Statement of Intent

The Implications and Statement of Intent need to carryout serious consequences. Smallholders in Ethiopia's lowlands depend continually on rain-fed cultivation as the primary basis of their earnings. However, this sector faces uncertainties due to widespread climate distress and a diminishing capability of pastoralists to regulate to the influences of weather change (Debela et al., 2019). Without a clear, empirically grounded understanding of the adaptation dynamics specific to the Somali Region, policymakers risk designing interventions that are poorly targeted, culturally inappropriate, and ultimately counterproductive. It means that without theoretical integration, the scholarly literature on pastoral adaptation in Ethiopia will continue to

produce descriptive accounts that fail to generate the analytical depth required for knowledge advancement of pastoral societies. Practically climate change interventions exist like PSNP and PCDP in the region but it miss stakeholder collocation and inadvertently displace indigenous adaptation remains poorly understood. This study therefore seeks to generate new knowledge by adaptation to climate change impacts on pastoralist communities in the Somali Region of Ethiopia, identifying the adaptation mechanisms they employ, assessing the extent to which institutional interventions complement these mechanisms, and proposing evidence-based pathways through which pastoralists can more effectively adapt to climate change. In doing so, the study makes a triple contribution: academically, empirically, by producing the first comprehensive mixed-methods evidence base on pastoral adaptation across six districts of the Somali Region. Theoretically, by integrating Afrocentricity, the Capability Approach, and the SLF in a coherent analytical framework applied throughout the study and methodologically. This means by employing a descriptive research design with mixed-methods that combines household survey data (n=384) followed by qualitative evidence from focus group discussions and key informant interviews to triangulate findings and deepen interpretation.

Stage 5: The Case for the Study Setting

The Somali Region of Ethiopia provides a uniquely compelling and analytically appropriate setting for this inquiry. With a pastoral population of approximately 5,748,998, the region is one of the most drought-prone and ecologically fragile parts of Ethiopia, characterised by agro-ecological conditions that make its communities acutely sensitive to climate variability and change (CSA, 2017). The region's pastoral communities have experienced multiple severe drought cycles in recent decades most notably in 2011, 2016–2017, and 2021–2022 yet remain among the least studied in the Ethiopian adaptation literature. Furthermore, the Somali Region's distinct cultural, linguistic, and institutional context, shaped by Somali pastoral traditions and customary governance systems, demands an Afrocentric analytical lens that centres indigenous knowledge and lived experience alongside formal scientific frameworks. Studying adaptation in this specific context therefore offers not only local policy relevance but also broader theoretical insights applicable to pastoral communities across the Horn of Africa and beyond.

1.3. Rational of the Study

Globally climate change mitigation strategies needs the intensive capital investments and prolonged international negotiations among industrialized nations, while immediate adaptation measures remain the most viable concern for vulnerable populations. This study delves the impacts of climate change on pastoralists by emphasizing the role of institutional interventions in complementing the management and adjustment mechanisms engaged by these communities. It provided valuable insight into how pastoralists

track diverse livelihood alternatives to endure their living under harsh and severe climatic conditions. This inquiry underscores the critical importance of climate change adaptation within pastoralist communities of Somali Region of Ethiopia. By focussing on the primary impacts of climate change and exploring existing community perceptions of how pastoralists leverage Indigenous Knowledge Systems (IKS) alongside modern scientific insights to navigate harsh and shifting climatic realities. Moreover, this study aims to fill a notable gap in climate adaptation scholarship by illustrating how formal institutional interventions can effectively complement, rather than override, the organic adjustment and survival mechanisms pioneered by these communities.

The practical outcomes of this research offer immediate and direct benefits to the pastoralists within the study setting as well as pastoralists in other parts of the country. For the local pastoralist communities, this study validates and documents their native knowledge, providing them with a structured framework to merge traditional skills with modern adaptation technologies to withstand climate-induced vulnerabilities like severe drought, poverty, and food insecurity. Furthermore, pastoralist societies across different regions of the country share comparable ecological pressures, the coping mechanisms and alternative livelihood paths identified in this setting can serve as a scalable blueprint. This allows pastoralists in other arid and semi-arid zones of the regions to engage in cross-regional learning, utilizing these documented reworking methods to enhance their own climate resilience and socio-economic security.

Beyond the communities themselves, this study yields significant administrative and strategic value for policymakers and development planners. For policymakers, the findings provide essential, bottom-up empirical data on community perceptions and localized vulnerabilities. This shifts the policy paradigm from generic, top-down mandates toward evidence-based, cost-effective frameworks that leverage existing indigenous structures to moderate climate shocks. Concurrently, development planners and regional administrators gain an informed roadmap to design and implement targeted intervention practices. By understanding the specific gaps where external aid can best integrate with local coping systems, planners can optimize resource allocation and execute alternative climate change adaptations that are socially, economically, and environmentally sustainable.

Finally, this research contributes foundational value to researchers and the broader academic community. By addressing specific geographical and thematic gaps in climate adaptation scholarship particularly regarding the role of Indigenous Knowledge Systems in the Somali Region of Ethiopia which was documented for their (value, perceptions, adaptation mechanism and knowledge) by integrating using

theoretical frameworks such as SLF, Capacity theory and Afrocentric theory. In addition, it provides future scholars with critical baseline data, conceptual tools, and fresh insights into how traditional societies undergo structural changes to solve modern environmental crises. In doing so, it opens new avenues of academic inquiry into the preservation and integration of indigenous sciences within global climate change literature.

1.4. Purpose of the Study: Research Objectives

1.4.1. General Objective of the Research

The general objective of this study is to examine adaptation to climate change among pastoralist communities of Somali Region, Ethiopia.

1.4.2. Specific Objectives

1. To explore the extent of climate change impact on pastoralist communities in the Somali region of Ethiopia.
2. To determine the existing pastoralist adaptation mechanisms in the Somali region of Ethiopia.
3. To examine the extent to which existing institutional interventions compliment pastoralists' adaptation mechanisms.
4. To suggest ways through which pastoralists can effectively adapt to the impact of climate change in the study area.

1.5. Research Questions

The study seeks to answer the following research questions in order to meet the aforementioned objectives:

1. To what extent does climate change impact pastoralist communities in the Somali region of Ethiopia?"
2. What are the existing pastoralist adaptation mechanisms in the study area? How effective are these adaptation strategies?
3. To what extent do the existing institutional interventions compliment pastoralists' adaptation mechanisms?
4. In which ways can pastoralists effectively adapt to the impact of climate change?

1.6. Scope and Limitations of the Study

The context of this research is delimited to pastoralist communities living in the Somali Region of Ethiopia. The investigation was focused on three zones within the region, with two districts were chosen from each zone, to find the bearing of weather change and alteration mechanisms involved by these populations. Similarly, while this study focuses on adjustment to climate change among pastoralist communities, it is essential to note that it does not extensively delve into various elements including political, monetary,

collective, and racial factors. These factors may be complex and require further investigation, but it was determined the extent of vulnerability among the communities and their capacity to adjust and manage the consequences of climate change.

In this study, a total of 384 respondents, twelve (12) key informants, and three (3) focus groups discussions were involved to gather the necessary data and insights. However, it is crucial to acknowledge certain barriers in collecting essential data for this research. These barriers include challenges related to poor road conditions in the area, limited transportation facilities, geographical distance, political instability, and participants' reluctance to give correct data about the topic. These elements may have a negative impression on the outcomes of the analyses. The study also highlight the complexities associated with the bearings of climate elements on the lives of pastoral people, as well as the roles of stakeholders' interferences to raise the ability of pastoralists to manage with climate transformation. Moreover, it is vital to know that the study's scope is restricted to adaptation to climate change and strategies for pastoralists' coping mechanisms, rather than encompassing climate change mitigation and policy development.

The reason for prioritizing adaptation as a reaction alternative to climate change is that pastoral communities already rely on their original knowledge to familiarize with the belongings of climate change. On the other hand, justification approaches intended at minimizing greenhouse gas emissions often require substantial funding and consultation with industrialized countries. However, investigating the relationship among the susceptibility of pastoralists to climate change and the existing reworking methods used in pastoral groups is crucial. To manage these challenges, the investigators needed to pay attention to the interrelationships among climatic factors, policy measures, adaptation mechanisms, demographic options, and natural aspects that influence the findings.

Structure of the Dissertation

Chapter One: General Introduction

This section delivers an outline of the study by offering its background, statement of the problem, rationale, objectives, research hypothesis, and scope. It outlines the significance of exploring adaptation to climate change among pastoralist communities in the Somali Region of Ethiopia. The chapter also introduces the methodological and conceptual foundation that guides the subsequent chapters.

Chapter Two: Literature Review

This section investigates crucial findings of existing literature on climate change, its impacts on pastoralist occupations, and the range of adaptation policies employed in world nations, with particular emphasis on Africa and Ethiopia. It synthesizes key concepts, theoretical perspectives, and empirical findings across

several thematic areas, including climate change and variability in the global context; climate change dynamics in Africa; the vulnerability of Sub-Saharan African pastoralists; climate change impressions on Ethiopian pastoralist societies; and the adaptation and coping mechanisms currently practiced. The review further examines the level to where climate change affects pastoral systems, drawing on evidence of ecological deprivation, resource scarcity, and livelihood stress. In addition, the chapter explores institutional interventions such as government policies, development programs, and humanitarian responses and their role in enhancing or constraining pastoral resilience. Special attention was given to the contribution of Indigenous Knowledge Systems (IKS), which played the vital role in shaping community-based strategies for managing climate variability. By integrating insights from these diverse bodies of literature, the chapter establishes both the academic foundation and the policy relevance of the current study, while also identifying gaps that the research seeks to answer.

Chapter Three: Theoretical/Conceptual Framework

This chapter gives the theoretic perspectives and conceptual models that reinforce the results. It examines key theories including Afrocentricity Theory, the Sustainable Livelihood Framework (SLF), and Capability Theory and explains their relevance to understanding how pastoralist communities respond to climate-related stresses. By defining the core concepts associated with each theory and illustrating how they interrelate, the chapter establishes an integrated conceptual framework. This framework connects cultural perspectives, livelihood assets, and human capabilities, thereby guiding the study's data gathering, analysis, and interpretation in a coherent and holistic manner.

Chapter Four: Research Methodology

This chapter sketches the methodological method involved to achieve the research objectives. The chapter offers in depth depiction of the study area, research paradigm, the research approach and design. It further describes the study setting and population, data collection methods and procedures, and data analysis strategies. In addition, the chapter discusses the steps made to guarantee rigour particularly validity and reliability and the ethical concerns upheld through the investigation procedure. By justifying the use of a mixed-methods design, the chapter demonstrates how combining mixed methods offers an extensive knowledge of climate change adaptation in pastoral regions.

Chapter Five: The Extent and Impact of Climate Change on Pastoralists

This chapter represents the results relates to demographic details of the participants and extent and impact of climate change on pastoralist communities in the Somali Region. It explores access to early warning information, observed changes in climate outlines particularly rainfall variability and temperature shifts and

effects on livestock productivity, grazing land conditions, and agricultural output. It also assessed the severity of climate change and its observed impacts on natural resources. By analysing forms of drought, rainfall variability, and temperature fluctuations, the chapter illustrates how these climatic changes shape livestock production, food security, migration dynamics, and social stability. The discussion further connects these empirical findings to the vulnerability and adaptation frameworks introduced in the preceding chapters.

Chapter Six: Existing Pastoralist Adaptation and Coping Mechanisms

This chapter examines the existing pastoralist adaptation and coping mechanisms, including the strategies used by pastoralist communities, qualitative insights into these responses, the character of the dependent variable in the analysis, and the outcome of the binary logistic regression analysis. It explores traditional knowledge systems, livelihood diversification practices, mobility patterns, resource-sharing arrangements, and social networks that contribute to community resilience. Furthermore, the episode estimates the usefulness and sustainability of these indigenous coping mechanisms in addressing both current and emerging climatic challenges. By integrating qualitative and quantitative findings, the chapter provides a comprehensive understanding of how pastoralists adapt to climate variability and the issues that influence their adaptation decisions.

Chapter Seven: Institutional Interventions and Complementarity with Pastoralist Adaptation Mechanisms

This chapter investigates institutional responses to climate change adaptation among pastoralist communities. It assesses the climate change interferences applied in the study region, the support provided to pastoralists, the degree of institutional assistance, and the major intervention strategies used to help communities cope with climate-related challenges. The chapter further analyzes the degree to which these institutional efforts complement or fail to complement existing local and indigenous coping mechanisms. By examining gaps in policy alignment, coordination, and implementation, the chapter highlights the strengths and limitations of current institutional approaches in supporting effective and sustainable adaptation among pastoralist populations.

Chapter Eight: Suggesting ways pastoralists can effectively cope with the impact of climate change.

Based on the findings, this chapter presents evidence-based suggestions for strengthening the capability of pastoralist societies to climate change. It discusses key themes, including climate variability and its implications for pastoralist coping strategies, effective ways of managing the consequences of changing the climate, the integration of indigenous and methodical knowledge, and the major constraints and challenges affecting the operation of adaptation tactics. The chapter highlights the importance of participatory,

community-driven approaches that link the gap between local practices and formal adaptation systems, ensuring that interventions are culturally appropriate, sustainable, and context-specific.

Chapter Nine: Conclusions, and Recommendations

The last chapter of findings conclusions the major findings of adaptation to climate change among pastoralist communities in relation to objectives and research questions. It highlights key insights regarding the extent of climate change impacts, the effectiveness of adaptation practices, and the role of institutions. The chapter then makes concrete suggestions to governments, collaborators in development, and the local population on strengthening climate resilience among pastoralist populations. It also suggests areas for future research to address remaining knowledge gaps.

Conclusion

In Conclusion, this chapter provided the introduction, followed by the background of the study, problem statement of the problem, research objectives, and research questions, significance of the study and structure of the dissertation. By establishing the conceptual, contextual, and methodological foundation of adaptation to climate, change among pastoralist communities in the Somali Region of Ethiopia is mandatory. The chapter outlined the background of the study, demonstrating that climate change pretences a severe danger globally, with particularly devastating effects on vulnerable populations whose occupations depend on cultivation and pastoralism. The discussion revealed that pastoralist communities in Ethiopia, especially in the Somali Region, face repeated droughts, food insecurity, and displacement due to the increasing variability of rainfall and rising temperatures.

The magnitude of climate change problem affects the sustainable pastoral livelihoods, emphasizing that limited institutional capacity, weak governance, and scarce resources exacerbate vulnerability. This study was underscored by the pressing need to examine both indigenous and institutional responses to climate change, recognizing that while the government has developed national adaptation strategies, tangible improvements at the community level remain limited. This research acknowledges the important role of Indigenous Knowledge Systems (IKS) in enhancing resilience, stressing that combining traditional and institutional approaches can yield more sustainable adaptation strategies.

The focus and objectives of the research were formulated to explore how pastoralist communities perceive and respond to climate change by identifying the existing coping mechanisms, and assess the effectiveness of institutional interventions. The corresponding research questions were designed to guide systematic analysis across these dimensions. Moreover, the scope focused on pastoralist communities in selected

zones and districts of the Somali Region, while the limitations were due to financial, logistical, geographical distance, and political challenges that may affect data collection and generalization of results. Ultimately, this chapter has provided a structured framework for thoughtful the complexity of climate change adaptation within pastoral contexts. It justified the relevance of investigating both local and institutional measures as complementary pathways toward sustainable resilience. The insights gained from this introductory chapter guide the subsequent analysis and underscore the need for integrated adaptation strategies that strengthen pastoralists' capacity to adjust the persistent and evolving encounters of climate change in Ethiopia.

Chapter Two: Literature Review

Introduction

This chapter reviews existing literature on climate change and adaptation strategies among pastoral communities, with a focus on Ethiopia and comparisons to other regions. Pastoralists, whose livelihoods depend on livestock and mobility across large areas, are among the highest defenceless to climate change. Their heavy reliance on natural resources makes them highly susceptible to droughts, erratic rainfall, and high temperature. The literature highlights both the challenges these communities face and the traditional coping and adaptation strategies with the support of three relevant theories, which are, Afrocentricity, the Sustainable Livelihoods Framework (SLF), and Capability Theory. However, these strategies are increasingly strained as climate change intensifies. The review identifies key themes, trends, and gaps in research concerning the usefulness and limits of pastoralist mitigation efforts.

The chapter discusses climate change and effects globally, in Africa, and specifically in Ethiopia, where pastoralism remains a dominant livelihood system. It observes the extent of ecological impressions on pastoralists, existing adaptation and coping mechanisms, institutional interventions, and how these support or hinder pastoralist resilience. Despite existing adaptive practices, pastoralists remain to face complications such as inadequate opportunity, weak institutional support, and rapid environmental change. By synthesizing current knowledge, this chapter aims to inform future research and policy efforts that strengthen sustainable and effective adaptation strategies for pastoral communities. The findings are intended to guide policymakers, practitioners, and researchers in promoting more resilient pastoral livelihoods.

2.1. Theoretical Review

2.1.1 Review of Concepts and Key Issues

2.1.1.1. *Climate Change*

Climate change refers to long-term shifts in global or regional temperatures, precipitation patterns, and other climatic conditions that persist over decades or longer, primarily driven by anthropogenic greenhouse gas emissions resulting from industrial activity, deforestation, and fossil fuel combustion (Abebaw, 2025). In the context of this study, climate change manifests in Ethiopia through rising mean temperatures, declining and increasingly erratic rainfall, intensifying drought cycles, and the progressive degradation of rangeland ecosystems upon which pastoral livelihoods depend. According to (Abtew et al., 2019) confirm that these long-term climatic shifts are compounding existing ecological stressors in dryland Africa, reducing the productive capacity of land and water resources that pastoral communities have historically managed through

indigenous governance systems. It is important to distinguish climate change conceptually from weather variability: while a single drought season represents a weather event, the systematic intensification of drought frequency and severity observed across the Horn of Africa over recent decades constitutes climate change in the fullest scientific sense (FAO, 2022). For pastoralist communities in the Somali Region, this distinction carries profound practical significance that determines whether adaptive responses need to be short-term and reactive, or long-term and transformational.

2.1.1.2. Climate Variability

Climate variability refers to fluctuations in climatic conditions particularly temperature and precipitation around a long-term mean, occurring over shorter time scales such as seasons, years, or decades (Amogne et al. 2017). Unlike climate change, which implies a directional and sustained shift in climatic baselines, climate variability encompasses the natural oscillations of the climate system, including phenomena such as the El Niño–Southern Oscillation (ENSO), which has historically driven rainfall variability across the Horn of Africa. Similarly document that increased climate variability even in the absence of directional climate change poses serious risks to agricultural productivity by disrupting planting calendars, increasing crop failure risks, and undermining long-term investment in land management (Hatfield et al. 2021). For pastoralists in the Somali Region, climate variability is not a new phenomenon; pastoral systems have historically been organized around managing variability through mobility, herd diversification, and communal resource governance. However, the convergence of intensified variability with long-term climate change is eroding the effectiveness of these traditional adaptive strategies, creating a qualitatively new challenge that demands both indigenous and institutional responses.

2.1.1.3. Adaptation

Adaptation to climate change refers to the deliberate adjustments made by individuals, communities, institutions, and systems in response to actual or anticipated climatic changes and their effects, with the aim of reducing harm or exploiting beneficial opportunities. The Intergovernmental Panel on Climate Change (IPCC, 2022) distinguishes between autonomous adaptations spontaneous responses to climatic stimuli without deliberate planning and planned adaptation, which involves intentional policy and programmatic interventions designed to reduce long-term vulnerability. In the context of this study, adaptation encompasses both dimensions: the indigenous and community-driven strategies that pastoralists in the Somali Region have developed over generations, and the externally designed institutional interventions implemented by the Ethiopian government and development partners. According to (Abebaw, 2025) identifies a wide range of adaptation strategies employed by farmers and pastoralists in sub-Saharan Africa, including crop and

livestock diversification, improved water harvesting, adoption of drought-resistant varieties, seasonal migration, and engagement in off-farm income activities. This conceptual distinction is analytically significant for this study because conflating the two risks misrepresenting the depth of community responses and overstating the transformative potential of what are, in many cases, survival strategies rather than developmental adaptations.

2.1.1.4. Coping Mechanisms

Coping mechanisms refer to the short-term, reactive strategies employed by individuals and households to manage the immediate consequences of climatic shocks, particularly during acute events such as droughts, floods, or livestock disease outbreaks. Unlike adaptation, which involves forward-looking restructuring of livelihoods, coping mechanisms are primarily defensive and temporary, aimed at maintaining survival and minimizing immediate losses rather than building long-term resilience (Aynalem, 2020). Common coping strategies among pastoral communities include distress sale of livestock, reduction of household food consumption, temporary migration to urban areas in search of wage labour, and reliance on social safety nets and food aid (FAO, 2022). This erosion of assets through coping represents one of the most damaging consequences of recurrent climatic shocks for pastoral communities in the Somali Region, as the progressive depletion of livestock herds reduces both immediate household welfare and the foundation for future adaptive capacity. In this study, coping mechanisms are treated as analytically distinct from adaptation strategies, though the two are recognized as existing on a continuum: effective institutional interventions should aim to shift communities from reactive coping toward proactive adaptation by strengthening the asset base and enhancing access to information, markets, and governance systems.

2.1.1.5. Resilience

Resilience, in the context of climate change and pastoral livelihoods, refers to the capacity of a system whether an individual household, a community, or an ecosystem to absorb disturbance, reorganize under stress, and continue developing along a trajectory that maintains its essential functions and identity (Deressa and Kassie, 2024). The conceptualized resilience in agricultural and pastoral systems as comprising three core dimensions, which are absorptive capacity (the ability to withstand shocks without losing core assets), adaptive capacity (the ability to adjust livelihood strategies in response to changing conditions), and transformative capacity (the ability to fundamentally restructure livelihoods when existing systems are no longer viable). Pastoral livestock systems exhibit considerable inherent resilience, rooted in centuries of adaptation to climatic uncertainty, but that this resilience is being eroded by the convergence of climate change, land degradation, sedentarisation pressures, and policy environments that marginalize pastoral

mobility (Escarcha and Zander, 2018). Theoretically, resilience in this study is understood through the lens of the Sustainable Livelihoods Framework, which positions resilience as an outcome of the interaction between livelihood assets, the vulnerability context, and institutional processes rather than as a static property of communities or individuals.

2.1.1.6. Vulnerability

Vulnerability refers to the degree to which a system, community, or individual is susceptible to harm from climate change, determined by the interaction of exposure to climatic hazards, sensitivity to those hazards, and adaptive capacity to respond to them. The (IPCC, 2022) defines vulnerability as a function of three components: the nature and magnitude of climate hazards to which a system is exposed; its sensitivity, or the degree to which it is affected by those hazards; and its adaptive capacity, to adjust, cope with, recover from, or take advantage of climatic changes. According to (Ahmed et al., 2023) demonstrate that vulnerability in climate-sensitive livelihood systems is not merely a function of environmental exposure but is deeply shaped by socioeconomic inequalities, governance failures, and structural marginalization that underscore the importance of examining vulnerability through both the Capability Approach and the Sustainable Livelihoods Framework of pastoralists communities. Moreover, according to (Assefa et al., 2022) further illustrate how climate-induced vulnerabilities cascade across livelihood systems, with the proliferation of agricultural pests demonstrating how changing climatic conditions create new and compounding threats that exceed the adaptive capacity of individual households.

2.1.1.7. Indigenous Knowledge

Indigenous knowledge, refers to the traditional ecological knowledge or local knowledge, encompasses the accumulated understanding, practices, beliefs, and innovations that communities develop over generations through direct interaction with their natural environment. Afrocentricity is one of the theoretical frameworks underpinning this study, positions indigenous knowledge not as supplementary or inferior to scientific knowledge but as epistemologically legitimate in its own right a primary source of adaptive intelligence that has enabled pastoral communities in the Horn of Africa to survive and manage climatic variability for centuries (Asante, 2003). However, the indigenous knowledge systems are increasingly under threat from sedentarisation, cultural change, and formal education systems that devalue local knowledge and institutional frameworks that privilege scientific over community-based approaches (Abebaw, 2025). The critical finding of this study that statistical relationship between indigenous knowledge and adaptation outcomes on how indigenous knowledge is operationalized in quantitative research and whether survey-based measures adequately capture and contextually embedded. This study therefore treats indigenous knowledge both as a

variable to be tested quantitatively and as a body of community experience to be understood qualitatively through focus group discussions and key informant interviews.

2.1.1.8. Pastoralism

Pastoralism refers to a livelihood system and way of life characterized by the extensive, largely mobile herding of livestock including camels, cattle, goats, and sheep across rangelands, in a manner that is adapted to the spatial and temporal variability of pasture and water availability in arid and semi-arid environments (Escarcha and Zander, 2018). Pastoralism is an ancient, ecologically efficient dryland system. Its core strategy is mobility by moving herds to track rainfall and pasture to navigate climate variability. This study transcends pastoralism through its social, cultural, and ecological dimensions, which grounded in an Afrocentric framework of lived experiences and indigenous knowledge of African communities. Moreover, the capability Theory further enriches this perspective, framing pastoralism not just as a production system, but as a way of life, that enables vital human freedoms such as mobility and communal governance. However, these culturally meaningful livelihoods are increasingly threatened by climate change and poorly designed institutional interventions.

Empirical Review

2.2. Climate change and variability in the global context

Global climate change and impacts have emerged as complex and formidable ecological challenges confronting humanity today. As global warming intensifies, shifts in daily temperature and precipitation patterns are becoming more evident, driven by changes in both their average values and day-to-day variability (Nordling et al., 2024). These evolving weather conditions are already manifesting as extreme climate events. For instance, in 2023, numerous regions faced an exceptionally hot summer marked by record-breaking temperatures. These heat waves were accompanied by widespread wildfires, and in some areas, extreme rainwater led to serious flooding, highlighting the growing impact of climate instability across the globe. The Inter-governmental Panel on Climate Change (IPCC) has concluded that there is a definite and statistically substantial rise in either the average global climate. This increasing movement will remain unless the world takes action to limit emissions of carbon dioxide (CO₂) and other greenhouse gases (GHGs) (Kidanu et al., 2016). Climate change, along with related disasters and punishing weather trials, has developed a major driver of food insecurity, impacting all aspects of food dimensions and elevating the risk of food insecurity leading hunger and malnutrition (Ozkan et al., 2022). This global trend is reflected at the regional context, specifically in sub-Saharan Africa, where agriculture tends the economic backbone of several nations. Despite its central role, agricultural production in the region has not kept pace with the rapidly

growing demand for food. These phenomena are acknowledged as severe pressures to growth insights, exerting profound effects on various aspects of our world, including the ecosystems, economic activities, human health, food security, natural resource administration, and development of infrastructure (Nicholson, 2014).

Climate variability, as stated by the Inter-governmental Panel on Climate Change (IPCC, 2007), encompasses fluctuations in the average mean and other statistical characteristics of the climate across various sequential and dimensional measures, extending besides distinct weather trials. Climate variability manifests as season to season difference in climatic essentials such as temperature and precipitation across various regions of the globe. These fluctuations contribute to an intricate tapestry of natural climate patterns, particularly affecting pastoral communities in unindustrialized nations. On the other hand, climate change denotes a lasting alteration in meteorological conditions that persists over long periods, spanning decades to centuries. It examines the broader picture, climate change emerges as a transformative force, signifying a significant shift in prevailing weather patterns and atmospheric conditions.

Climate change is complex and challenging issues affecting both humans and the environment, with especially significant impacts on pastoralist activities and agricultural production. In this context, placing a strong emphasis on long-term planning becomes crucial for managing dryland systems, as global warming is expected to increase aridity and further strain these already vulnerable livelihoods (Salinger, 2017). Climate projections consistently suggest that increasing aridity in these regions was further constrained farming systems due to reduced soil moisture levels. Climate change affects rainfall patterns, including timing, intensity, and distribution, leading to droughts, floods, and prolonged dry spells. As a result, the availability of water for livestock and crops is disrupted, creating challenges for pastoralists to meet their water requirements (IPCC, 2014, p. 11; Thornton et al., 2009, p. 327). Additionally, increasing temperatures and fluctuating precipitation patterns reduce the productivity of natural pastures, making it difficult for pastoralists to find enough forage for their livestock. This exacerbates water stress by limiting water availability for livestock and irrigation in agricultural production (IPCC, 2014). This water stress, coupled with climate-related factors, can also increase the distribution and prevalence of livestock diseases, thereby negatively impacting the health and productivity of pastoral herds. Habitat degradation and loss endured by climate change contribute to a decline in biodiversity, affecting the diversity of plant and animal species that are essential for the long-term existence of pastoralist structures (Perry et al., 2013, p. 10). These cumulative effects of reduced agricultural productivity, livestock losses, and limited access to water and pasture ultimately lead to food insecurity among pastoralist communities.

Currently, around 3.3 to 3.6 billion people live in environments that are more susceptible to climate change (Solecki et al., 2022). This vulnerability has profound implications for people's livelihoods, agricultural practices, and their capacity to ensure food security. Consequently, these circumstances contribute to the heightened occurrence and severity of future disease outbreaks, particularly in pastoral regions, which are marginalized communities facing exclusion from policy formulation and implementation. For instance, it is important to prioritize and invest in climate change adaptation measures which are responsive to the needs of susceptible pastoral communities. Adapting to climate change poses significant challenges for pastoral societies, further complicated by issues of climate justice and uncertainties regarding future effects due to limited knowledge and financial constraints among communities (Petzold et al., 2020). Communities worldwide face several obstacles in implementing effective climate change adaptation due to financial scarcity, knowledge limitations, and the rising frequency of natural events. For instance, climate change has contributed to escalating number of people facing extreme food insecurity, with more than 828 million people going to bed hungry every night (WFP, 2022). It is important to recognize that human activities significantly contribute to climate change, thereby exacerbating its detrimental effects on society and environmental sustainability year after year. Those human activities include the release of industrial greenhouse gases, deforestation, the heating of fossil fuels, charcoal production, agricultural practices, and urbanization (IPCC, 2023). Climate change poses a significant danger to development initiatives by influencing various areas such as the environment, human health, economic growth, and social services (Nicholson, 2014).

2.2.1. Global Temperatures

The global warming signal, inter-annual to decadal climate variability is a strong feature of east coast dry land climates (Salinger, 2017). According to global climate data of 2024 ranks as the warmest year since instrumental records began in 1850, with a global surface temperature anomaly of 1.29°C (2.32°F) above the 20th-century average of 13.9°C (57.0°F). This marks a significant increase of 0.10°C (0.18°F) over the past record set in 2023, further emphasizing the on-going trend of accelerated global warming. Notably, each of the ten warmest years in the 175-year observational record has occurred within the past decade (2015–2024), underscoring the persistent and intensifying impact of anthropogenic climate change.

This recent warming trend also highlights a significant shift in the historical temperature rankings. For instance, the year 2005 were the initial year to set a new world heat record in the twenty-first century, has now been surpassed by numerous subsequent years and currently ranks as the 13th-warmest year on record.

Similarly, 2010, was the period exceeded 2005 in global temperature, now occupies the 12th position (Vose et al., 2021). These changes reflect not only the increasing frequency of record-breaking temperatures but also the rapid pace at which previous climate benchmarks are being eclipsed in the modern era.

Global Land and Ocean Average Temperature Anomalies

January-December

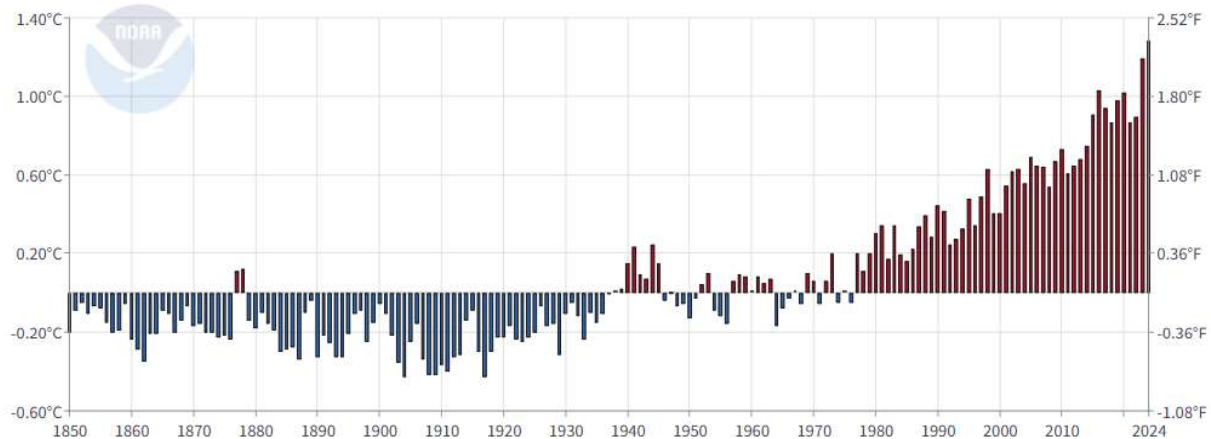


Figure 1: Global Land and Ocean Average Temperature

From June 2023 through July 2024, the planet experienced 14 successive months of record-breaking worldwide surface temperatures, with July 2024 likely being the hottest month ever recorded (NOAA, 2024). Although monthly temperatures from September 2024 onward slightly trailed those of the corresponding months in 2023, the sustained anomaly throughout the year culminated in a new annual global temperature record for 2024 (WMO, 2024). This pattern aligns with the long-term warming trend observed since 1850, characterized by an average temperature rising of 0.06 °C (0.11 °F) per decade. Notably, this rate has accelerated markedly since 1975, reaching 0.20 °C (0.36 °F) per decade (IPCC, 2021).

In parallel with atmospheric warming, global ocean temperatures have exhibited similarly concerning trends. From April 2023 through June 2024, the oceans recorded 15 successive months of unprecedented surface temperature highs (NOAA, 2024). Each month from January to April 2024 outdone past records by at least 0.15 °C (0.27 °F), underscoring a pronounced and persistent marine heatwave that could have significant ecological and climatic consequences (Dunn et al., 2024).

The Arctic region also experienced anomalous warmth in 2024, registering its second-warmest year on record. Average temperatures were 2.71 °C (4.88 °F) above the long-term norm, just 0.24 °C (0.43 °F) below the record set in 2016 (WMO, 2024). These findings collectively reinforce the trajectory of global climate

change and emphasize the urgency for continued monitoring and mitigation efforts (IPCC, 2021). The extent of Arctic sea ice reached its annual minimum in September, marking the seventh lowest record. Since 2007, the Arctic sea ice limit has continuously decreased under 5 million square kilometers (1.93 million square miles) every year, with the exception of 2009, 2013, and 2014, while it hardly surpassed that threshold (Adler et al., 2017).

The table below shows the worldwide entire land and ocean yearly mean temperature rankings and anomalies for the 10 warmest years on record, emphasizing the worrisome rate of global temperature rise.

Table 1: Warmest Period of Record: 1850–2024

Warmest Period of Record: 1850–2024	Year	Anomaly °C	Anomaly °F
1	2024	1.29	2.32
2	2023	1.19	2.14
3	2016	1.03	1.85
4	2020	1.02	1.84
5	2019	0.98	1.76
6	2017	0.94	1.69
7	2015	0.91	1.64
8	2022	0.90	1.62
9	2018	0.87	1.57
10	2021	0.87	1.57

2.2.2. Global Precipitation

Global precipitation is a fundamental component of the Earth's climate system, regulating the distribution and movement of water across the planet. According to (Y. Zhang and Wang, 2021), the variation in precipitation system size between day and night is less pronounced over oceans located at latitudes above 30°, but more evident over land and tropical ocean regions. Additionally, the size of precipitation systems exhibits a strong positive spatial correlation with the amount, frequency, intensity, and duration of precipitation. Climate change increases temperatures and decreases precipitation levels, lowering crop yields (Tazeze et al., 2012). Precipitation anomaly data for 2024, derived from the Global Historical Climatology Network (GHCN) and enhanced through broader spatial coverage by the Global Precipitation Climatology Project (GPCP), reveal significant global hydrological imbalances. These datasets collectively illustrate regions that experienced

anomalously high precipitation juxtaposed with extensive areas that were markedly drier than average (Adler et al., 2017). In particular, below-average annual precipitation was observed across large portions of Canada, extending into the western United States and northern Mexico. However, the most pronounced and widespread negative precipitation anomalies were recorded across South America. In Brazil, Bolivia, and Peru, numerous locations experienced their driest or near-driest conditions in the historical record, signifying an unprecedented regional drought event. Similarly, southern and south-western Africa experienced significant rainfall deficits, with record to near-record dryness reported in Zimbabwe and Zambia, as well as substantial anomalies in Cameroon, the Republic of the Congo, and Gabon.

These severe precipitation shortfalls, often coinciding with record-breaking or near-record surface air temperatures, have intensified drought conditions across multiple continents (Menne et al., 2018). The concurrence of elevated temperatures and reduced precipitation has exacerbated soil moisture deficits, reduced water availability, and heightened the risk of wildfires and crop failures (Navarro et al., 2024). This pattern highlights the compounding properties of climate elements and change, reinforcing concerns about the increasing frequency and severity of hydro meteorological extremes under on-going global warming.

2.2.3. Global Drought

Severe drought conditions in 2024 have emerged as a dominant climatic stressor across multiple global regions, including vast areas of South America, southern Africa, the Zambezi River basin, the Mediterranean, and Eastern Europe (Navarro et al., 2024). These regions have experienced prolonged episodes of abnormally dry and warm weather, with precipitation deficits further exacerbated by persistent heat waves and warm spells. The compounding effect of reduced rainfall and elevated temperatures has led to record-breaking average global temperatures, with July 2024 registering the highest monthly global temperature in recorded history.

The interaction between extreme heat and low precipitation has significantly depleted soil moisture and degraded vegetation health, as evidenced by widespread negative anomalies in terrestrial water storage and vegetation indices across affected regions (Dunn et al., 2024). In South America, the hydrological impacts have been particularly severe, with key river schemes such as the Amazon, La Plata, and Zambezi experiencing some of the lowest water discharge levels on record during the 2023–2024 periods. These anomalies are indicative of large-scale hydrological stress, affecting ecosystems, water availability, agriculture, and energy production.

In parallel, the contiguous United States (CONUS) experienced unusually warm conditions throughout much of the year. Seventeen states recorded their warmest year since records began in 1895, while an additional twenty states reported their second- or third-warmest year on record. These temperature extremes, consistent with broader global warming trends, further highlight the intensifying nature of climate-driven extremes across both hemispheres (Navarro et al., 2024).

The increasing occurrence and level of droughts worldwide reflect the complex interplay between increasing heats and changing rainfall forms in a changing climate. Elevated global temperatures enhance evapotranspiration, leading to faster depletion of soil moisture and disrupting regional hydrological cycles. These conditions not only reduce precipitation reliability but also intensify the risk of prolonged dry spells across many regions (Masson-Delmotte, et al., 2021). The emergence of such climate-driven droughts, often occurring alongside extreme heat, has profound implications for natural and human systems. Globally, drought conditions reduce agricultural productivity, jeopardize food availability, and contribute to rising food prices, particularly in already vulnerable regions (Zscheischler et al., 2018). Water scarcity becomes more acute, affecting both drinking water supplies and irrigation systems, while also increasing competition over limited resources. Public health is also at risk, as droughts exacerbate heat stress, reduce sanitation standards, and heighten the spread of waterborne diseases. Additionally, ecosystems suffer from prolonged water deficits, leading to loss of vegetation, habitat degradation, and declines in biodiversity (IPCC, 2021). These widespread and interconnected impacts of drought highlight the imperative necessity for comprehensive adaptation policies that incorporate climate management across sectors and scales, from local water management to global food systems.

2.3. Climate change and variability in Africa

Africa's climate exhibits remarkable diversity and variability, ranging from the scorching arid regions of the Sahara Desert to the exceedingly moist expanses of the Congo forest. Three key drivers shape the continent's climate: the Inter Tropical Conjunction Zone (ITCZ), the West African Monsoon, and the El Nino-Southern Oscillation (ENSO). While Africa generally experiences a hot climate, there exists significant variation in humidity levels and rainfall patterns across different areas (World Book, 2009). Africa faces significant vulnerability to climate variability and influences due to factors including widespread poverty and inadequate access to social, economic, political, and technological resources. These constraints impede the adaptation abilities of societies and nations. Climate change brings a variety of issues for humans, animals, plant life, and ecosystems. It also disrupts both social and economic systems, placing hard-won development

progress at risk (Africa Union, 2022). Although Africa contributes less than 4% of global greenhouse gas (GHG) emissions, it remains one of the most susceptible regions to climate impacts and change. Despite contributing least to the factors that exacerbate climate change and unpredictability, Africa is particularly susceptible to its impacts (Hope, 2009). The exposure of African pastoral people stems from their high disclosure and compassion to risky weather situations, coupled with a limited adaptive ability to modify their livelihoods in response to climate change (Veerbeek and Husson, 2013). These groups, particularly those inhabiting African rangelands, seriously depend on climate-sensitive actions such as livestock grazing. Rising temperatures and the raising the incidence of severe heat waves have disrupted grazing patterns, reduced pasture availability, and heightened the risk of livestock mortality (Formetta & Feyen, 2019). As an outcome, climate change not only undermines pastoral productivity but also pretences a severe hazard to food security across the continent. The destabilization of pastoral systems has ripple effects on rural economies that are heavily dependent on agriculture, thereby exacerbating poverty and social vulnerability (Cho et al., 2024). Strengthening the adjustment abilities of pastoral societies is therefore critical to enhancing resilience and ensuring the sustainability of both livelihoods and regional food systems in the time of a fluctuating climate. Communities living in marginalized regions with limited access to coping mechanisms and adaptive technologies are at greater risk from climate change. Furthermore, climate elements is possibly to exacerbate current poverty by reducing food security, intensifying water scarcity, increasing financial anxiety, and raising the occurrence of disease. While understanding the adaptation strategies employed by pastoralists is important, it is equally crucial to examine the broader enabling environment that influences their capacity to adapt effectively (Cho et al., 2024). However, the limited research on key aspects such as governance, indigenous knowledge, policy frameworks, and conflict dynamics results in a narrow assessment of the efforts made in these areas.

Africa continent took a long time for recognizing the influence of climate variability on agrarian and pastoralism activities (Yator, 2024). However, the susceptibility of pastoralist and agricultural production varies across the continent depending on different factors such as physical, cultural, political and socio-economic aspects (NYAMAI, 2024). This means that most African countries experience a warm climate, but the moisture, precipitation, adaptation knowledge, and available assets vary significantly from country to country (Busani, 2021). Moreover, politically and economically marginalized pastoralist regions in developing countries, particularly low-income African nations, are susceptible to the impacts of climate change. These regions face increased liability due to several features, such as limited infrastructure and resources, high

degree of agriculture dependence, limited financial resources and technological capabilities, historical inequalities, and a limited capacity for adaptation and resilience-building (Pavanello, 2009). The combination of these challenges exacerbates the susceptibility of pastoralist societies to the negative consequence of ecological disparity. Limited infrastructure, such as roads, healthcare facilities, and educational institutions, hinders their access to essential services and capability to adjust the climate-induced trends (Fortnam et al., 2020). Additionally, pastoralist societies rely heavily on natural resources such as grazing grounds and water supplies; they are extremely vulnerable to changes in climatic outlines, such as extended droughts and unpredictable rain.

Furthermore, the lack of monetary funds and technological capabilities restricts the capability of marginalized pastoralist regions to invest in climate adaptation measures. These factors can negatively, effects the acquiring of modern agricultural practices, accessing climate evidence and early advice systems, and implementing supportable land and water managing systems. The historical inequalities prevalent in these regions, often stemming from discriminatory policies and practices, further compound their vulnerability. Pastoral communities in these areas face barriers in accessing resources, services, and administrative procedures, which exacerbates the influence of climate change impacts (Fortnam et al., 2020). Lastly, the limited capacity for adaptation and resilience-building poses significant challenges for pastoralist communities. The traditional knowledge and coping mechanisms developed over generations may no longer be sufficient in the face of quickly fluctuating climatic settings. The need for external support, including technical assistance, capacity-building initiatives, and financial resources, is critical for these communities to enhance their adaptation ability and build resilience to climate issues. Despite contributing very little to climate change, these regions bear a disproportionate burden of climate changes consequences (Atwoli et al., 2022). This means that they contribute very little to man-made climate change, such as industrial released carbon dioxide (CO₂) and greenhouse gas (GHG) emissions, but they consume and experienced the greatest impact year after year. For instance, adapting the existing influence of climate change poses a significant challenge for pastoralists from low-income countries due to rain based agriculture livelihoods, imperfect adaptive capability, and socio-economic challenges (IPCC, 2014). The continent is a home of substantial portion of the global population living in highly vulnerable environments (UNEP, 2020). Climate change affects multiple dimensions of African societies, with far-reaching consequences for people's livelihoods, food security, and overall well-being. Shifting rainfall amounts, increased temperatures, and thrilling weather trials disrupt agricultural practices and reduce crop yields (Adger et al., 2007). Smallholder farmers, who constitute a

substantial percentage of the people in the continent, are particularly affected by climate change. This has consequences on countryside and towns' society, as well as regional and global food supply chains. The resulting food insecurity exacerbates the challenges faced by these farmers and poses risks to the stability and reliability of food production and distribution systems at various levels (IPCC, 2014). The impact of climatic fluctuation on pastoralist communities in Africa between 1970 and 2019 has been significant, resulting in a staggering number of deaths and economic damages (WMO, 2021). The primary causes of this devastation have been floods and droughts. This climate variability become more frequent and prolonged, leading to water scarcity and conflicts over water and pasture (UNEP, 2020). Rising temperatures also contribute to increased evaporation rates, further intensifying water stress (IPCC, 2014). Climate change highly affects vulnerable population, such as marginalized communities and those with limited access to healthcare. Unfortunately, institutions have not effectively fulfilled their role in facilitating climate change adaptation, despite pressing need for adaptation mechanisms. The implementation of adaptation strategies, such as livelihood diversification, sustainable farming practices, and the adoption of climate-resilient technologies, requires resources, knowledge, and supportive policies, which are often lacking in these vulnerable regions.

In addition, emerging nations have substantial problems in adjusting to and moderating the effects of climate change due to various factors including inadequate building designs, agricultural practices, food insecurity, low income, deforestation, and inefficient solid waste management systems. These elements jointly weaken the capacity of African countries to respond effectively to climate change (Chinasho et al., 2015). Among the most affected populations in the Horn of Africa are the pastoralists, who find themselves on the frontline of climate change impacts. The pastoralist groups in this area are experiencing increasingly frequent and intensive weather-related changes, posing significant challenges to their way of life. Having an inclusive sympathetic of the consequences of these changes is important for early warning systems as it enables them to prepare and establish vital resilience among vulnerable communities. This comprehension facilitates improvements in early warning systems, strengthens awareness initiatives, and supports the development of essential resilience measures within at-risk communities (Chinasho, 2017). Additionally, many studies reveal that administrative borders are often established without considering the mobility needs of pastoralists (Muchuru & Nhamo, 2017). This oversight leads to inter-communal tensions, increased insecurity, and conflicts among pastoralist communities. Furthermore, the encroachment of alternative livelihood systems onto pastoralist lands further marginalizes these communities, pushing their social and economic exclusion.

Climate change in sub-Saharan African countries has become a pressing issue, by imposing major constraints to numerous areas, like agriculture, water resources, and employments. These countries are principally weak due to their high degree of climate sensitive livelihood and limited adaptive capacity (IPCC, 2014). Among the populations contending with the impacts of climate variations are pastoral societies, which rely on livestock rearing as their major basis of revenue. Pastoral communities in sub-Saharan Africa, including those in Ethiopia, face unique challenges in familiarizing to climate change. The inter-linkage between climate change and pastoralism is complex, as directly affect the livelihood, resource availability, and production and productivity of livestock. These changes disrupt traditional migration patterns, increase the repetitions and magnitude of droughts, by negatively impacting the resilience of pastoralist societies (Catley & Scoones, 2013).

Various issues prejudice the adaptation status of pastoral populations to climate change. Firstly, their traditional ecological knowledge and adaptive practices have allowed them to navigate environmental variability for centuries (Galvin, 2009). Pastoralists have developed resilience mechanisms, such as mobility and herd diversification, to cope with changing conditions and minimize risks to their livelihoods. However, the rising intensity and unpredictability of climate change pose new challenges that require innovative adaptation strategies (Hesse & Thebaud, 2006).

Unfortunately, pastoral communities regularly face serious obstacles that hinder their adaptive capacity. Historical inequalities and discriminatory policies have marginalized these communities, affects their right to assets, facilities, and policymaking processes (Gebrehiwot et al., 2019). Efforts to support the adaptation of pastoral societies to climate adjustments require a multi-dimensional approach. It is crucial to address the structural inequalities and discriminatory practices that perpetuate their marginalization and hinder their adaptive capacity. This involves promoting inclusive governance systems that promote pastoralists in administrative manners and make sure equitable right to properties and services (Osbahe et al., 2010). Additionally, there is a necessity to improve context-specific adaptation tactics that build on the traditional ecological knowledge of pastoral communities. This includes strengthening their ability to monitor and reply to climate change, enhancing their entrée to climate data and early warning systems, and supporting ways for managing land and water sustainably (UNEP, 2016).

2.4. Climate change and its impact on pastoralists in Sub-Saharan Africa

Pastoralist communities in Sub-Saharan African countries, which greatly rely on rain, based agricultural production and pastoralism, are defenceless due to impacts of climate change. Pastoralist communities in Kenya primarily reside in the country's arid and semi-arid regions which traditionally depend livelihoods have centred on livestock

rearing, with cattle, goats, and sheep playing a vital role in both their economic activities and cultural identity (Yator, 2024). Pastoralism is not only a way of life in these areas, but also an important method for exploiting marginal lands by transforming scant vegetation into lucrative cattle products like meat, milk, and skins. These products not only sustain pastoral households but also contribute to local and regional economies through trade and market activities (Homewood et al., 2012). The effectiveness and sustainability of pastoralism in these areas are deeply intertwined with the ecological dynamics of the rangelands, requiring careful management of grazing patterns and water resources to avoid deterioration and guarantee long-term viability. The social structures and cultural practices of pastoralist communities are deeply intertwined with their economic activities. As smallholder farmers many of whom are pastoralists these communities contribute significantly to the overall agricultural output in numerous Sub-Saharan African countries (Nzengya, 2023). However, in recent years, this adaptive livestock-based system has come under increasing pressure from a range of external threats. These include the impacts of climate change, political instability, agricultural encroachment, and rising incidents of rural banditry all of which have significantly altered the dynamics of the rangelands.

Climate change continues to pose the region challenges, placing food security and livelihoods at risk, particularly for smallholder farmers in sub-Saharan Africa (SSA). Current estimates indicate that smallholder farmers contribute to 75% of the overall agricultural output and 70% of the marketed agricultural produce in Kenya (Nzengya, 2023). Agriculture plays a crucial role in Ethiopia's economy as it serves as the primary source of food, feed, and income for the majority of Ethiopians. The agricultural sector is predominantly composed of smallholder farming, which accounts for 80% of employment, 90% of total agricultural output, and 95% of the total land used for agriculture (Gebrehiwot & Van Der Veen, 2013).

Therefore, implementing climate change adaptation strategies among smallholder agrarians is crucial for safeguarding the resilience of occupations and ensuring the long-term sustainability of the agricultural sector, particularly in regions that are among the most susceptible globally. These communities depend heavily on rain-fed agriculture and livestock rearing, which makes them especially susceptible to climate risks such as erratic rainfall, prolonged droughts, and extreme weather events. Addressing their specific vulnerabilities through targeted and effective adaptation measures is thus critical for strengthening their ability to cope with climate impacts, securing their livelihoods, and maintaining the stability of the agricultural sector as a whole.

Countries in Sub-Saharan Africa are particularly defenceless to climate change due to their strong dependence on agricultural production and limited adaptive capacity. As a result, prioritizing increased investment in rural and agricultural development is crucial to enable households to make informed, long-term decisions that can protect

their future well-being. With poverty affecting approximately 52 percent of the population and about 73 percent of the labor force relying on agriculture, the region faces significant trials in pursuing sustainable development. Climate change further complicates this situation by undermining agricultural productivity and increasing the vulnerability of rural livelihoods, thereby highlighting the urgent need for strategic adaptation and resilience-building interventions (Bryan et al., 2013). Agricultural activities remain the primary source of income for rural communities which require robust adaptation measures to strengthen the resilience of the agricultural sector, protect the livelihoods of the poor, and ensure long-term food security. This need becomes more critical for pastoralist communities, whose livelihoods are directly shaped by climatic variability and ecosystem health. At the pastoralist level, adaptation requires the adoption of diverse strategies such as adjusting crop and livestock management practices, optimizing land-use systems, and employing livelihood activities that are tailored to the unique ecological, cultural, and socio-economic conditions of pastoralist households. These measures not only help pastoralists cope with increasing climate risks but also support broader efforts toward sustainable development in highly vulnerable regions (Ngetich et al., 2022). These measures contributed to building resilience and mitigating the hostile effects of climate change on agrarian systems in the counties.

Pastoralism communities in the horn of African take a dynamic role in the economies and other livelihood means of East African countries such as Ethiopia, Uganda, Tanzania, and Kenya (Lind et al., 2020). The rangelands across this region have experienced profound changes driven by population growth and agriculture practice evolving land use practices, the expansion of livestock trade, and increased investment from both domestic and international actors. Furthermore, approximately 10% of the rural population consists of pastoralist communities who rely almost entirely on livestock for their livelihoods. These communities are predominantly located in arid and semi-arid regions, which are susceptible to climatic extremes. Between 2020 and 2023, Kenya's pastoralist populations endured the most severe drought in four decades, marked by five consecutive failed rainy seasons. This prolonged dry period led to the loss of 2.6 million livestock and left 4.4 million people especially those in Arid and Semi-Arid Lands (ASAL) facing acute food insecurity (Obi, 2023). This worst and longest drought has effect of widespread livelihood losses and massive displacement. Livestock accounts for over 95% of family income generating activities in the Arid and Semi-Arid Lands (ASAL) areas (Yator, 2024). Apart from droughts climate change has also disrupted traditional weather patterns, leading to more erratic and extreme weather events, including heavy rains and flooding. Adaptation to climate change involves adjusting to actual or anticipated climate conditions and their impacts, with the aim of minimizing harm or taking advantage of potential benefits (Lind et al., 2020). Traditionally, pastoralists' communities in Africa regions demonstrated relatively high attainments to adapt the effect of climate change.

2.5. Climate change and adaptation strategies in Sub-Saharan Africa

Sub-Saharan African nations, despite being among the least responsible for global greenhouse gas emissions, experience disproportionately severe impacts from climate change. This vulnerability stems from two primary factors: the heavy reliance of many African economies on climate-sensitive natural resources (agriculture and livestock) and the limited financial, human, and institutional capacities to effectively respond to extreme climatic events. Consequently, pastoral communities, particularly those in the Somalia, Ethiopia and Kenya, face systemic challenges that undermine the long-term viability of their livelihoods. These threats include exclusion from development policy, violence, displacement, insecure land rights, and a diminishing forage base (Osman, 2018).

Traditional pastoralists' adaptive tactics include movement and transhumance, which remain the key coping strategy in arid and semi-arid rangelands, allowing for seasonal movement to areas with better grazing and water availability (Marić et al., 2023). Pastoralists also utilize herd management techniques such as herd diversification (maintaining a mix of livestock species to mitigate risks) and selective breeding programs to promote livestock breeds better adapted to local conditions (Lelenguyah, 2023). Moreover, indigenous communities possess valuable knowledge for climate forecasting, observing natural signs like animal behavior, cloud formations, and wind patterns (Kummo, 2016). To enhance resilience, these indigenous communities also rely on social networks, customary rules, and institutions used to regulate access to grazing lands, share resources, and resolve conflicts during times of distress (Tura, 2023; Abde, 2025). Consequently, Non-Livestock Activities constitute another strategy, as pastoralists increasingly explore non-livestock income sources, such as handicraft production, petty trading, and labor migration (Mustefa et al., 2022; Cheru, 2020). Pastoralists are also engaged in market participation, taking livestock to markets, across international borders (e.g., from Ethiopia to Kenya and Somalia), and becoming involved in value chain activities like milk processing, which helps diversify income and manage risk (Mustefa et al., 2022). These pastoral communities employ various adaptation strategies, such as mobility, herd diversification, social networks and promotion of drought-adapting livestock, labor migration and the sale of charcoal (Ahmed, 2023).

The Sub-Saharan region is home to predominantly pastoralist communities who rely heavily on livestock for their livelihoods. This region is prone to frequent droughts, erratic rainfall patterns, and other climate-related challenges, making adaptation strategies crucial for the sustainability of pastoralist communities. Despite these sophisticated mechanisms, the effectiveness of adaptation is often hampered by significant barriers.

Currently, many smallholders employ a resilience-based approach focused on short-term goals to avoid disruptions, rather than adopting long-term transformative strategies that address underlying vulnerability (Debela et al., 2019). Coping mechanisms such as traditional cultivation, overstocking, and cutting trees for charcoal are common but unsustainable coping strategies (Kandji et al., 2016).

Moreover, the effectiveness of adaptation is heavily influenced by supportive policies and institutional intervention (Nebere et al., 2025). However, pastoral development policies often lack consultation and fail to adequately acknowledge and strengthen customary land tenure systems and communal rangeland management, despite the state granting lifetime land-holding rights (Abebe & Flintan, 2021). Also, there is a limited understanding of the effectiveness of adaptation initiatives and a need for defining best practices (Mills-Novoa, 2023). Attempts at market diversification often fail due to market constraints, drought, and the inadequate capability of pastoral people to engage in diverse activities.

Addressing the waves of climate change requires a move from mere awareness to the implementation of viable, sustained societal strategies. It is crucial to prioritize and invest in inclusive climate change adaptation measures that recognize pastoralism as a viable livelihood system (Teffer et al., 2020). Future adaptation pathways must achieve sustainable and substantial changes by integrating indigenous knowledge and leveraging the complex interaction between past experiences and future perspectives. Consequently, addressing local adaptive capacity requires linking adaptation efforts with local development initiatives (Debela et al., 2019). Establishing institutional support mechanisms, such as early warning systems, veterinary services, and improved facility to loans and markets linkage is mandatory for pastoralist livelihood sustenance (Stark & Terasawa, 2011).

2.6. The role of the indigenous knowledge system and climate change

Indigenous Knowledge Systems (IKS) refer to the accumulated knowledge, practices, beliefs, and skills advanced by local societies over generations of interaction with their environment. These systems are holistic, community-centered, and deeply embedded in cultural, spiritual, and social values. Among pastoralist societies, IKS guides critical aspects of survival such as livestock management, weather prediction, rangeland use, conflict resolution, and mobility planning. Unlike scientific knowledge, IKS evolves within specific ecological and cultural contexts, making it highly relevant for localized climate adaptation. Indigenous knowledge holds value not only within the cultural contexts in which it develops but also for intellectuals and planners seeking to improve rural livelihoods (Ajani et al., 2013).

Pastoralists possess extensive traditional knowledge, accumulated over generations, which enables them to interpret and respond effectively to environmental changes. One of the major strengths of IKS lies in its contextual relevance grounded in long-term observation and experience within specific environments. This makes it highly adaptive to local ecological variability, particularly in pastoralist regions where climate conditions are unpredictable. For instance, among the Maasai community of Kenya, traditional knowledge is integral to livestock management and climate adaptation strategies. Maasai herders rely on indicators such as the behavior of birds, the flowering of specific plants, and the formation of certain cloud patterns to forecast weather and plan livestock movements accordingly (Opiyo et al., 2014). This indigenous forecasting system allows them to adjust grazing strategies and minimize losses during periods of drought or heavy rainfall. Similarly, the Sami people of northern Scandinavia have developed a sophisticated understanding of reindeer herding in response to changing climatic conditions. Their traditional knowledge encompasses observations of subtle environmental shifts, including changes in snow patterns, ice formation, and plant growth, which guide decisions on migration routes and timing (Turi et al., 2019). Such adaptation strategies enable them to navigate climate challenges and maintain sustainable reindeer husbandry.

Indigenous knowledge systems contribute to climate change adaptation by providing context-specific insights, adaptive strategies, and flexible resource management approaches. They offer valuable lessons on resilience and sustainable practices to the adaptation efforts of climate change. The integration of indigenous knowledge with scientific approaches can thus lead to more effective and contextually appropriate adaptation measures for pastoral communities (Ford et al., 2016). It is also important to recognize that indigenous knowledge systems are dynamic and evolve over time in response to changing environmental conditions. Climate change presents new challenges that may require combining traditional and scientific knowledge to ensure the continued resilience of pastoral livelihoods. IKS is context-specific, implying that communities whether in developed or developing countries possess unique forms of indigenous knowledge (Nyong et al., 2007). This underscores the importance of understanding what IKS entails and how it functions. IKS is the wisdom, knowledge, and practices of indigenous peoples, gained through long-term experience or transmitted orally from generation to generation. They offer valuable insights and strategies rooted in cultural practices and deep interactions with the environment. Integrating IKS and scientific knowledge enhances climate change adaptation and supports sustainable rural livelihoods. This knowledge qualifies as IKS when it significantly contributes to solving local problems, including those related to climate variability and other

socio-environmental challenges. Indigenous peoples often observe natural activities such as animal behavior and plant cycles and use this knowledge to adapt to environmental threats (Mugambiwa, 2018).

Changes in the environment is recognized through local indicators, including certain bird species, animal mating patterns, and the flowering of plants, which signal expected environmental shifts related to climate variation (Mugambiwa, 2017). According to the (Salick and Byg, 2007) note that indigenous people have historically used biodiversity as a buffer against variation and catastrophe, helping them cope with natural hazards. Across Africa, indigenous communities respond to fluctuating rainfall or drought conditions by cultivating diverse crop varieties with different levels of drought and flood resistance. These efforts was supplemented by hunting, fishing, and gathering wild plants (Svotwa et al., 2007). Therefore, IKS forms the foundation for local-level decision-making in rural communities and is valuable for not only cultural preservation but also helps the scientists and planners improve rural development outcomes. This highlights that IKS serves as a starting point for meaningful, community-based development. Climate variability has considerable influence on agricultural success in rural Zimbabwe (Svotwa et al., 2007). Communities worldwide have long experienced climate-related disasters such as droughts, floods, hailstorms, thunderstorms, tsunamis, and strong winds all of which cause severe losses to people, livestock, and crops (Oluoko-Odingo, 2010). Over time, human cultural development has evolved, and communities have extended their cultural beliefs to environmental responses in addressing climate challenges (Oluoko-Odingo, 2010). Communities have learned to interpret various natural indicators including the positions of stars, the sun, and the moon as well as wind strength, direction, cloud positions, and lightning patterns. These experiences remain crucial for predicting climatic changes and interpreting them within cultural contexts. Among African pastoral communities, knowledge of past climate events and disasters transmitted orally from generation to generation forms a core component of IKS. Generally, IKS refers to knowledge systems that have developed independently of modern scientific traditions but remain vital for local survival and adaptation. The concept of IKS introduces a cultural dimension to climate change discussions. Scholars such as Ajibade and Shokemi (2003) argue that cultural perspectives are crucial in shaping national development strategies, particularly in Africa. Addressing climate change and environmental issues needs culturally and locally appropriate strategies. For example, in Nigeria, local farmers use IKS-based weather forecasting to interpret rainfall, thunderstorms, and wind patterns to plan their agricultural activities (Ajibade & Shokemi, 2003). Unlike meteorologists who rely on satellite imagery and global models, indigenous forecasting draws on lived experiences and environmental cues from flora and fauna.

Despite its importance, IKS faces several limitations. It often lacks the scientific precision necessary to respond to rapidly changing climate patterns that fall outside historical experience. The increasing frequency of extreme events such as unprecedented droughts or floods may limit the predictive accuracy of traditional indicators. Furthermore, the transmission of IKS is threatened by socio-economic transformations, modernization, youth migration, and education systems that tend to marginalize traditional knowledge. In some cases, IKS practices are constrained by cultural rigidity and may not easily integrate with technological or policy frameworks. Some communities rely on individuals believed to possess supernatural abilities to predict environmental changes, though these predictions may not always align with actual conditions (Mugambiwa, 2017). Additionally, pastoralists are widely used indicators, such as the timing and duration of cold spells, sometimes fail to match real outcomes.

2.7. Extent and impact of climate change on pastoralists in Ethiopia

Pastoralist communities across Africa have long confronted a range of social and economic challenges, compounded by climate-related risks and hazards. The impressions of climate variability and the increasing frequency of extreme weather events have further exacerbated their vulnerability, posing significant difficulties for herders in sustaining their livelihoods (Nagy et al., 2020). Furthermore, pastoralist communities often have limited participation in policy-making processes, resulting in their marginalization and exposure to the negative effects of policies that inadequately address their needs for sustainable development and poverty reduction. In addition, declining rainfall and increasing temperatures are expected to further deteriorate agricultural conditions across much of Africa, particularly in regions dependent on pastoral and agro-pastoral livelihoods (Henderson et al. 2017). It is reported that two-thirds of Africa's arable land is expected to be lost by 2030 because of the long period of rainfall missing, floods and drought (Nagy et al., 2020). Therefore, many economic activities of pastoralists communities are likely to be negatively influenced by climate changes which is needed to develop adaptation and coping capacity of communities. The extent of climate change between 1970 and 2019 is significant; in Africa alone, it caused 731,747 deaths and \$38.5 billion in economic damage, with floods and droughts as the major drivers (WMO, 2021). The primary source of income in Africa is agriculture, which includes the production of crops and livestock, which require a variety of management and climate adaptation techniques. Ethiopia, in particular, is one of the most susceptible Sub-Saharan African countries to the consequences of climate change. These are because of the absence of access to adaptive capacity-building mechanisms such as knowledge, resources, and technology used for rain-fed agriculture (Asmare & Mekonnen, 2019).

Climate change has had significant impacts on pastoralist communities in Ethiopia, affecting their livelihoods, resources, and overall well-being. Nowadays in Ethiopia there are substantial increase in temperature, a longer annual dry period, and seasonal rainfall fluctuations, which negatively impacted both crop and livestock production overall (Abrham et al., 2020). Rising temperatures associated with climate change have led to increased heat stress in livestock, resulting in reduced productivity, reproductive issues, and increased mortality rates. A study by (Gebremedhin et al. (2019) found that heat stress negatively affected the body weight and milk production of dairy cattle in Ethiopia. Similarly, a report by the International Livestock Research Institute (ILRI) highlights the vulnerability of Ethiopian pastoralists' livestock to heat stress, which threatens their livelihoods and food security. Moreover, erratic rainfall patterns and prolonged droughts, attributed to climate change, have resulted in water scarcity and reduced pasture availability. This directly impacts the survival and well-being of livestock. Climate variability has had significant impacts on livestock production and the livelihoods of pastoral and agro-pastoral communities. These means that changes in rainfall patterns have reduced water availability for livestock, further intensifying the challenges faced by Ethiopian pastoralists (Habte et al., 2022). The report by (OCHA, 2022) also emphasizes the challenges faced by pastoralist communities in accessing water and maintaining adequate grazing resources. Climate change has led to an increase in the frequency and intensity of droughts in Ethiopia, posing significant challenges to pastoralist communities. The Fourth National Communication on Climate Change of Ethiopia (MoARD, 2017) highlights the higher occurrence of drought events in recent years, leading to livestock losses, migration, and food insecurity among pastoralists.

Traditionally transhumance pastoralists practice, moving with their livestock to search a better pasture and water resources. However, climate change impacts, such as changes in rainfall patterns and land degradation, have disrupted these migration patterns. A study by (Desta and Coppock (2004) found that pastoralists in Ethiopia have experienced limitations in their mobility due to resource constraints caused by climate change. The combination of climate change impacts, limited resources, and disrupted livelihoods has increased the vulnerability of pastoralist communities in Ethiopia. A report by the United Nations Development Programme (UNDP) highlights the high levels of poverty and food insecurity among pastoralist households, exacerbated by climate change impacts (UNDP, 2020). Recognizing the specific impacts and vulnerabilities of pastoralists is crucial for developing targeted adaptation strategies, policy interventions, and support mechanisms to enhance their resilience and ensure their sustainable development.

The Somali Regional State (SRS) is one of Ethiopia's regional states with a large number of pastoral and agro-pastoral communities that are badly impacted by climate change. The region is currently experiencing

the serious impacts of droughts induced by climate change. Droughts lead to scarcity of water and forage, resulting in malnutrition and reduced livestock productivity. Pastoralists heavily depend on livestock for their livelihoods, and the loss of animals due to droughts can have severe economic and social consequences (UNDP, 2020). The on-going food shortages in the Somali Region have resulted in over two million people experiencing food insecurity, with the majority of the population depending on livestock as their primary source of livelihood. This means that the impacts of changing the climate is highly evidenced by shifts in two key climatic parameters of temperature and rainfall which has caused in rising temperatures, erratic rainfall patterns, and a shortened crop-growing season. These climatic disruptions have made the region increasingly vulnerable to recurrent droughts, further intensifying existing challenges and prompting growing concern among federal and regional administrations, as well as humanitarian organizations (Berhe et al., 2023). Droughts disrupt agricultural activities and diminish crop yields, leading to food shortages and increased food insecurity among agro-pastoral communities. The lack of water for irrigation and the drying up of rivers and wells exacerbate the challenges faced by farmers in the region (Berhe et al., 2023). Drought-induced resource scarcity compels pastoral and agro-pastoral communities to migrate by finding alternative pasture lands and reliable water sources. As drought conditions intensify, households are often forced to leave their homes, resulting in widespread displacement. This movement not only strains the resilience of migrating communities but also increases pressure on host areas, where growing competition over limited resources can heighten tensions and potentially lead to conflict (World Bank, 2018). The severity and frequency of droughts have escalated the susceptibility of pastoral and agro-pastoral societies in the Somali Regional State, resulting in recurring humanitarian crises. Climate change-induced droughts disrupt traditional knowledge systems and cultural practices that have allowed communities to adapt to environmental fluctuations for generations. The loss of ancestral knowledge on resource management and coping strategies hampers the resilience of pastoral and agro-pastoral communities in the face of droughts (Desta and Coppock, 2004).

The extent of climate change on pastoralist communities has been substantial in recent years, as they heavy dependence on natural resources for sustenance. These communities have witnessed a rise in the frequency and intensity of droughts, floods, and other extreme weather events. Moreover, alterations in seasonal timings and durations have adversely affected water availability and pasturelands for their livestock, thereby straining existing coping mechanisms and augmenting vulnerability within these communities. Consequently, the implementation of effective institutional interventions and coping mechanisms becomes imperative to mitigate the consequences of a warming planet on pastoralist communities

2.8. Climate change and adaptation mechanism amongst pastoralists in Ethiopia

Ethiopian pastoralists are facing significant encounters due to Climate change is characterized by shifting weather arrays and rising in the probability of severe occurrences like droughts are disrupting their traditional way of life. The environmental base of the country is severely degraded, which has significantly reduced its environmental resilience (Sani et al., 2016). This degradation, when combined with the ongoing special effects of global environmental change, further exacerbates the vulnerability of local communities to climate-related shocks. Numerous reports have consistently highlighted the region's exposure to recurrent droughts, reflecting its high susceptibility to the opposing impacts of climate inconsistency. As a result, communities in the area are increasingly experiencing a range of climatic and environmental shocks, leading to heightened levels of vulnerability. The interplay between natural resource degradation and climate change thus presents a compounded challenge, threatening the livelihoods and adaptive capacity of the population in the region. The nation's primary source of income is farming for subsistence, which is heavily reliant on rainfall; hence, pastoralists must adapt to shifting circumstances (Temesgen et al., 2014). These pastoralists largely rely on cattle for a living and have evolved adaption strategies over generations to deal with environmental change. In order to adjust the effect of climate variability these pastoralists have developed various adaptation and coping mechanisms in response to climate change impacts. These mechanisms include livelihood diversification, mobility and transhumance, water management strategies, rangeland management practices, utilization of indigenous knowledge and social networks, and the selective breeding of livestock and cultivation of drought-tolerant crops.

The landscape of the country is diverse, with towering peaks, craggy mountains, and broad plateaus with flat tops, undulating plains, carved river waterfalls, and deep valleys. These geographical variations contribute to significant altitudinal differences, which, in turn, variety of temperature variations. As a result, Ethiopia is divided into three distinct climatic zones: the cool zone (Dega), the temperate zone (Weyna Dega), and the hot zone (Kola) (TENAW, 2021). The altitudinal gradient shows a pivotal character in shaping the country's climate and contributing to its climatic diversity. The cool zone (Dega) experiences lower temperatures due to its higher elevation, while the temperate zone (Weyna Dega) enjoys a more moderate climate. In contrast, the hot zone (Kola) is characterized by warmer temperature that is most pastoral communities were found. The altitudinal variation across these zones creates distinct microclimates and weather patterns throughout Ethiopia. Furthermore, Ethiopia exhibits a wide range of annual rainfall distribution. The country's

southwestern highlands receive the highest levels of precipitation, exceeding 2000 mm annually. In contrast, the southeastern and northwestern lowlands experience considerably less rainfall, with annual totals falling below 300 mm. This disparity in rainfall distribution across different regions of the country contributes to varying ecological conditions, agricultural practices, and water availability, which remarket economics activities and livelihood style of pastoral community.

Undoubtedly, the agricultural sector holds immense importance as a primary livelihood source and a significant contributor to the national economy in every country, including Ethiopia. The agricultural sector in Ethiopia, for instance, plays a pivotal role in the nation's economy, as contributing by the National Planning Commission (NPC, 2018). According to their findings, the agricultural sector accounted for approximately 35% of the national GDP during the 2017/18 period (Tirfi, 2022).

Within the agricultural sector, the crop sub-sector stands out as a prominent contributor to the national GDP. It alone contributes around 65% of the total agricultural sector's economic output, while the remaining 35% is contributed by livestock, fishery, and forestry sub-sectors. This emphasizes the significant role of crop production in driving economic growth and development in Ethiopia. The reliance on agriculture in Ethiopia extends beyond its economic contribution. It serves as a vital source of sustenance and livelihood for a large portion of the population. The agricultural sector provides employment opportunities, food security, and income generation for rural communities, playing a crucial role in poverty reduction and rural development (Tirfi, 2022). Given the substantial dependence on agriculture, it becomes imperative to prioritize sustainable agricultural practices, promote technological advancements, and invest in infrastructure and research to enhance productivity and resilience in the face of challenges such as climate change, market fluctuations, and resource limitations. By strengthening, the agricultural sector both crop and livestock, Ethiopia can further harness its potential by enhancing economic growth, alleviate poverty, and ensure food security for its population.

Ethiopia is home to a significant population of pastoralists who rely on livestock rearing as their primary livelihood strategy which in comprise approximately 12-15% of the Ethiopia societies and occupy around 60% of the total landmass (Yimer, 2015). Specifically, in the Somali region, it is estimated that these communities account for approximately 57% of the total pastoral population in the country. These communities face unique challenges in the context of climate change, as their way of life is intricately linked to the environment that influenced climate change components, such as increased temperatures, erratic

rainfall patterns, production failures, inflation in market prices, food insecurity and prolonged droughts, have significant implications for pastoralist communities and their adaptive capacity. These pastoralists face a range of climate change impacts that directly affect their livestock, grazing patterns, and overall well-being. The rising temperatures have led to increased heat stress in livestock, impacting their health and productivity (OCHA, 2022). Erratic rainfall patterns and prolonged droughts have resulted in water scarcity, reduced pasture availability, and compromised livestock survival rates (Yacob & Chin, 2022). These challenges further exacerbate existing vulnerabilities, including limited access to markets, healthcare, and education of pastoral communities.

Table 2: Ethiopian pastoral area population projections, 2014-2017

Region	2014	2015	2016	2017
Somali	5,307,002	5,452,994	5,598,002	5,748,998
Afar	1,678,000	1,723,007	1,769,002	1,812,002
SNNPR	722,655	738,346	753,880	769,817
Oromia	2,022,309	2,074,007	2,126,327	2,178,734
Gambella	138,640	142,067	145,529	149,410
Total	9,868,606	10,130,421	10,392,740	10,658,961

(Gebremeskel et al., 2019)

Ethiopia's government has shown commitment for addressing climate change and promoting sustainable practices within its agricultural sector. As part of its efforts, the country has ratified policies on environmental friendly agricultural transformation economy policy. To achieve this goal, Ethiopia has implemented several intervention policies that are focused for mitigating the influences of climate change and fostering resilience within the agricultural sector and pastoral communities (LEMMA, 2016). These policies include the National Policy on Disaster Prevention and Preparedness, which focuses on reducing the vulnerability of communities to climate-related disasters. Additionally, the National Biodiversity Conservation and Research Policy aim to protect and preserve the country's rich biodiversity. The government has also established the National Accelerated and Sustainable Development Plan to End Poverty, which integrates climate change adaptation and mitigation strategies into poverty reduction efforts. Furthermore, the Plan for Growth and Transformation (GTP) outlines a comprehensive framework for sustainable economic development, with a focus on promoting environmental friendly practices across various sectors, including agriculture. The implementation of those policies to address climate change and its implications on sustainable development is evidenced through its failure to create a sustainable and climate-resilient agricultural sector that aligns with the country's

overall development goals. There is a clear need for the government to enhance adaptation mechanisms based on scientific and indigenous knowledge systems.

Implementing sustainable land management practices, such as soil conservation, watershed management, and afforestation, can take a crucial part for improving ecosystem resilience and improving water availability in the face of climate change. These sustainable land management (SLM) strategies have been shown to effectively mitigate soil erosion, enhance soil fertility, and increase water infiltration, thereby contributing to improved agricultural productivity and reduced vulnerability to climate change impacts (Abiyu et al., 2020). Furthermore, diversifying agricultural practices and promoting the cultivation of climate-resilient crop varieties are important adaptation strategies to enhance food security and adapt to changing climatic conditions. This entails adopting drought-tolerant crops, implementing agroforestry systems, and utilizing conservation agriculture techniques, which collectively help build resilience and enhance adaptive capacity in agricultural systems (Tadesse et al., 2019).

In addition to sustainable land management and agricultural diversification, the development of water harvesting techniques is crucial for adapting to changing rainfall patterns and improving water availability. Small-scale reservoirs, ponds, and rainwater harvesting systems can effectively capture and store water, bolstering agricultural activities and other water-dependent uses. Integrated water resources management, including efficient irrigation practices and water conservation measures, is essential for optimizing water utilization and adapting to the variability in precipitation (Alemayehu et al., 2019). Strengthening climate information services and early warning systems is a critical component of proactive adaptation. By providing accurate and localized climate forecasts and agricultural advice, communities can make informed decisions and take timely actions to adapt their cropping patterns, livestock management strategies, and resource allocation. Accessible and tailored climate information enables farmers to effectively respond to impacts and reduce susceptibility to climate change impacts (Zelege et al., 2021).

Furthermore, implementing adaptive livestock management practices is essential for improving resilience to environmental alteration in pastoralist populations. Measures such as improved animal health services, feed supplementation, and breed diversification can support to alleviate the argumentative influences of climate change on livestock productivity and livelihoods. Additionally, diversifying livelihood options beyond livestock, including income-generating activities and off-farm employment, can minimize susceptibility and increase adaptive capability of these communities (Desta and Coppock, 2004). By integrating these scientifically

supported adaptation strategies, Ethiopia can enhance its capacity coping with the changing climate and variability, reduce vulnerability, and build resilient and sustainable livelihood systems.

In reaction to environmental degradation and impacts in sub-Saharan Africa, rural societies have employed various adaptive strategies. These include the construction of additional wells in dry and semi-arid areas to ensure access to water, engagement in off-farm ways to earn income to diversify livelihoods, and reducing livestock quantities through slaughtering or selling during prolonged drought periods, followed by restocking after the drought subsides (Abdullahi, 2014). Additionally, some pastoralists have shifted their focus towards livestock breeds that are more resilient to water scarcity and high heats. The Somali pastoral societies, in particular, have a long-standing relationship with climatic changes. They have traditionally adapted to volatile climatic conditions towards their way of life which accrued local knowledge, such as recognizing and interpreting ecological and climatological indicators. Pastoralists use a variety of tactics to reduce the detrimental consequences of climate change and climatic variability, such as:

- ✚ Purchasing and preserving food to eat during the dry spell
- ✚ Migrating with their herds to regions where pasture and water are more abundant.
- ✚ Cooperating and negotiating with neighbouring communities to share existing resources.
- ✚ Diversifying livelihood strategies by engaging in multiple economic activities.
- ✚ Keeping livestock that are resilient to drought and disease, such as camels and goats.
- ✚ Adjusting herd size and structure by reducing the number of animals and altering the composition (Abdullahi, 2014).

In general, the producers receive little government assistance for climate change adaptation. The analysis indicates that although there is awareness of climate change and its potential effects of smallholder farmers' occupations, local-level development interventions often fail to effectively address the challenges faced by resource-poor farmers and environmental issues (LEMMA, 2016). It is crucial to urgently utilize the existing awareness and knowledge, document successful adaptation interventions, and package and disseminate them to farmers. This will help bridge the gap between awareness and practical implementation, ensuring that farmers receive the necessary support and guidance for adaptation to climate change. The study conducted on rural agricultural creativity and local techniques in marginal areas highlights that effective adaptation techniques to preserve rural livelihoods are frequently developed by indigenous groups, local government agencies, and non-profit institutions. These strategies focus on areas such as soil preservation, water collecting, and improving environment quality and productivity. Acknowledging and supporting the efficiency of climate adjustment strategies at the community level is crucial, aligning them with national

development frameworks, strategies, and policies. These adaptation strategies, when integrated with scientific knowledge, traditional practices, and local knowledge systems, can contribute to building resilience in the face of climate change in Ethiopia, ensuring active operation and long-term sustainability.

2.8.1. Constraints to climate change adaptation strategies

Pastoralists face significant challenges in adjusting to climate variability and its uncertainties. Their ability to implement necessary adjustments is constrained by a combination of physical, collective, cultural, financial, political, and legal aspects. The vulnerability of pastoral livelihoods is particularly linked to inadequate rainfall, limited access to natural, financial, and institutional resources, and the scarcity of essential resources such as pastureland and water points (Solomon, 2013). This vulnerability is further exacerbated by institutional weaknesses, inadequate infrastructure, conflicts, limited entrance to loan, gender disparities, restricted migration, food price inflation, land arguments, and land fragmentation (Seyoum, 2020). These complex and interconnected challenges pose significant obstacles to pastoralists' communities to manage effect of climate change.

Drought mitigation strategies in pastoral areas face numerous capability boundaries. The government institutions, including those at the district level, are unfamiliar with the concept of protecting livelihood assets, often relying primarily on food aid as the default coping mechanism. While there is growing recognition of the importance of livelihood-focused interventions at the local level, where delegates of pastoralists groups are included the decision makers which often lack the methodical knowledge required to investigate appropriate incomes enhancement method (Kebede, et al., 2015). Recruitment within these communities often follows clan-based quotas and may include individuals lacking formal education, while a significant proportion of officials originate from non-pastoral backgrounds. As a result, the general level of expertise tends to be low, especially in remote regions. Variables such as gender, age, work experience, income, household size, educational attainment, access to extension services, and participation in off-farm or non-farm activities play a vital role in influencing the adoption of climate change adaptation strategies (Acquah-de Graft & Onumah, 2011).

Pastoralists in East Africa continue to face challenges arising from poverty, population growth, poor institutional structures, environmental decline, disputes, rising temperatures, long droughts, migration, and starvation. Climate variability and impacts have emerged as additional threats, compounding these pre-existing problems. The combined effects of climate and non-climate stressors pose a serious risk to the livelihood of rural societies through the region.

Females' society in the Horn of Africa is among the highest weakness groups due to their limited adaptive capacity and heavy rely on climate sensitive livelihood activities. Climate change's unpredictable impacts on women are exacerbated by socially connected gender roles and relationships. Women and girls are often allocated tasks that increase their exposure to climate-related risks. During drought periods, for instance, women frequently travel long distances to fetch water and collect firewood, which not only enhance their workload but also exposes them to sexual and physical violence, affecting their health. These responsibilities also contribute to higher school dropout rates among girls. Overall, constraints to climate change adaptation strategies are shaped by a complex interplay of social, economic, and environmental factors. According to a study by Adger et al. (2009), several key constraints can hinder effective adaptation efforts. These constraints include:

1. Institutional Constraints: Limited institutional capacity and inadequate governance structures can impede the implementation of coping mechanism strategies (Adger et al., 2009). Insufficient institutional structures hinder the management of clashes and arguments, while weak institutions and systems contribute to ineffective adaptation efforts additionally; gender insensitivity and the lack of meaningful participation and consultation with pastoral societies during project development and implementation have been identified as key limitations (Menghistu, 2020).
2. Financial Constraints: Insufficient financial resources, funding gaps, and imperfect facility to credit can restrict the operation of mitigation measures (Adger et al., 2009).
3. Knowledge and Information Constraints: Lack of awareness, inadequate facilities to climate info, and limited understanding of adaptation options can hinder the assumption of suitable strategies (Adger et al., 2009).
5. Social and Cultural Constraints: Social norms, cultural beliefs, and practices may act as barriers to adopting new adaptation strategies (Adger et al., 2009).
6. Technological Constraints: Limited availability and accessibility of appropriate technologies for climate change adaptation can pose challenges (Adger et al., 2009; Fankhauser et al., 1999).
7. Vested Interests and Power Dynamics: Conflicting interests, power imbalances, and competing priorities among stakeholders can hinder the implementation of adaptation strategies (Adger et al., 2009).
8. Environmental constraints significantly affect climate change adaptation in pastoral communities. These constraints include a decrease in rainfall, resulting in persistent drought conditions, limited availability of grassland and water for cattle, and subsequent challenges in livestock husbandry (Kebede, et al., 2015).

9. Low health and education services: inadequate service to health and education is observed due to factors such as the nomadic lifestyle, limited livestock health services, and a lack of market outlets caused by the absence of infrastructure like roads and information systems.
10. Low level of pastoralists' participation: Pastoralist groups were not appropriately engaged or involved in the project's conception and operation.

Addressing the aforementioned constraints necessitates targeted interventions focused on enhancing institutional capacity, implementing financial mechanisms, disseminating knowledge, addressing social and cultural factors, promoting technological innovations, and fostering inclusive decision-making processes (Adger et al., 2009). By effectively addressing these constraints, the usefulness of climate change reworking strategies can be enhanced, leading to the support of more resilient pastoral communities.

It is crucial to recognize that the countryside community historically lacked well-designed structures, which directly impact availability of public facilities such as healthcare, education, and potable water and hygiene (MoARD, 2005). The challenges and limitations faced by extension agents are complex and interconnected issues. Mostly institution involvements have followed a fragmented advance method, resulting in unsustainable outcomes and the continuous deterioration of the well-being of pastoralist societies.

By promoting effective adaptation of climate change in pastoral communities, it is essential to address both environmental and institutional constraints. This necessitates implementing measures to improve water and pasture availability, enhance access to vital services, strengthen institutional structures for conflict management, and adopt gender-sensitive approaches. Additionally, ensuring meaningful participation and consultation with pastoral societies during decision-making processes and project implementation is crucial for the long-term sustainability and inclusivity of adaptation strategies.

2.9. Government policy and climate change in Ethiopia

Ethiopia is one of the country's most susceptible to the belongings of climate change, primarily due to its dependence on rain-fed farming, ecological decline, and limited adaptive capacity. In response, the Ethiopia has shown a strong commitment to tackling climate change through a range of government policies and strategic initiatives that balance environmental sustainability with economic development. The country's flagship policy, the Climate-Resilient Green Economy (CRGE) Strategy launched in 2011, aims to achieve middle-income status by 2030 while maintaining low carbon emissions (Federal Democratic Republic of

Ethiopia, 2011). This ambitious plan focuses on improving agricultural productivity, expanding renewable energy, promoting forest conservation, and fostering sustainable industrial growth. Associated with the international obligations under the Paris Agreement, Ethiopia has Updated Nationally Determined Contributions to reinforce these goals by pledging a 68.8% reduction in greenhouse gas emissions by 2030 compared to business-as-usual levels (FDRE, 2021). To implement these commitments, institutional coordination among bodies such as the Environmental Protection Authority, the Ministry of Agriculture, and Ministry of Water and Energy has entrusted to play critical role for integrating climate considerations into all levels of governance. Initiatives such as the Green Legacy Initiative, which has led to the planting of billions of trees to counter deforestation and soil degradation, and significant investments in hydropower and other renewable energy sources, illustrate tangible progress towards these objectives (Ministry of Water and Energy, 2022; United Nations Development Programme, 2020). Moreover, the government's focus on climate-smart agricultural practices and early warning systems demonstrates a proactive approach to building resilience against recurrent droughts and floods (World Bank, 2022). However, challenges remain in the form of limited financial resources, institutional overlap, dependence on international climate finance, and socio-economic pressures driven by rapid population growth (African Development Bank, 2021). Overall, Ethiopia's government policies reflect a clear recognition that climate change is environmental and developmental challenge which needs sustained implementation, effective coordination, and adequate support, for moving toward a climate-resilient and sustainable future. While enhancing resilience in certain sectors can decrease the necessity for emergency planning and response, it may not be feasible to enhance resilience universally (Arnell, 2022). Consequently, the focus of emergency planning is expected to evolve in response to the varying impacts of climate change among pastoralist communities. Outstanding a balance between initiatives to enhance resilience and manage climate-related events is necessary to promote pastoral livelihood initiatives. However, food insecurity is a continuously evolving global developmental challenge that need comprehensive and dynamic policy responses from government and multilateral institutions (Zafar & Zehra, 2022). The prevalence of food insecurity, which has been linked to poverty, malnutrition, and poor health outcomes across pastoral communities, is further exacerbated by climate change. The country is characterized by higher temperatures; irregular rain fall and persistent droughts which negatively affect the food sources of pastoral communities (WFP, 2016). Despite these challenges, pastoralist communities have acknowledged the necessity of adopting various adaptation strategies. These strategies include diversifying their livestock species, social networks to help each other, investing in small-scale irrigated agriculture and reducing the dependence on livestock by transforming other sources of income (Michael, 2019).

Consequently, pastoralist communities in the Horn of Africa have been facing natural calamities such as droughts, which have been affecting the lives and livelihoods. Nowadays, there is a growing recognition of the effects of climatic and other circumstances on pastoralist communities. However, less is recognized about how an available policy intervention is effective on the issue of climate change (Campbell, 2022). Pastoral production and their livelihood are already being harmed by the impacts of climate change (Tosin, 2020). Therefore, there is a need for a permanent policy intervention to address this issue.

Local communities have employed various coping and adaptation measures to mitigate risks associated climate change. The strategies include, mobility traditional grazing and herd management to responses and recognize but not all local strategies are suitable for long-term solutions (Abate, 2017).

Government interventions and coping mechanisms are essential for addressing the encounters caused by climate change. In Ethiopia has historically paid little attention to pastoralist population, which projected to be over 15 million (Mohamed, 2015). However, the 1995 EPRDF constitution marked a significant turning point by incorporating the issue of pastoralism and agriculture. The constitution provided legal recognition of pastoralism and led to the establishment of measures aimed at supporting pastoral development (TENAW, 2021). This included the creation of a department within the Ministry of Federal Affairs to direct progress efforts in pastoralists' settings, as well as the formation of the rural development minister to operate pastoral communities' issues.

Pastoralist societies have complex social structures and are often located in dry and semi-arid areas with fragile environments. Moreover, climate change and extreme weather events have caused Ethiopia's agricultural production to decline and exacerbated food insecurity over the last few decades (Belay et al., 2022). This descent of dynamic incomes and increased domestic food shortage has been exacerbated by prolonged droughts. Factors such as increasing growth of population and climate variability have adversely impacted the adaptation ability of pastoralists and government organizations to manage resource.

Pastoralist communities historically face cultural, social, economic, and political marginalization (Amwata & Nyariki, 2021). Key development challenges include weak government organizations, inadequate public involvement in policymaking procedures, and inadequate social facilities such as education and healthcare. Pastoralists also rely on extensive herd-based livelihoods that often lack adequate management, experience, markets access, and face long-term environmental decline of rangelands and water resources. In addition, their vulnerability to recurrent droughts intensified by climate change combined with growing competition over natural resources which contributed to ethnic tensions and conflicts (MoARD, 2013). There is a need for

policy intervention on pastoralists' concern development livelihoods and ways of life. This government intervention can take various forms, including the implementation of policies for sustainable land use, water management, and livestock management practices (IFAD, 2019). To design effective institutional interventions, policymakers must have a flawless thoughtful of the extent of climate change's impact on pastoralist communities. This necessitates consulting with pastoralist communities to ensure that interventions are relevant and effective. Several steps can be taken to achieve this objective.

1. Enhancing awareness among pastoralist societies on the impact of climate change and how policies can facilitate adaptation is essential (Asegid, 2024). Providing information and education can empower pastoralists to understand the challenges they face and the potential benefits of institutional interventions.
2. Launching advocacy campaigns can be instrumental in advocating for policies that address the specific needs of pastoralist communities, with a particular focus on sustainable land management, livestock management, and water management practices (UNEP, 2019). These campaigns can help build support and create momentum for policy changes that benefit pastoralists.
3. Conducting research studies and collecting data are crucial steps to assess the effects of policies on climate change amongst pastoralist groups. This research can provide evidence-based insights on the effectiveness of interventions and inform future decision-making processes.
4. Ensuring community participation in decision-making processes is vital to guaranteeing the relevance and effectiveness of interventions (FAO, 2018). Involving pastoralist communities in discussions and allowing them to provide input on policies that affect their livelihoods can lead to more inclusive and context-specific interventions.
5. Implementing capacity-building initiatives to strengthen the skills and knowledge of pastoralist communities is essential (UNCCD, 2018). This enables them to actively participate in the enlargement and operation of policies, to raise pastoralist adaptive ability and resilience of climate change. However, the nature of local knowledge held by pastoralists in relation to climate change and adaptation responses has received insufficient emphasis (Abate, 2017). The climate changes experienced have resulted in recurring droughts, limited availability of animal feed, crop failures, and low yields, ultimately leading to food insecurity, among pastoral communities.

The integration of institutional intervention and indigenous knowledge is critical to efficient of climate change adaptation among pastoralist communities in Ethiopia, particularly in the Somali Region. For instance, the governments need to be equipped to address climate change within this broader context and understand its

implications across all policy areas such as public health, food security, national security, migration, pastoral policy, economics, and fiscal policies (Kaur et al., 2023). Government provide policy frameworks, funding, capacity building, and technical assistance, while indigenous knowledge offers valuable insights derived from generations of experience. This research aims to explore climate change adaptation among pastoralists, providing valuable insights for future interventions and policy development. Policymakers need to understand the livelihood reality of pastoral societies and the impacts of climate variability to effectively intervene the pastoralist livelihood needs.

2.10. Research Gaps and Lessons Learned

A critical synthesis of the global, regional, and national literature reveals that while the inherent flexibility of pastoralism has historically functioned in the ecologically for dryland survival strategy, but the accelerating climate volatility is severely outpacing traditional adaptive thresholds. The existing body of scholarship widely acknowledges that pastoralist adaptation is non-uniform across households; however, severe empirical and theoretical gaps persist regarding to the socio-economic, environmental, and institutional drivers such as age, educational attainment, and primary income sources that dictate this differential adaptive capacity within the Somali Regional State. Methodologically, conventional research frequently presents a narrow, descriptive overview of climate impacts, presenting an acute deficit in how Indigenous Knowledge Systems (IKS) are quantitatively operationalized and measured within empirical studies. Consequently, studies often fail to connect statistically traditional ecological indicators with actual household adaptation outcomes, obscuring how context-embedded local knowledge influences behavioural responses. To bridge these analytical gaps, this study utilizes a Binary Logistic Regression Model to isolate and identify the precise household-level variables that govern adaptation, while evaluating how the systematic integration of traditional ecological monitoring with modern scientific forecasting can exponentially improve local resilience. Furthermore, the literature highlights a profound "implementation gap" between ambitious, top-down national climate frameworks such as Ethiopia's Climate-Resilient Green Economy (CRGE) strategy and successive Growth and Transformation Plans (GTP) and their practical, ground-level execution in marginalized rangelands. State-lead resilience initiatives and institutional interventions remain fragmented, underfunded, and under-evaluated, frequently failing to align with the unique livelihood realities of pastoralists. By employing qualitative insights from Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs), this study directly investigates these structural frictions, explicitly examining why some of sampled respondents remain non-adaptive due to institutional neglect, low policy awareness, or malfunctioning infrastructure. Additionally, while spatial mobility has historically served as the cornerstone of pastoral resilience, modern macro-level

constraints including rangeland privatization, land fragmentation, and rigid administrative boundaries established without considering transhumance needs with increasingly migration and inter-communal resource conflicts. Applying Capability Theory, this research quantifies these modern spatial disruptions and demonstrates how the systemic exclusion of pastoralists from top-down governance architectures directly hinders long-term community freedoms and resilience. Simultaneously, crucial lessons emerge from the literature regarding the long-term sustainability of livelihood diversification. Structurally, an essential analytical distinction must be drawn between productive diversification strategies (such as engaging in viable wage labour or petty trade) and erosive, maladaptive coping mechanisms (such as the distress sale of breeding stock or tree-felling for charcoal production). While defensive, short-term coping mechanisms offer immediate economic relief to asset-poor households, they ultimately function as maladaptive traps that deplete household capital assets, accelerate localized environmental degradation, and destroy critical rangeland biomass. The literature establishes that near-universal cognitive awareness of climate hazards does not automatically translate into functional resilience without addressing key socio-institutional prerequisites. Given the high rates of illiteracy, missing financial credit lines, and severe gender disparities that disproportionately expose women and girls to climate-induced hazards during resource scarcity, adaptation programming cannot run parallel to basic human development. The climate acceleration is pushing environmental conditions past the predictive accuracy of historical experience; future interventions must reject top-down models. Instead, it must implement the hybrid framework that blends the localized, cultural legitimacy of indigenous forecasting with modern scientific meteorology, supported by inclusive, community-participatory governance.

Conclusion

This chapter has provided a thorough overview of the current research on climate change and response strategies of pastoral communities, with particular emphasis on Ethiopia and comparative insights from other global and African contexts. The discussion has established that climate change represents one of the most pervasive and complex threats to human and ecological systems, manifesting through increased temperatures, erratic rainfall, prolonged droughts, and intensified weather extremes. Its impacts extend beyond the environmental domain to influence food security, health, livelihoods, and socio-economic stability dimensions that are especially critical for pastoral communities whose survival is intricately linked to natural resources.

At the global level, the literature review highlighted that climate change has led to notable deviations in temperature and precipitation patterns, causing widespread ecological and economic disruptions. These effects have been most pronounced in developing regions such as sub-Saharan Africa, where adaptive capacities are constrained by limited financial resources, technological deficiencies, weak institutions, and socio-political marginalization. Consequently, despite contributing minimally to global greenhouse gas emissions, African nations and the pastoralists within them bear a disproportionately high share of climate-induced hardships.

In the African context, the continent's high dependence on climate-sensitive economic sectors such as agriculture and livestock rearing exacerbates vulnerability. Pastoralists in the Horn of Africa, including Ethiopia, Kenya, and Somalia, face recurrent droughts, fluctuating rainfall, and diminishing pasture and water resources that severely undermine productivity and food security. Climate change has also intersected with pre-existing structural challenges including poverty, resource-based conflicts, and historical marginalization, thereby complicating adaptation efforts. Importantly, the review identified that while pastoralism remains an inherently adaptive livelihood system given its flexibility, mobility, and traditional ecological knowledge these capacities are increasingly strained by the accelerating pace and scale of climatic change.

Focusing on Ethiopia, the literature underscored the country's high exposure to climate variability and the sensitivity of its livelihood systems, particularly in pastoral and agro-pastoral zones. Ethiopian pastoralists have demonstrated remarkable resilience through various coping and adaptation mechanisms such as herd diversification, transhumance, livelihood diversification, and the integration of indigenous knowledge in weather and resource management. However, these mechanisms are increasingly constrained by environmental degradation, limited institutional support, market challenges, and policy gaps. In particular, weak institutional frameworks, inadequate infrastructure, gender disparities, and insufficient access to education, health, and market services perpetuate vulnerability across pastoralist communities.

The study also emphasized the pivotal role of Indigenous Knowledge Systems (IKS) in local adaptation. This body of accumulated experience, based on close observation of environmental cues, forms the foundation of decision-making among pastoralists and complements scientific knowledge. The effective synthesis of IKS and modern scientific approaches offers considerable potential for improving climate change adaptation. The socio-cultural transformations, modernization, and knowledge erosion pose threats to its preservation and

application. Despite the array of adaptation practices documented, numerous constraints institutional, financial, technological, social, and environmental continue to impede sustainable progress. The inadequacy of institutional interventions and policy frameworks remains particularly notable. As the review demonstrated, while Ethiopia has instituted several climate- and development-oriented policies, the implementation and integration of these measures remain limited in scope and often fail to address the unique needs of pastoralists. Enhancing institutional capacity, fostering inclusive governance, integrating indigenous knowledge, and strengthening early warning and climate information systems are therefore imperative to building resilience and long-term sustainability.

In conclusion, the literature affirms that climate change exerts profound and multifaceted impacts on pastoral livelihoods globally and in Ethiopia. Although pastoralists possess deep-rooted adaptive strategies, these are insufficient to cope with the compounded pressures of environmental degradation, socio-economic marginalization, and policy neglect. Effective adaptation in pastoral areas requires a multi-dimensional and integrated approach linking scientific innovation, indigenous knowledge, institutional collaboration, and community participation. Strengthening institutional support mechanisms, improving access to resources, and embedding climate resilience into development policy are critical for securing pastoral livelihoods and ensuring sustainable adaptation in the face of future climatic uncertainty

Chapter Three: Theoretical/Conceptual Framework

Introduction

The fundamental objective of this theoretical framework is to integrate indigenous and scientific knowledge systems to enhance adaptation to climate change. To ensure academic rigor, this study is grounded in the triangulation of three theoretical perspectives: Afrocentricity, the Sustainable Livelihoods Framework (SLF), and Capability Theory.

Afrocentricity emphasizes the central role of African peoples, cultures, and experiences in interpreting and understanding the world. This lens ensures that adaptation strategies are culturally relevant and rooted in the knowledge systems of the communities being studied. Capability Theory focuses on individuals' abilities and opportunities (their 'capabilities') to achieve well-being, thereby highlighting the importance of human agency in effectively responding to climate challenges. The Sustainable Livelihoods Framework (SLF) provides a holistic and participatory approach to support communities in building resilience, diversifying livelihoods, reducing poverty, and promoting long-term sustainability. By triangulating these theories, the study establishes a robust methodological foundation for understanding how knowledge passed across generations supports climate change adaptation. This integration not only bridges Afrocentric and sustainable livelihoods perspectives but also ensures that adaptation strategies are context-specific, locally relevant, and grounded in both cultural understanding and scientific rigor.

3.1. Afrocentricity Theory

3.1.1. Definition and Theoretical Intent

Afrocentricity theory is an intellectual and philosophical framework that places African people, their values, and worldviews at the center of analysis, interpretation, and understanding of their lived realities (Mkabela, 2005). It developed primarily by Molefi Kete Asante in the 1980s, Afrocentricity emerged as a response to the dominance of Eurocentric paradigms in global scholarship, which often marginalized African experiences. It calls for a shift from externally imposed perspectives to ones that originate from within African cultural, historical, and social contexts. In this regard, Afrocentricity represents both a methodological and ideological repositioning of African people as active subjects rather than passive objects of knowledge and development. Afrocentricity seeks to restore African agency in knowledge creation, interpretation, and application. It emphasizes that Africans must define their own problems and design solutions that resonate with their socio-

cultural and environmental realities. The theory aims to correct epistemic injustices created by colonial and post-colonial systems that suppressed African intellectual traditions. Therefore, Afrocentricity is not about rejecting external knowledge but about decolonizing it by ensuring that it becomes contextually relevant and respectful of African thought systems. Its broader intent is to promote self-determination, cultural confidence, and intellectual sovereignty, all of which are essential foundations for sustainable development. Afrocentricity can provide a framework for understanding African cultural practices and traditional ecological knowledge of pastoral communities, which have enabled them to adapt. In the face of insufficient disciplinary external support, future African scholars must focus on the continent's problems, and identify solutions for problems to promote African-centeredness in the investigative discourse (McAllister, 2012).

Understanding Afrocentricity perspectives can take a key role in the construction of adaptation to climate change using the Local Knowledge System among pastoral communities. It is used as an alternative of Western framework to guide African communities to solve their problems by using ancestral experience and knowledge. Afrocentricity theory perspective is concerned with the mode of thought and action of African interests, values, and minimization of European scientific predominance (Lateef, 2014).

Afrocentricity Theory aims to respond to the question, "What African people can do without white people?" It emphasizes the importance of cultural heritage and social identity in shaping the pastoralist communities' perspectives and responses to climate change. Study conducted in Nigeria explores the role of Afrocentricity in climate change reworking among pastoral communities (Mugambiwa & Rukema, 2019). It highlights the need to recognize the unique cultural and historical context of pastoralism and integrate indigenous knowledge and practices into climate change adaptation policies. The theory emphasizes the importance of preserving cultural identity and empowering pastoral societies in the process of adapting to climate change. For instance, pastoralist communities have an indigenous knowledge to identify climate effects and obstacles, such as limited grassland, floods, droughts, outbreaks of disease, temperature and rainfall amounts that affecting agricultural production (Zhang et al., 2019).

This means that, pastoralist community possesses indigenous knowledge and experience to identify seasonal periods, recognizing signs of the changing seasons, and predicting the amount of rainfall. This knowledge and experience were instrumental in examining how pastoral communities adapt to climate change, into how institutional interventions can be tailored to complement pastoralists' coping mechanisms and strengthen their overall resilience to climatic stresses.

In general Afrocentricity intends to solve multiple interrelated challenges that have historically hindered African progress (Asante, 1995). These include the marginalization of African epistemologies, the

dependence on foreign development models, and the dislocation of indigenous value systems. It also responds to environmental mismanagement that often arises from external interventions insensitive to local ecological systems. By positioning African perspectives at the center of inquiry, Afrocentricity proposes a holistic and inclusive approach to solving social, economic, and environmental challenges. It promotes the idea that sustainable solutions must emerge from within, grounded in local culture, social institutions, and traditional ecological wisdom.

3.1.1. Afrocentricity and Climate Change Adaptation

The association among Afrocentricity and adaptation to climate change is closely linked through their shared emphasis on context-specific, culturally grounded solutions. Afrocentricity promotes the practice of native knowledge systems and local worldviews as central to understanding and responding to environmental challenges. By valuing traditional ecological wisdom and community-based practices, Afrocentricity strengthens the adaptive capacity of African societies, ensuring that climate change responses are both sustainable and culturally relevant. Community-based adaptation, however, often lacks adequate support for exploring the nature of obstacles, which hinders the proposal of effective solutions to climate change problems. This disjointed process underscores the need for a more holistic and robust approach to climate adaptation that fully incorporates the knowledge and practices of local communities (Eisenack & Stecker, 2011). In ancient African perspectives, knowledge of climate change adaptation sometimes involved a spiritual dimension, such as praying to God and following the advice of religious leaders to observe blessings. For instance, lack of rainfall was often associated with divine displeasure or priests' curses, emphasizing the value of communal supplication for rain.

The application of Afrocentricity (Asante, 1995) aims to systematically collect the local knowledge and practices of pastoral communities to inform climate change prevention and adaptation strategies. This approach seeks to leverage and preserve pastoralist customs and habits. By engaging in community-driven coping mechanisms, it is possible to reduce exposure to climate risks and enhance the resilience of local communities. Historically, pastoral communities rely on their knowledge to develop their adaptive capacities and cope with the influences of climate variability. Incorporating indigenous knowledge with scientific knowledge can significantly aid these communities by efficiently familiarizing to the challenges of climate change (Mugambiwa, 2018). This reworking mechanism is employed to sustain indigenous African practices for climate change adaptation among pastoral communities by responding to real or anticipated climatic conditions using their traditional knowledge and wisdom.

Despite their resilience, indigenous peoples in Africa experience numerous challenges, including inadequate support, lack of recognition, and external pressures on their beliefs. Furthermore, high temperatures, livestock disease, and floods have increased their vulnerability, causing food insecurity, personal instability, and impacting overall livelihoods (IWGIA, 2020). Consequently, pastoralists have faced challenges such as competition for water and pasture, socioeconomic and political factors, ethnic-based disputes, poverty, and drought, all of which demand locally available solutions. This study employs a mixed-methods approach to investigate adaptation to climate change, using the Afrocentricity theory perspective as its backbone. The research assesses individuals' level of knowledge and their engagement in climate change adaptation.

Additionally, it provides deeper insights into the underlying mechanisms linking Afrocentric perspectives with climate change adaptation. The finding indicated potential correlations between Afrocentricity and individuals' adaptive capacities, including their knowledge, attitudes, and practices interconnected to adaptation to climate change. Individuals who have stronger self-confidence and beliefs may demonstrate greater resilience, community cohesion, and innovative adaptation strategies by utilizing their indigenous knowledge systems and cultural values (Mugabe, 2015; Kagan, 2022). Recognizing the cultural dimensions of adaptation can inform policymakers and practitioners in developing sustainable and context-specific strategies that build upon local knowledge systems and promote community ownership in addressing climate change challenges (Daudi et al., 2020; Leal Filho et al., 2022). While the Ethiopian government has initiated several programs to improve pastoral regions, many development policies and techniques appear to be state-centered and lack meaningful pastoral consultation (Mohamed, 2019). Climate change presents significant challenges for pastoralist communities, including those in the Somali region. Recognizing the influence of cultural values and indigenous knowledge on adaptation strategies is crucial for developing effective and sustainable responses (Carter, 2018; Mugambiwa, 2018). It is important to understand how cultural values and indigenous knowledge shape adaptation strategies among pastoral communities. By examining how these communities navigate climate change impacts and build resilience, valuable insights and context-specific approaches to climate change adaptation can be developed. Pastoralism is changing in its modern dynamics, as the pastoral way of life is influenced by external and internal factors, including climate change and the growing abandonment of traditional practices, as Western culture influences the younger generation of Africans.

3.1.2. Afrocentricity Theory and Pastoralist Adaptation Strategies

The relevance of Afrocentricity to climate change lies in its insistence on context-based, culturally rooted responses to environmental challenges. For many African communities, climate change is not only a biophysical phenomenon but also a social and epistemological issue; how communities understand, interpret, and respond to climate variability depends on their worldview. Afrocentricity challenges the dominance of Western technocratic solutions and instead advocates for African-centered climate adaptation strategies. These strategies integrate traditional ecological ethics, communal resource management, and local coping mechanisms. By emphasizing indigenous worldviews, the Afrocentric approach promotes resilience-building that aligns with Africa's ecological systems, rather than imposing models that may not fit local realities.

A central component of Afrocentricity is the recognition of Indigenous Knowledge Systems (IKS) as legitimate and scientifically grounded (Asante, 1995). It asserts that these systems, developed through generations of environmental interaction, provide empirical evidence for observation, experimentation, and adaptation. In this view, indigenous knowledge is not inferior to Western science but represents an alternative epistemology that offers crucial insights into local climate dynamics, resource management, and sustainable livelihoods (Asante, 1995). Afrocentricity thus provides a theoretical justification for integrating IKS into modern climate policies and adaptation frameworks, ensuring that interventions are culturally relevant, participatory, and ecologically sound.

Contrary to prevailing stereotypes that often portray pastoralism as backward or environmentally destructive, pastoralists' adaptation strategies are sophisticated forms of environmental management aligned with the realities of Africa's drylands (Eisenack & Stecker, 2011). These practices include:

- ✚ Mobility: Strategic movement of herds to follow changing pasture and water availability.
- ✚ Herd Diversification: Maintaining a mix of livestock species with varying resilience to drought and disease.
- ✚ Traditional Conflict Resolution: Mechanisms for peacefully managing resource competition.
- ✚ Water-Sharing Systems: Equitable communal resource governance.

These practices are understood as expressions of indigenous environmental governance that enhance resilience to drought, floods, and other climatic stresses. Thus, Afrocentricity validates pastoralists' ecological intelligence and positions their knowledge as a crucial foundation for community-based climate adaptation and sustainable resource management. Similarly, indigenous communities have developed intricate agricultural systems by utilizing different altitudes to cope with changing climatic conditions, including

temperature variations and precipitation (Kohler et al., 2022). The integration of traditional knowledge and practices into agricultural systems has demonstrably contributed to the sustainability and adaptive capacity of pastoral communities. Incorporating cultural perspectives into climate change adaptation not only strengthens the resilience of communities but also contributes to the preservation of cultural diversity and identity. It recognizes the intrinsic value of cultural heritage in fostering social cohesion and well-being. To effectively implement pastoralist adaptation strategies, effective collaboration and partnerships between communities, policymakers, and researchers are essential (Djoudi et al., 2016). Afrocentricity, grounded in the pursuit of human knowledge from a culturally and historically informed perspective, emphasizes that understanding must originate from the lived experiences and worldviews of the pastoralists.

In this research, cultural-based climate change adaptation is used as a vital component of Indigenous Knowledge Systems (IKS) to promote inclusive climate governance. The conceptual model developed from local knowledge highlights the significance of cultural dimensions by incorporating traditional leaders and pastoralists as key actors in the adaptation process. These custodians of culture are strategically positioned to provide culturally supported guidance and insights to smallholder farmers and pastoral communities, ensuring that adaptation practices align with cultural beliefs and indigenous environmental ethics.

3.1.3. Afrocentricity Views and climate change Adaptation knowledge

In the African perspective, climate change knowledge is often understood through a spiritual and cultural lens, where environmental changes are linked to moral and religious dimensions of life (Nunn et al., 2014). Phenomena such as prolonged droughts and insufficient rainfall are frequently interpreted as manifestations of the anger of God, believed to result from human wrongdoing or neglect of cultural and spiritual obligations. This cultural view reflects a deep-seated belief in the interconnectedness between nature, spirituality, and human behaviour suggesting that maintaining harmony with divine and ancestral forces is essential for ecological balance. In this context, responding to climate variability is not merely a technical issue but also a spiritual and moral responsibility, requiring individuals and communities to restore their relationship with the divine through rituals, repentance, and adherence to traditional values (Kohler et al., 2022).

Although Afrocentricity Theory effectively emphasizes African values and indigenous knowledge in addressing climate change adaptation among pastoral communities, it faces certain limitations that constrain its practical application. One of the key weaknesses lies in its limited integration of scientific and policy-based knowledge, which reduces its effectiveness in guiding contemporary climate interventions that require empirical evidence and institutional collaboration. Moreover, the theory often generalizes African experiences, overlooking the continent's vast cultural, ecological, and livelihood diversity. This generalization

poses challenges when applying Afrocentric principles to specific contexts, such as the Somali pastoral system, where adaptive strategies, environmental conditions, cultural views and socio-political structures differ significantly from other regions. In addition, Afrocentricity lacks clear methodological frameworks that translate its cultural and philosophical principles into measurable adaptation outcomes, making it difficult for policymakers and researchers to operationalize the theory in practice.

To address these limitations, Afrocentricity should be contextualized to reflect the lived realities of specific pastoral communities, ensuring that its application is grounded in local environmental, social, and institutional contexts. Researchers and policymakers should strive to integrate Afrocentric principles with scientific and policy frameworks, creating a hybrid model that values indigenous perspectives while maintaining analytical rigor and policy relevance. Developing methodological tools and indicators that link cultural value to tangible adaptation outcomes enhanced the theory's empirical strength. Furthermore, fostering collaboration between traditional knowledge holders, scientists, and government institutions can help building inclusive and culturally relevant climate adaptation strategies. Such an integrated approach would preserve the essence of Afrocentric thought its emphasis on African agency and cultural integrity while enhancing its practical utility in modern climate governance and community resilience building.

Consequently, pastoralist communities in the Somali Region possess limited knowledge on ways to effectively adjust to climate change, highlighting the need for stronger collaboration among different stakeholders. Indigenous knowledge is essential for addressing climate-related challenges, as it offers valuable insights into local environmental patterns and community-based coping mechanisms (IWGIA, 2021). This indigenous knowledge can inform cost-effective, participatory, and sustainable strategies, aligning closely with the principles of Afrocentric theory, which emphasizes culturally grounded and community-driven approaches to resilience building.

3. 2. Capability Theory

This study explores the application of Capability Theory in understanding and addressing the adaptation challenges faced by pastoral societies in the perspective of climate change. The principles of Capability Theory, was focused on enhancing individuals' freedoms and capabilities, provide insights into empowering pastoral people to adjust effectively to climate change impacts. The capability method is a moral framework for estimating social arrangements based on community functioning values and sovereignty, aiming to promote an active community (Adams et al., 2012). It aims to "have a more fine-grained approach to understanding what determines well-being, which traditional metrics and statistics fail to capture" (Justin, 2020). Capability Theory was developed by Amartya Sen in the 1980s based on his work on famines, poverty,

and quality of life measures. According to Sen, there was a difference between collective measures of well-being, such as GDP or tons of food, and other measures of well-being, such as life expectancy, literacy, and health outcomes. The capability method is a moral framework for estimating social arrangements based on community functioning values and sovereignty, aiming to promote an active community (Adams et al., 2012). Likewise, Capability Theory emerged from perceived flaws in several modern moral and political theories, including utilitarianism, preference-based strategies, and social contract theory. It helps to identify the diverse range of capabilities needed for pastoralist groups to mitigate to climate elements and enhance their resilience (Adger et al., 2013; Amare, 2023).

Geographical perspective of pastoralist societies in Ethiopia, adaptation to climate change requires considering various capabilities, such as water and grazing lands, knowledge and skills for sustainable land management and livestock rearing, social networks for information sharing and collective action, and decision-making power in shaping adaptation strategies (Amare, 2023). It is important to empower pastoral communities by enhancing their capabilities and adaptation to climate change, fostering sustainable livelihoods, preserving cultural identities, and achieving long-term resilience (Justin, 2020). However, in Ethiopia, most pastoral policies were designed and developed at central government without consultation of the concerned communities. Therefore, it is impossible to evaluate the effectiveness of a policy in improving the livelihood systems of pastoralists if they were not consulted. It is important to consider the consultation of the concerned communities in the policy-making process to ensure that their needs and perspectives are taken into account (IWGIA, 2021). Furthermore, Ethiopia's economy is mainly agricultural and agro-pastoral, and 85% of the population lives in rural areas. A notable policy of the current administration is the Green Legacy initiative, launched in 2019 by Prime Minister Abiy Ahmed, which has positively impacted the lives and livelihoods of pastoral communities. The initiative is part of the government's plan to plant 20 billion seedlings by 2024. If successfully implemented, this reforestation effort will assist to moderate the adverse impact of deforestation and climate change that disproportionately affect pastoral communities.

Additionally, successful policy implementation will encourage pastoralists to reorganize their resources and utilize them based on effective intervention. This includes improving access to education, healthcare, infrastructure, and other essential services that enable individuals to make meaningful choices and pursue livelihood strategies that align with their aspirations. This means enhancing governance structures that involve pastoralists in policy development, planning, and implementation, ensuring their voices is heard and their needs are addressed.

This study was employed the pragmatic paradigm and utilize separate measures, including qualitative and quantitative approaches, to comprehensively investigate the issue of adaptation to climate change among pastoral communities. While capability theorists have traditionally concentrated on human well-being in terms of capacities and functioning, this study was specifically examined economic, social, and cultural values. This research was involved combining quantitative data collection through surveys to assess the capabilities and adaptive capacities of pastoral communities, along with qualitative methods such as interviews and focus group discussions to explore the lived experiences and perspectives of the community.

3.3. Sustainable Livelihood Framework

This research was involved the Sustainable Livelihoods Framework (SLF) as an analytical tool to understand how pastoralists can adjust to the belongings of climate change using Native Knowledge Systems (IKS) in a scientifically interconnected manner. The framework guides the research objectives and interlinks methodological steps, allowing for a comprehensive analysis of the factors influencing pastoral livelihoods. This framework was developed by Scoones, and Conway in the 1990s, which extends beyond mere monetary variables to incorporate valuations of susceptibilities and social exclusion among rural communities. It provides a valuable approach for analyzing the multiple factors affecting the livelihoods of households and individuals, which can stem from cultural, environmental, governmental, and other relevant sources (Soussan et al., 2003). A livelihood is considered sustainable only if it can effectively deal with and recover from stress and shocks. Therefore, pastoralist groups must preserve their existing competencies and assets to ensure sustainable livelihoods for future generations (Chambers & Conway, 1992). This conceptual framework of sustainable livelihoods specifically analyzes the adaptation of climate change among pastoralist communities, focusing on pastoralist coping mechanisms, institutional interventions, and their compatibility with these coping strategies. It also suggests ways can pastoralists to manage the influences of climate change effectively, providing recommendations for policymakers. The SLF was guided the design of questionnaires and the overall exploration of factors that influence both dependent and independent variables. In the Somali region, three out of every four individuals are pastoralists who are predominantly susceptible to the bearings of climate change. This situation calls for both community-level and institutional-level adaptation strategies aimed at transforming livestock-based livelihoods into more sustainable alternatives. This refined approach emphasizes the importance of integrating indigenous knowledge with scientific insights to improve the resilience and adaptive capability of communities in the face of climate change. The SLF framework is conceptualized the key parts of interdependence such as vulnerability context, livelihood assets, institutional policies and processes, livelihood strategies, and livelihood outcomes in order to

address and improve poor people's livelihoods earnings. It was developed as an alternative to previous approaches that solely focused on addressing specific aspects of poverty reduction, such as low income and vulnerability within communities (Karki, 2021).

The pastoralists' management systems, perceptions, age-based experience, and weather forecasting knowledge can offer valuable insights for formulating effective guidelines and policies to solve the problems modelled by climate change. Understanding the reactions of individuals to the concerns of climate change and how these impact their livelihood practices is essential for assessing household livelihood outcomes, including income and food security, as well as the adaptive capacities of herders and the types of livelihood pursued (Teffer et al., 2020). These factors are crucial for planning policies and strategic developments associated to climate change management and sustainable livelihoods. By rigorously analyzing these aspects, researchers and policymakers can gain a comprehensive understanding of the contextual dynamics affecting pastoral livelihoods. This knowledge empowers them to create up-to-date resolutions and develop effective strategies that mitigate the contrary impact of environmental change, enhance adaptive capacities, and promote sustainable livelihood practices (Kollmair & Gamper, 2002). Vulnerability, characterized by insecurity in well-being for individuals and their families, is inclined by innumerable factors, comprising external shocks, seasonality, and internal defensiveness stemming from an inability to cope. To enhance resilience and mitigate vulnerability, individuals and communities can leverage diverse livelihood assets such as natural, physical, financial, human, and social capital. When effectively managed, these assets contribute to sustainable livelihoods and the capacity to adapt to changing circumstances. In this study, the Sustainable Livelihoods Approach was guided the research objectives and interlink methodological steps, focusing on the interdependence of vulnerability, livelihood assets, skills, and the skill of pastoral societies to achieve positive outcomes (Titay, et al., 2017). This approach provides valuable insights into the livelihood strategies and capitals that pastoral societies utilize to adjust to climate change. By relying on a range of assets including livestock, natural resources, social networks, and indigenous knowledge communities can improve their livelihoods. Adaptation efforts should concentrate on strengthening these assets through measures such as diversifying income sources, enhancing access to water and grazing resources, improving social safety nets, and supporting community-based coping mechanisms. These strategies can enhance the resilience and adaptive capacity of pastoral communities, enabling them to effectively address climate-related challenges. This conceptual framework facilitates the analysis of climate change adaptation among pastoralist communities, guided by predefined objectives that necessitate interventions at both community and institutional levels. By employing this framework, researchers and practitioners can thoroughly understand

the complexities involved in climate change adaptation, allowing for the development of targeted interventions that address the specific needs and challenges faced by pastoralist communities. Moreover, the framework draws from participatory and people-centred development approaches, viewing individuals as active agents who employ various livelihood strategies in response to climate change-induced hazards and other adversities (Aisa et al. 2019). It acknowledges that livelihoods are complex and dynamic, involving a range of activities. Development encompasses all stakeholders, including the private sector, public institution, community-based organizations, and developing decentralized government organizations. The framework recognizes that livelihoods are not static; they evolve over time and across different contexts as individuals involved in diverse income generating activities ((Karki, 2021).

Monitoring and evaluating the transmission of indigenous knowledge is a critical stage in addressing climate change adaptation. Effective monitoring and evaluation (M&E) should focus on developing actionable strategies to minimize poverty and support adaptation efforts (Karki, 2021). The vulnerability context encompasses the external environment that directly impacts resource availability and includes trends, shocks, and seasonality factors over which stakeholders have limited control. Vulnerability can be categorized into contextual vulnerability, which addresses a system's capacity to withstand shocks, and outcome vulnerability, which needs integration of different stakeholders to enhance capacities for coping (Fussel, 2009). The vulnerability of pastoralist communities is shaped by a combination of environmental, social, and economic factors, including floods, droughts, livestock diseases, and social conflicts. Additionally, seasonality poses challenges for pastoral communities reliant on rain-fed agriculture. Livelihood assets, defined as the resources individuals or households can utilize to meet survival needs, are crucial for responding to climate impacts. Regarding the SLF, capitals are categorized into five types: human, social, natural, physical, and financial capitals, which are interlinked with the transforming structures and take a dynamic role in determining access to resources and the effectiveness of adaptation strategies (Kollmair & Gamper, 2002).

3.3.1. Guiding Conceptual framework of the study

Adaptation to climate change is a crucial aspect for pastoralist communities, who are mainly liable to the impacts of climate variability and revolution. The guiding framework incorporates various factors that play a significant role in understanding and enhancing the adaptive capacity of pastoralists. This guiding conceptual framework incorporates and interconnected factors such as socio-economic factors, climate change variability factors, adaptive capacity, and climate change interventions strategy. This study aims to investigate the impression of climate variation on pastoralist communities in the Somali region of Ethiopia and explore

their adaptation and coping mechanisms. By aligning the study objectives with the guiding conceptual framework, researchers can gain a comprehensive understanding of the vulnerability, resilience, and adaptive capacities of pastoralists in the face of climate change impacts.

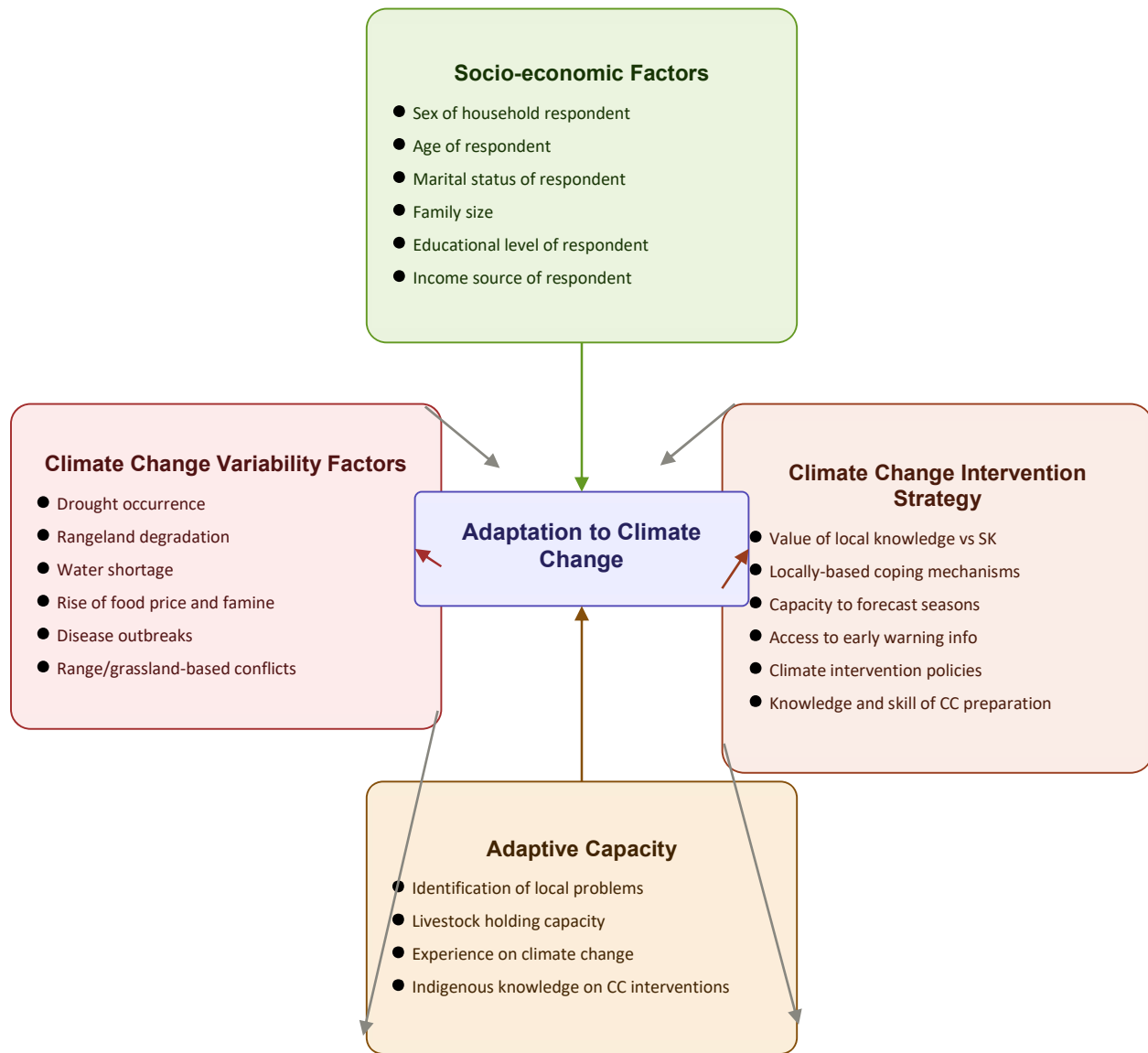
Objective 1: To explore the extent of climate change impact on pastoralist communities in the Somali region of Ethiopia. This objective aligns with the climate change variability factors within the guiding conceptual framework. By assessing factors such as drought occurrence, floods, rainfall variability, temperature changes, livestock and human disease outbreaks, and range/grassland-based conflicts, the researchers can examine the extent of climate change impacts on pastoralist communities in the Somali region. This analysis was provided insights into the specific climate change-related challenges faced by pastoralists in the study area.

Objective 2: To determine the existing pastoralist adaptation mechanisms in the Somali region of Ethiopia. This Objective directly relates to the adaptive capacity component of the guiding conceptual framework. By exploring the capacity of pastoralists to recognize symptoms of climate change, their indigenous knowledge on climate change interventions, livestock holding capacity, and their experience with climate change, the researchers can assess the existing adaptation and coping mechanisms employed by pastoralist communities. Additionally, investigating the indigenous knowledge on climate change interventions was shed light on the traditional practices and coping strategies that pastoralists have developed over time.

Objective 3: To examine the extent to which existing institutional interventions complement pastoralists' adaptation mechanisms. Moreover, this objective is closely linked to the climate change interventions strategy category in the guiding conceptual framework. By examining the capacity of pastoralists to engage in livelihood diversification, the value of local knowledge and locally-based coping mechanisms, the ability to identify upcoming seasons, access to early warning information, and the knowledge and skills of the community, the researchers can evaluate the existing institutional interventions in the Somali region. This analysis was helped to determining the extent to which these interventions align with and support the adaptation and coping mechanisms of pastoralists. It was also highlight any gaps that need to be addressed to enhance the effectiveness of institutional support in promoting livelihood diversification and leveraging local knowledge and skills for climate change adaptation among pastoralist communities.

Objective 4: To suggest ways through which pastoralists can effectively adapt to the impact of climate change in the study area. Consequently this objective aligns with the principal goal of the guiding conceptual framework, which is to develop climate change interventions strategies. By considering the socio-economic factors, climate change variability factors, adaptive capacity, and existing institutional interventions, the study can propose targeted and context-specific recommendations for pastoralists in the Somali region of Ethiopia. These recommendations may include promoting sustainable land and water management practices, strengthening early warning systems, fostering knowledge exchange between pastoralists and relevant stakeholders, and supporting livelihood diversification efforts.

Guiding Conceptual Framework of Study



Source: Author's own construction, 2024

Figure 2: Guiding Conceptual framework of the study

Socio-economic factors, including the sex of the household respondent, age, family size, marital status, educational level, income sources, and distance from the market, are essential for assessing the socio-economic context of pastoralist communities. These factors influence access to resources, decision-making processes, and the ability to adopt and implement adaptation strategies. Understanding these complex relationships is crucial for policymakers, researchers, and communities to develop targeted interventions that address socio-economic disparities and promote inclusive sustainable development. Climate change

variability such as droughts, floods, rainfall fluctuations, temperature changes, livestock and human disease outbreaks, and resource-based conflicts directly impacts pastoralist livelihoods. The interconnected nature of climate change exacerbates its effects on natural systems and human societies. Addressing the multifaceted nature of climate change requires comprehensive, interdisciplinary approaches that emphasize adaptive strategies and sustainable development to build resilience in the face of uncertainty. Furthermore, it is vital to develop strategies for community-led natural resource management, disease prevention, and conflict resolution among pastoral communities. Adaptive capacity refers to the ability of pastoralists to identify local problems, evaluate their livestock holding capacity, draw on their experiences with climate change, and utilize indigenous knowledge related to climate interventions. Strengthening this capacity involves enhancing the skills, knowledge, and resources available to pastoralists, empowering them to anticipate and respond to climate-related challenges. Climate change intervention strategies play a crucial role in facilitating adaptation among pastoralist communities. These strategies include livelihood diversification, recognition of local knowledge, support for community-based coping mechanisms, and enhancing skills for seasonal anticipation. Implementing policies that drive sustainable practices and enhance community knowledge empowers pastoralists to adopt effective adaptive measures.

This research aims to provide a comprehensive analysis of climate change impacts, adaptation and handling strategies, and institutional interventions among pastoralist communities in the Somali region of Ethiopia. By integrating the factors outlined in the guiding framework, policymakers and stakeholders can develop targeted interventions that support climate adaptation. These interventions should prioritize building resilience, enhancing livelihood diversification, promoting sustainable resource management, strengthening local institutions, and fostering partnerships between government agencies, communities, and other relevant stakeholders.

3.4. Definition of Key Concepts/ Operationalization of Variable

Pastoralism is frequently characterized as a culture and way of life in which livestock production accounts for more than half of all income.

Climate Change Adaptation: it's an attempt alteration of the economic, ecological and social schemes, to react to the anticipated or real incentives in climate as well as their impacts. Adjustments in practice, techniques, and structures are required to mitigate potential harms or capitalize on opportunities related to changes in climatic patterns (UNFCCC, 2014). The procedure of adjusting to the existing weather and its impacts to reduce harness and take full advantage of positive opportunities to endurance the effect of climate change (Herrero et al., 2016).

Climate Change: These refer to alterations in the atmospheric state that can be identified through variations in the mean or in other climatic properties, persisting over an extended period typically 30 years or more resulting from natural variability or human-induced activities (IPCC, 2021).

Climate Variability: A change in average condition and unique weather systems on all land and spatial build-up that surpasses the occurrence of the state of the atmosphere on its own. It refers to the deviation of climatic statistics over a specific time period (such as a year, month, or season) when compared with long-term data for the same period (WMO, 2021).

Drought Occurrence: As rainwater is less than average for duration of weeks to seasons, the stream flows such as, lake, reservoir water balance decrease, and well depths increase. Drought is a prolonged period of wetness in the weather patterns that can occur in any place on Earth. It is a calamity with a regular onset that is marked by a lack of rainfall, which bases a water deficit (WHO, 2022). For instance, drought may have a significant detrimental impact on health, agriculture, the economy, energy, and the environment.

Indigenous knowledge: To bridge the gap between abstract concepts and empirical research, operationalizing indigenous knowledge (IK) means breaking it down into measurable, verifiable variables that can be integrated with scientific data. In the context of the Ethiopian Somali Region, IK is operationalized through specific, observable practices: rainfall prediction based on astronomical and celestial observation, and adaptation mechanisms rooted in livestock and resource endurance strategies developed over generations. Far from being mere folklore, indigenous knowledge functions as a systematic, observational science one used by pastoralist communities to predict environmental hazards and manage scarce resources under conditions of high climatic uncertainty.

Conclusion

This chapter presented the theoretic and conceptual foundations that guide the findings, emphasizing how indigenous knowledge, cultural values, and institutional processes influence climate change adaptation among pastoralist communities. By integrating Afrocentricity Theory, Capability Theory, and the Sustainable Livelihoods Framework (SLF), the study demonstrated that effective adaptation requires a holistic understanding of pastoralists' worldviews, capabilities, and livelihood systems. Afrocentricity underscores the centrality of African perspectives, cultural identity, and indigenous ecological knowledge in shaping adaptive responses. Capability Theory adds depth by highlighting the freedoms, opportunities, and resources pastoralists need to make meaningful choices in the face of climate risks. The SLF provides an operational

structure for examining vulnerability, livelihood assets, institutional arrangements, and the adaptive strategies that pastoralists employ.

Composedly, these concepts generate a comprehensive analytical lens through which the study examines climate change adaptation, recognising pastoralists not as passive victims but as active agents with rich cultural knowledge and adaptive skills. The conceptual framework developed in this study illustrates that adaptation is shaped by the interaction of socio-economic conditions, climate variability, adaptive capacity, and institutional support mechanisms. This theoretical grounding strengthens the methodological and analytical direction, ensuring that proposed adaptation pathways are culturally appropriate and scientifically informed. The convergence of these theories highlights the importance of recognising cultural context, livelihood strategies, and community capabilities in climate change adaptation. This entails integrating indigenous knowledge into formal adaptation strategies, empowering pastoralists to partake in decision-making practises, and strengthening their assets and capabilities.

In general, pastoralists' indigenous knowledge and long-standing environmental practices play a crucial role in coping with droughts, floods, and other climatic extremes. These means that the value of cultural heritage and social identity that highlights the need to improve access to education, healthcare, infrastructure, and other necessary facilities to expand pastoralists' ability to pursue livelihood strategies. Moreover, this study establishes a solid theoretical foundation for examining pastoralist adaptation strategies by demonstrating that culturally grounded, capability-enhancing, and livelihood-oriented approaches are essential for building sustainable climate resilience.

Chapter Four: Research Methodology

Introduction

To effectively address the research objectives and response the research queries mentioned in chapter one, the researcher strategically implemented a mixed-methods approach, integrating numerical and insights to ensure the collection of diverse data and produce reliable, accurate results. This comprehensive methodology, which is detailed in this chapter, covers the selection of the research paradigm, the specific design, the study setting, the population and sampling strategies, the data collection procedures, and the analytical plan. For the quantitative component, the study utilized both descriptive statistics and a binary logistic regression model to provide robust and valid statistical findings. Ultimately, the mixed-methods design provides a necessary foundation for triangulating the findings, ensuring that the final conclusions are grounded in both objective metrics and the deep, context-specific insights of the study's participants.

4.1. Description of Study area

According to the Central Statistical Agency of Ethiopia (CSA) population projections of 2017 data shows, the Somali Region has a total population of 11,748,998 people where 25% are urban residents and 75% are pastoralists and agro-pastoralists. The region's annual population growth rate is estimated at 2.6 percent (CSA, 2018). Whereby the average household in the Somali Region consists of 6.4 members, with the average household size of urban areas is 6.3 and rural areas is 6.5 respectively. For instance, from the total population of the region, which is 11,748,998 people, out of that 5,748,998 people were pure pastoralists, whose livelihood is directly linked to livestock rearing.

The Somali person speaks Cushitic family languages which predominantly rely on pastoral and agro-pastoral livelihood systems. Among the Ethiopian regional states, the Somali Region is the second largest in land area after Oromia, covering about 375,000 Km² (Tenaw, 2021). The ethnic composition of the Somali Region has remained relatively homogeneous over the past few decades. According to CSA (2018), about 99.2% of the population are ethnic Somalis, followed by small populations of Oromo (0.46%), Amhara (0.06%), foreign-born Somalis (0.20%), and Gurage (0.08%).

Administratively, the Somali Region is one of the eleven regions of the Federal Democratic Republic of Ethiopia, with Jigjiga city is serving as its capital since 1995, following its relocation from Gode City. The region is subdivided into eleven zonal administrations, ninety-five districts, and six city administrations. Governance operates through a hierarchical administrative structure in which districts are accountable to zonal chairpersons, who in turn report to regionally appointed ministries. These regional ministries are

accountable to the regional president, who is, in turn, responsible to the Prime Minister and the regional parliament.

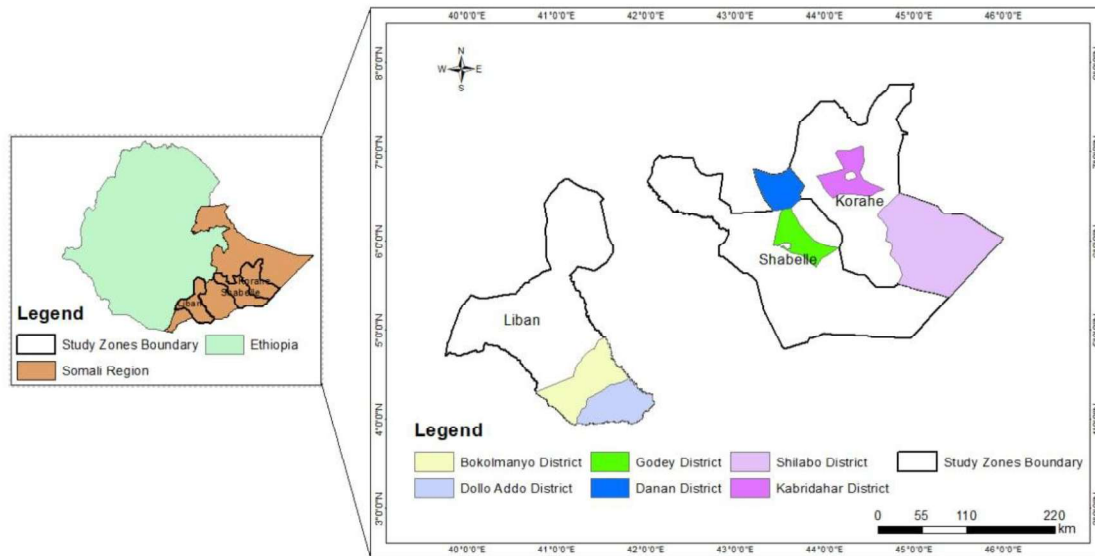


Figure 3: Map of the study Area

The study region is found in the east and southeast part the country, lying between latitude of 7° 26' and 19.43° N and a longitude of 44° 17' and 48.75° E. The region shares borders with Somalia to the east, northwest, south, and southeast; Kenya to the south; and the Republic of Djibouti to the north. Additionally, it borders other regional states within the country, such as the Oromia Regional State to the west and southwest, and the Afar Regional State to the north and west (World Bank, 2020).

4.1.1. Livelihood activities of the Study Communities

Pastoralism, agro-pastoralism, agriculture (both rain-fed and riverine), and urban-based economic activities are the main sources of livelihood in the Somali Region. Among these, pastoralism is the most dominant form of livelihood, with approximately 60% of the population relying on livestock rearing as their primary means of livelihood. Agro-pastoralism accounts for about 25% of the total population and involves mixed farming activities that combine livestock rearing with crop production. The remaining 15% of the population engages in rain-fed agriculture in the Fafan Zone and irrigation-based farming along the Shabelle and Liban Zones, where crop and vegetable production are the main economic activities (Abdisalam et al., 2018).

Pastoralists in the Somali Region primarily depend on the sale of livestock as their main source of income, particularly within the agro-pastoral livelihood zones. However, this livelihood system faces several challenges, including limited market competition, recurrent droughts, livestock diseases, and conflicts over rangeland resources. In addition, crop production in this zone is relatively low due to gully erosion and the widespread invasion of *Prosopis juliflora*, an invasive species that dominates extensive crop and

grazing lands. Despite these challenges, livestock numbers especially goats, camels, and sheep remain significantly high across the region, continuing to serve as the primary source of livelihood and income for the majority of pastoralist households.

4. 1.2. Climate information

The Somali Region is highly drought-prone, characterized by erratic and below-average rainfall that occurs twice a year but varies significantly in timing, volume, and distribution. The region's elevation ranges from approximately 200 meters above sea level in the southern and central areas to about 1,800 meters in the Jigjiga Zone. Annual temperatures also vary widely, from around 19°C in the Jigjiga Zone to nearly 40°C along the river basins of the Shebelle, Dawa, Genale, and Shinile zones. In recent years, the impacts of climate change have become increasingly evident, contributing to greater variability and unpredictability in weather patterns across the region.

The mean annual rain in the Somali Region ranges from 150 mm to 1,000 mm, with considerable fluctuations attributed to climate change (Tekalign, 2021). Historical global climate data indicate that the region's average annual high and low temperatures are approximately 31.95°C and 22.26°C, respectively, with an overall mean daily temperature of about 28.04°C throughout the year. The highest average monthly precipitation occurs in April and November, ranging between 48.9 mm and 70.11 mm. Overall, the region's average annual precipitation is about 18.36 mm, and the relative humidity averages around 47.2%.

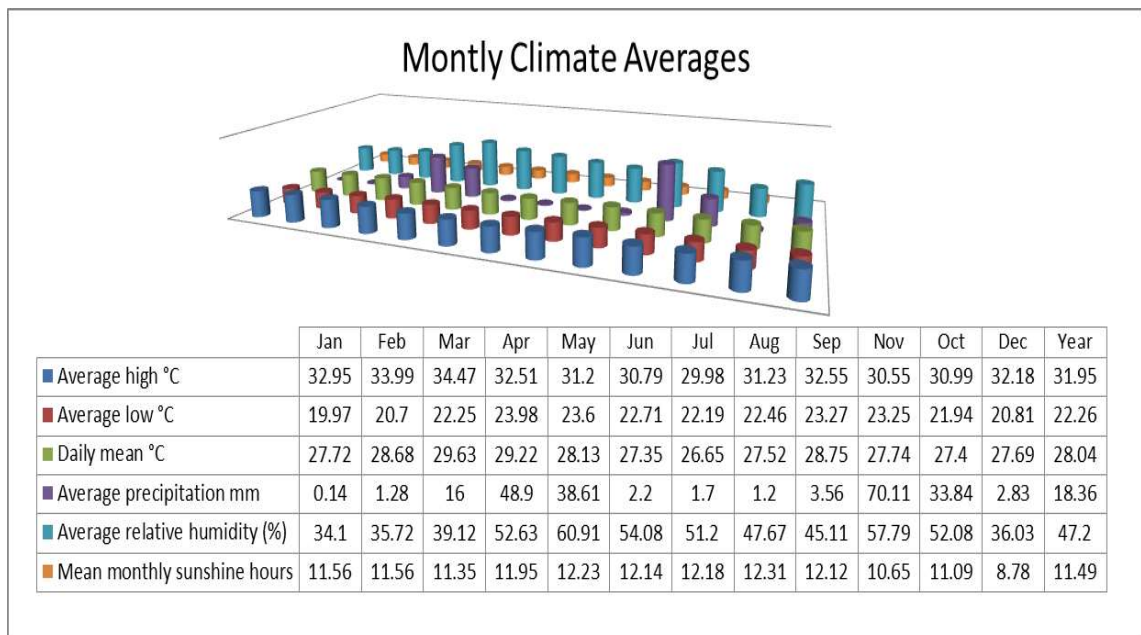


Figure 4: Monthly Climate Average

Source: (Global Historical Weather and Climate Data, 2022)

The climatic zones in the region consist of dry and semi-arid lands that are highly susceptible to droughts. It classified as a subtropical desert climate of terrestrial and aquatic ecosystems which experienced significant degradation, creating it increasingly hard for pastoral communities to sustain their livelihoods due to the unpredictability caused by climate change.

4.2. Research paradigm

This study engaged a mixed-methods research design, combining both quantitative and qualitative approaches, a choice appropriate to and widely accepted under the pragmatism research philosophy. A research paradigm is more than just a technique; it is a fundamental framework, model, or conceptual lens used for conducting inquiry. It represents a set of core ideas, opinions, or considerations that guide the theories and practices in relation to the researcher's topic (Abbadia, 2022). Essentially, it provides a set of perspectives and sympathies that shape one's research ideas and methods. It helps the researcher address foundational questions like why, what, when, where, and how to engage with respondents and answer the research questions. It contains three components such as ontology, epistemology, and research methodology.

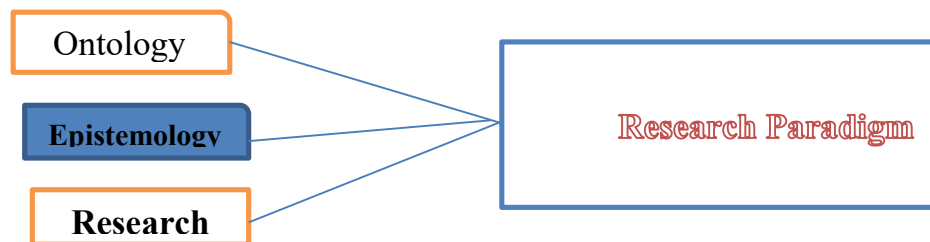


Figure 5: Research paradigm

Ontology is a philosophical theory that pertains to the nature of reality and suggests that there is either only one reality or none at all. Ontology seeks to answer the question, "What is reality?"

Epistemology is the study of knowledge, which focuses on the correctness, scope, and methods of acquiring knowledge. The aim of epistemology is to provide a response to the question, "How can we know reality?" Epistemology encompasses the reliability, parameters, and techniques of acquiring knowledge.

The research methodology seeks to answer the question, "How can research help us understand reality?" This involves the method of collecting and investigating data to provide plausible responses regarding the adaptation of pastoral communities to climate change.

As already stated this study involves, pragmatic research paradigm to support the combination of qualitative and quantitative data type to gain a more comprehensive understanding of a phenomenon.

Pragmatists often blend positivist and constructivist concepts in a single research effort, using both qualitative and quantitative approaches to explore various components of the research issue. Rather than using single research paradigm, they employ a framework that is most applicable to the research question to be examined. For instance, this research seeks to enhance the quality and analytical performance by investigating adaptation to climate change among pastoral communities through the incorporation of Afrocentric theory, capability theory, and a sustainable livelihood framework to focus insights into the coping mechanisms of pastoral societies and addressing the research questions effectively.

Key Assumptions of Pragmatism in Research with relevance to adaptation to climate change among pastoral communities

Table 3: Key Assumptions of Pragmatism in Research

Element	Explanation
Ontology	Reality is both singular and multiple influenced by context and perspective.
Epistemology	Knowledge is constructed through both objective (positivist) and subjective (interpretivist) means.
Axiology	Research is value-driven the researcher's values and social context play a role.
Methodology	Pluralistic uses the methods that best answer the research question.

This research adopts a pragmatic philosophical stance, which aligns with the mixed methods approach used in the study. Pragmatism allows for the integration of both quantitative and qualitative data, recognizing that different types of data can offer complementary insights. For instance by understanding the research methodology and philosophical foundations related to pastoral society's adaptation strategies to climate change is crucial for enhancing the quality and analytical performance of research findings. Moreover, pragmatism is a research philosophy that emphasizes practical consequences, real-world applications, and the usefulness of knowledge in solving community problems. The perspective of climate change adaptation among pastoral communities, pragmatism offers a highly relevant and flexible approach. Pragmatism, as a research philosophy, is highly relevant to climate change adaptation among pastoral communities due to its emphasis on practical, context-driven solutions. It focuses on identifying workable strategies such as rotational grazing or alternative livelihoods that are grounded in the lived experiences of affected communities. By encouraging the combination of scientific and native knowledge, it supports the creation of locally viable responses that enhance ownership and sustainability. Its methodological flexibility allows for the use of mixed methods, such as surveys, interviews, and participatory approaches, to capture both measurable impacts and nuanced perspectives. Moreover, pragmatism prioritizes actionable outcomes that empower communities, influence policy, and drive

meaningful change. By bridging research and decision-making, it ensures that adaptation efforts are not only informed by evidence but are also directly applicable in reducing vulnerability and enhancing resilience on the ground.

Having a strong understanding of the research methodology and philosophical foundations allows the researcher to effectively collect and analyse data by interpreting the results, and drawing valid conclusions on adaptation to climate change among pastoral communities. This collaboration of methodological knowledge were enhanced the quality and consistency of the research outcomes and contributes to the broader body of knowledge in subject matter. Additionally, it can serve as a source for developing priority policy measures and interventions to support pastoral communities' projects in adapting to the challenges of climate change.

4.3. Study approach and design

This research was focused on the Somali National Regional State to analyse adaptation to climate change among pastoral communities. It also planned to take place in 2022 up to 2025 to develop main contexts of the findings expected to answer the research questionnaires as prior plan of study by using both scientific and indigenous knowledge systems, with mixed approach. Through the research era, the key informant interviews and focus group discussions collected data was planned to analysis qualitative approach. This was ensuring that all data is accurately captured and can be analysed in a structured manner. By utilizing qualitative method, the researcher aimed to obtain a comprehensive understanding of the adaptation mechanisms used by pastoral societies. These methods provided insights into the experiences, perceptions, and local knowledge on climate change, coping strategies, and adaptive measures. On the other hand, quantitative data was focused on variables such as socio-economic characteristics, demographics factors, livestock and crop production, access to resources, climate change consequence, interventions, and adaptation practices adopted by pastoralist communities. Additionally, climate data was collected, through gathering the historical climate data from meteorological stations or remote sensing sources. This quantitative data type analysis aims to assess climate trends, variability, adaptation performance and other climate variability results. By using this approach, researcher was gained a better understanding of the changing climate and its implications for the pastoral community.

The integration of the qualitative and quantitative data was a crucial in providing a comprehensive understanding of the adaptation to climate change among the pastoral community. Triangulation of both approaches was helped to identify patterns, differences, and climate conjunction which enhance the validity and reliability of the findings. The mixed-methods analysis was involved thematic analysis for qualitative data and statistical analysis for quantitative data. By exploring the relationships, correlations,

and associations between different variables, researcher can identify the factors influencing adaptation outcomes by using econometric model analysis.

A study design is a type of analysis that employs qualitative, quantitative, and mixed approaches to provide proper guidance for research operations. On the other hand, a research approach is a blueprint and process for conducting research that extends from broad assumptions to precise data collection methods and analysis (Creswell, 2014). By selecting an appropriate research design and approach, researchers can ensure that their study is conducted in a systematic and rigorous manner, which was enhanced the validity and reliability of findings.

In this study, a convergent parallel mixed-methods design was employed, in which quantitative and qualitative data were collected concurrently, analysed separately, and then merged during interpretation. A convergent parallel mixed-methods design (also called a concurrent triangulation design) is a research approach in which the researcher collects both quantitative and qualitative data at roughly the same time, analyses each dataset separately using methods appropriate to that data type, and then merges. The results interpretation of this method draws more comprehensive conclusions than single method analysis.

One of the key strengths of the mixed-methods approach is the ability to generate rich and in-depth and numerical data analysis. It seeks to comprehend the interplay between individuals, their surroundings, and the wider social systems that influence their experiences. It involves a careful blending of methodologies for data gathering, analysis, and interpretation (Shorten & Smith, 2017). Furthermore, cross-sectional data collection methods was involved mostly, but, some extent other data type was encouraged the findings. The previously collected data was reviewed to determine past and future climate trends, to encourage the collected data from sampled population to understand the socioeconomic and demographic characteristics, and perception on climate change, and ways to manage it. This study was triangulated multiple methods, including interviews, observations, focus group discussions (FGDs), key informant interviews, expert consultations, household surveys, and secondary data, to examine the impacts of climate change on pastoral livelihoods and adaptation strategies employed by this communities. Throughout the fact-finding of this research, the data were gathered from randomly selected pastoralist communities, those whose livelihood depends mostly on agricultural production and pastoralism activities, from six (6) districts among the three (3) zonal administrations of the region containing 739,089 people.

Throughout the research process, community knowledge was prioritized, with particular emphasis on local understandings of the changing environment and the adaptation measures used by pastoral communities. This indigenous knowledge was systematically integrated into data analysis and interpretation through participatory approaches, enhancing that the speeches of community members

are central to the research. Furthermore, feedback sessions and the dissemination of findings were conducted with both the pastoral community and relevant stakeholders. This inclusive process was ensured that local perspectives are adequately represented and that the research outcomes remain relevant, applicable, and beneficial to those most affected. By utilizing a mixed-methods approach and fostering active community engagement, the study was generated an inclusive sympathetic of climate change adaptation among pastoralists in the Somali region of Ethiopia. The findings contributed to the development of pastoral policies, interventions, and strategies that are contextually appropriate, for enhancing the flexibility and well-being of pastoral communities in the face of on-going climate challenges.

4.4. Student setting, study population

4.4.1. Study Setting

The study setting is a crucial component of the research methodology as it can ensure substantial influence on the outcomes of the study. Therefore, it is important for investigators to thoroughly document the characteristics, procedures, findings, and other relevant factors of the study situation to ensure ethics approval (Majid, 2018). In order to obtain reliable results on climate change adaptation among pastoral communities, it is crucial to consider the physical, social, economic, and cultural contexts of the respondents. This involves understanding the specific context in which the study is conducted, including the environmental conditions, social structures, economic dynamics, and cultural factors that influence the respondents' lives. During the literature review phase, the researcher was examined how similar research settings have been approached in the past. This involves considering the context, environment, knowledge, experiences, and behaviors of the participants regarding adaptation strategies. By reviewing the existing literature, the researcher can gain insights into the challenges and opportunities faced by pastoral societies in the area, as well as the strategies they have employed to adjust environmental changes.

Using the unique characteristics of the area setting and drawing on existing knowledge, the researcher can design a research methodology that is well-aligned with the context and captures the intricacies of climate change adaptation among pastoral communities. This approach ensures that the study findings are relevant, valid, and applicable to the specific setting, thereby contributing to a well appreciative of the adaptation approaches employed by pastoral people in the face of climate change challenges.

4.4.2. Study Population

The population for this study comprises all pastoral communities in the Somali region, which a contains 5,748,998 of people according to the country's pastoral society record (Gebremeskel et al., 2019). Due to various factors and the large size of the population, the study focused on a sample size of 384 respondents. To achieve the research objectives and assess local knowledge and perceptions

of climate change among pastoralists, the researcher employed various data collection methods, including FGDs, KIs, and a household survey. The researcher was facilitated group interactions and discussions, providing an opportunity to gather collective insights, explore shared challenges, and understand local knowledge on climate change adaptation practices. Moreover, key informant interviews were conducted at the district level. These qualitative methods were provided deeper insights into livelihood activities, pastoral knowledge, and perceptions of climate change among pastoralists in the study area.

By combining household survey, FGDs and KIs, the researcher can gather quantitative data with qualitative insights to analyse the local knowledge, perceptions, and adaptation practices of the pastoralists. This mixed-methods approach was provided a comprehensive understanding of how the pastoral community perceives and cope with climate change impacts, by employing their strategies to adapt existing challenges. Moreover, the researcher engaged in various interactions and discussions to analyse climate challenges, local knowledge, and existing institutional and community-level intervention practices. The finding was contributed to a deeper understanding of the challenges faced by pastoral communities and the adaptation mechanisms they employ. This enhanced understanding is valuable for development actors and policymakers working with pastoral communities in the Somali Region, as it supports the design of more effective, context-specific adaptation strategies.

4.4.3. Sampling and Sampling Size

Sampling is the procedure of picking a selection of people or units from a larger group to stand for that group in a research study. It allows researchers to draw conclusions about the entire population without having to study every member. However, the primary participant in this study was members of the pastoral community, including kebele administrators, community key persons, and households' heads and representatives from government institutions. These individuals are selected due to their diverse experiences with, and perceptions of climate change, as well as their vulnerability to its impacts in the study area. The Government representatives were facilitated to provide insights into existing policies, interventions, and support systems designed to address climate change in the region. These perspectives were offered a broader understanding of institutional responses and strategies aimed at mitigating climate change's implications on pastoral communities.

A multi-stage selection method was engaged to select the target districts and respondents from pastoral communities in the Somali Regional State. The participants included pastoralist household heads, key community members, and selected government representatives who possess diverse experiences associated to the situation and climate change adjusting. To ensure a representative sample, six (6) pastoral dominate districts were purposively selected, from 95 districts of the region by considering

geographical repetitiveness of the region, pure livelihood activities of pastoralism, cultural context, time and budget consideration.

Kothari (2004) defines sampling methods as the statistical procedure for choosing a subset (called a "sample") of a population of interest in order to make observations and statistical judgments about that population. Furthermore, selecting sampling size various methods are used to select the respondents in the scientific community. In this study, the researcher used a sample size determination tool provided as a public service by Creative Research Systems (2012) survey software on its online calculation website, www.surveysystem.com/sscalc.htm. To determine the number of respondents that the investigators need to interview, the researchers must first understand terms such as confidence interval and confidence level.

Based on the sample size determination tool of Creative Research Systems survey software, with a population frame of 5,748,998 people, 5% confidence interval, and 95% confidence level, the sample size calculation provided us 384 respondents.

Additionally, researcher get the same results on the basis of sample size calculation determined by Kothari (2004) formula: $n = \frac{Z^2 P q}{(e)^2}$ at 95% and 5%, where N = sample size, P = estimated proportion, e = level of precision, q = 1-p and Z = inverse standard (tabulated value of 95% = 1.96) = $\frac{(1.96)^2 * 0.5(1-0.5)}{(0.05)^2}$ = 384.

Table 4: Proportional of sample size distribution among selected six districts from three zones

Sample districts	Total Population of the districts	Study zones	Climate feelings	change	Target population	Selected Sampled
Kabridahar	200,228	Korahey	High		n	104
Shilabo	83,701	Korahey	High			43
Gode	163,894	Shabele	High			85
Danan	35,148	Shabele	High			18
Dollo Addo	166,118	Liban	High			87
Bokolmany	90,000	Liban	High			47
Total	739,089					384

Source: Ethiopian Statistics Service web (2022).

4.5. Data collection methods and Procedures

The data-gathering methods and procedure are crucial elements of research, ensuring that data is collected systematically and ethically. Choosing the right method depends on the research goal, and a clear procedure that enhance the credibility of findings. This study was used quantitative and qualitative techniques to integrate primary and secondary data collection methods to capture the complexity of

adaptation strategies. The procedure was beginning with research objectives, followed by data collection after receiving ethical approvals from university of South Africa. Quantitative data was analyzed using statistical tools to identify adaptation trends and opportunities, while qualitative data was undergone thematic analysis to interpret narratives and direct quotation. By combining statistical findings with qualitative insights to ensure a broad sympathetic of how pastoralist communities navigate climate change challenges.

The data-gathering procedure outlines the step-by-step process of collecting data using the selected methods such as questionnaires, FGD, KII, observation of fields and secondary data. It involves various stages such as planning and designing the data-gathering instruments, selecting the sample or participants, conducting data collection, managing and organizing the collected data to draw meaningful conclusions.

Moreover, data-gathering procedure should be carefully planned and applied to confirm the strength, dependability with ethical considerations of the data. It involves the research objectives, determined sample size and sampling technique to guide data collectors by directing the instruments, conducting the actual data collection, and ensuring quality control measures. The primary data collection methods for this study were included household surveys, focus group discussions, key informant interviews, and field observations.

4.5.1. Primary data collection

Primary data collection encompassed quantitative measurements through surveys and qualitative insights through focus group discussions (FGDs), key informant interviews (KIIs), and field observations. To examine how pastoralist communities are responding to climate variability, the study measured the interaction between explanatory and dependent variables related to adaptation.

Household Survey: - To achieve the research objectives, household surveys were conducted using structured, closed-ended questionnaires administered to 384 respondents from pastoralist communities across six selected districts in the Somali Region of Ethiopia. A pre-test survey was conducted prior to the main data collection to safeguard the rationality and consistency of the instrument. "Moreover, the language used in the questionnaires was English, but the enumerators were academicians who all held master's degrees, and their native language was Somali. The principal researcher provided them with short training before data collection began. This preliminary step allowed for the refinement of questions and correction of ambiguities, thereby improving data quality.

The first objective of the study was to assess the extent of climate change impacts on pastoralist communities. The household survey gathered quantitative data on perceived disparities in weather, rainfall amounts, drought frequency, and other climate indicators, enabling the analysis of pastoralists'

experiences and observations of long-term environmental trends. The second objective was to identify existing adaptation and coping mechanisms within the pastoralist system. This was analyzed using descriptive statistics and Binary Logistic Regression Model (BLRM) to determine factors influencing households' decisions to adapt to climate change. Survey responses served as independent variables, while the binary outcome whether a household practiced adaptation strategies represented the dependent variable. The model results provided insights into the relative importance of determinants shaping pastoralists' adaptive behavior and informed possible policy interventions to support effective responses.

The third objective was to evaluate institutional interventions and their alignment with the adaptive needs of pastoralist households. Questions related to institutional support were included in the survey to capture data on assistance provided by government agencies, NGOs, and other stakeholders. These responses helped identify existing gaps and opportunities for strengthening institutional efforts in enhancing pastoral resilience.

Finally, in the household survey, respondents were also asked to suggest ways pastoralists can effectively deal with the consequences of the changing climate. The suggestion was highlighted key areas of focus, including the implications of climate variability on traditional coping strategies, promoting the integration of indigenous and scientific knowledge to enhance adaptive responses, and addressing the constraints and challenges that limit the effective implementation of adaptation strategies within pastoral systems.

Focus Group Discussions (FGDs):- The FGDs were conducted to gain deeper qualitative insights into pastoralists' adaptive responses. FGDs provided an opportunity to explore the socio-cultural dimensions of adaptation, indigenous coping practices, and local perceptions of climate policies. Discussions involved community elders, herders, and key representatives from zonal pastoralist associations. Each zone hosted one discussion group containing at minimum of four participants were selected based on maturity, experience, and practical knowledge of adaptation mechanisms. The FGDs were guided by a structured checklist aligned with the study objectives. The open discussion format encouraged participants to share diverse experiences, values, and local knowledge, enabling a more nuanced understanding of adaptation dynamics. Data from the FGDs enriched the quantitative results by revealing contextual insights and cultural dimensions that numerical data alone could not capture. The integration of qualitative findings thus facilitated a holistic understanding of both the behavioral and structural aspects of pastoral adaptation.

Key Informant Interviews (KIIs):- To enhance community-level viewpoints, Key Informant Interviews (KIIs) were performed with semi-structured interview guidelines. These interviews targeted experts from the pastoral development and disaster prevention offices who have a minimum of a diploma degree and

years of work experience in the office. One member was selected from each of the six districts, resulting in a total of 12 key informants. The purpose of these interviews was to obtain detailed information on district-level climate challenges, institutional responses, and the integration of both scientific and indigenous knowledge in policy and practice. Key informants provided critical institutional insights into the coordination of adaptation programs, implementation challenges, and the relationships between administrative structures and community initiatives (Tenaw, 2021). They also commented on policy awareness and the responsiveness of formal systems to local realities.

Field Observation: - Field observation served as an essential data collection tool to directly examine the ground realities of climate change impacts and adaptation among pastoralist households. By visiting the six study districts, the researcher systematically observed livelihood activities, rangeland conditions, and water resource management practices. Observations also focused on infrastructure quality, functional institutional support systems, and visible signs of environmental degradation or recovery. This method provided firsthand evidence of how climate change influences pastoral livelihoods, enabling a realistic assessment of adaptive capacity and resilience. During data interpretation, insights from field observations were complemented by findings from household surveys, FGDs and KIs contributing to inclusive and coherent consideration of the multi-dimensional challenges faced by pastoralists in the Somali Region.

4.5.2. Secondary method collection

Secondary data collection is the procedure of acquiring knowledge and data which are already been collected and analysed by other researchers or institutions. In investigating climate change and adaptation among pastoralist communities, researchers often utilize secondary sources to obtain climate variability data such as temperature, rainfall patterns, and drought occurrences. These sources may include empirical studies, journal articles, academic theses, government reports, databases, surveys, and other publicly accessible materials. By analysing such data, researchers can gain valuable insights into the adaptive approaches involved by pastoralist societies to reply climate change. This, in turn, supports the development of effective interventions by policymakers and practitioners.

Secondary data collection offers several advantages, including cost-effectiveness, time efficiency, and access to comprehensive datasets that span diverse geographical regions and extended time periods. However, it also presents certain limitations. These may include issues related to data availability, relevance to the specific research context, and potential biases inherent in the original data collection processes. Therefore, it is crucial for researchers to critically assess the quality, reliability, and limitations of the secondary data used. Acknowledging these limitations ensures more accurate analysis and interpretation.

In this study, secondary data collection is a valuable research approach that allows researcher to leverage existing information to address research objectives, complement primary data collection efforts, and generate meaningful insights into complex issues such as climate change adaptation while conserving both time and resources.

4.6. Data analysis strategies

The process of gathering, modelling, and analysing data to gain insights that improve decision-making is known as data analysis (Carlzon, 2022). In this study involves both qualitative and quantitative approaches which interconnect quantitative results with qualitative narratives to support the research findings. Mixed approach is a side-by-side comparison (Creswell, 2014). The collected data from various methods were accurately and systematically prepared. The data was comprehensively tested to ensure quality, reliability, and inclusiveness of answers. Subsequently, the finding variables were described, and checked their relationships to determine the important of variables to study outcomes. The data was coded, edited, and presented to facilitate computerizing of the outcomes. Then the data was analysed and interpreted by using quantitative and qualitative methods toward the nature of the research objectives.

4.6.1. Qualitative analysis strategies

Qualitative research analysis requires the researcher to engage systematically with the target population through discussions, interviews, and observations, ensuring that the findings reflect the participants' actual lived experiences and remain both valid and accurate. In this study, the qualitative data drawn from key informant interviews (KIIs) and focus group discussions (FGDs) were analysed using thematic analysis, guided by three theoretical frameworks: Afrocentricity, the Sustainable Livelihoods Approach (SLA), and Capability Theory. These frameworks did not merely inform data collection; they also structured how the data were interpreted, helping the researcher connect pastoralists' indigenous knowledge and coping strategies to broader theoretical understandings of vulnerability, adaptation, and human capability. The analytical process of qualitative representation was followed these six sequential steps:

Step 1: Instrument Preparation: - Before data collection, interview and discussion guides were carefully developed based on the study's main objectives and expected outcomes. Questions were designed to elicit detailed, context-specific responses on pastoralists' experiences of climate change and their adaptation mechanisms.

Step 2: Informed Consent and Data Recording: - Prior to each interview or discussion, the researcher obtained informed permission from participants, explaining the purpose of the study and their right to participate voluntarily. Responses were recorded through detailed note-taking, following a standardized format to ensure consistency across all interviews and focus groups.

Step 3: Data Familiarization and Organization: - After data collection, the researcher reviewed all raw notes and transcripts, organizing responses according to key thematic areas (e.g., water scarcity, livestock loss, indigenous adaptation practices, and impacts on children's education). This step involved breaking the data into manageable, coded segments to ensure clarity and coherence before deeper analysis began.

Step 4: Coding and Theme Development: - The organized data were then coded that is, similar ideas, phrases, and experiences expressed by different participants were grouped together into categories. These categories were subsequently refined into broader themes that captured recurring patterns across the interviews and FGDs, such as "loss of pasture," "diversification of livelihoods," and "children's labor obligations.

Step 5: Theoretical Interpretation:- Afrocentricity centered the pastoralists' indigenous knowledge and worldview rather than viewing their coping strategies solely through Western development frameworks, while the Sustainable Livelihoods Approach (SLA) examined how households draw on natural, social, human, physical, and financial capital to build resilience against climatic stress; together with Capability Theory, which framed adaptation not merely as a response to hardship but as a reflection of the real freedoms and choices available to pastoralists in securing their wellbeing, these three lenses provided a holistic understanding of pastoralists' adaptive practices. Together, these three frameworks enabled the researcher to explain the interrelationships within the data connecting what pastoralists said and did to the underlying theoretical logic of vulnerability, livelihood strategy, and capability.

Step 6: Refinement and Final Presentation: Finally, the interpreted findings were reviewed and refined for clarity and consistency, checked against the study's guidelines and objectives, and presented as a coherent, polished analysis. Where relevant, the researcher noted implications and suggestions for policy or programmatic improvement based on the identified themes. Through this structured thematic approach, the study was able to move systematically from raw qualitative data to a theoretically grounded understanding of the adaptation mechanisms pastoral communities use to cope with climate change, while remaining faithful to participants' own contextual realities and lived experiences.

4.6.2. Quantitative research strategies

Numerical data was obtained from selected respondents by filling questionnaires, and analysed using descriptive statistic and econometric model. The data analysis was conducted using the Statistical Package for Social Science (SPSS) version 28 software. This method was analysing the information gathered from the questionnaires on how the communities respond changing climate. To improve the accuracy of the results, the researcher linked the analysis with qualitative data. This study, seasonal climate variability (rainfall, temperature, humidity, and precipitation) which shows that the past twenty years has fluctuated due to climate change-related factors (Tekalign, 2021). The climatic data was utilized

to depict the annual maximum, minimum, and average temperatures; the annual maximum, minimum, and mean scores of rainfall; as well as the hottest and coldest days of the years, and the years with the highest and lowest rainfall levels during the analysis period. The temperature differences were estimated using the formula $X - \bar{x} / \sigma$, where X represents individual temperature values, $\bar{x}$ denotes the mean temperature, and σ represents the standard deviation.

Furthermore, in this study, the dependent variable is binary, which is whether the household adapted to climate change or not. The study was employed Binary Logistic Regression Model (BLRM) to investigate the elements that persuade pastoralist decision to adapt or not to adapt. This statistical method has been widely used by scholars to investigate comparable studies on livestock farmers' decision-making processes regarding the belongings of climate change (Seo et al., 2005). The BLRM, also known as the logistic regression model, is suitable for analyzing binary outcomes, such as the decision to adapt or not to adapt. It allows for the examination of the connection between a set of explanatory variables (determinants) and a binary dependent variable (adaptation decision). By estimating the probability of a particular outcome, the BLRM enables researchers to identify the factors that significantly influence the decision-making process of pastoralist.

The statistical model that fits the dummy variable is the binary logistic regression model. The logistic regression model was used to assess the factors of adjusting to climate change: $Logit(P_i) = \ln(P_i / (1 - P_i)) = \beta_0 + \beta_1 X_1 + \dots + \beta_n X_n$ Where $(P_i / (1 - P_i))$ is the logit of adaptation to climate change; P_i represents adaptation choice to climate change; $1 - P_i$ and 0 no adaptation to climate change, and the X_i represents covariates.

The existence of multi-collinearity was estimated among independent variables. When the square root of R^2 is closed to 1 or -1 that indicates variables are highly related to each other and have multicollinearity problems. Moreover, Variance Inflation Factor (VIF) was determining the level of linear associations with continuous variables by looking coefficient among discrete variables by taking threshold level of less than 10 for non-existence of association between the continuous variables by using the formula $VIF(\beta_j) = \frac{1}{1 - R_j^2}$.

Generally in this research was used data analysis process that involves conducting a comprehensive analysis of both qualitative and quantitative data collected through a cross- study design. The data sources was included primary data from household surveys, focus group discussions (FGDs), key informant interviews, and observations, as well as secondary data sources based on the research objectives.

1. *For the objective of exploring and examining the extent of climate change on pastoralist communities, the data analysis was involved qualitative and quantitative analysis methods. The*

quantitative data was analyzed using descriptive statistics, while the qualitative data was subjected to thematic narration analysis to identify key patterns and themes.

2. To determine the existing pastoralist adaptation and coping mechanisms, the data analysis was primarily focus on quantitative analysis and qualitative support. The data collected through questionnaires was analyzed using descriptive statistics and a binary logistics regression model to identify factors influencing adaptation and coping mechanisms as well as qualitative data was support the findings.
3. The analysis of existing institutional interventions and their complementarity with pastoralists' adaptation and coping mechanisms was involved both qualitative and quantitative data analysis. The data collected through household surveys, FGDs, key informant interviews, and observations was analyzed using qualitative methods such as thematic analysis and quantitative methods such as descriptive statistics.
4. To suggest effective ways for pastoralists to cope with the impact of climate change, the data analysis was primarily focus on qualitative analysis and quantitative support. The qualitative such as FGDs, key informant interviews, and observations was analyzed using qualitative data analysis techniques to identify the impact and suggestions as well as quantitative data was supported the findings.

Table 5: Summary of data analysis methods

Objectives	types of data	Data sources	Data collection methods	Data analysis methods
To explore the extent of climate change impact on pastoralist communities in the Somali region of Ethiopia	Cross-sectional with qualitative and quantitative data	Both Primary and secondary	Household survey, FGD, Key informant, Observation	Qualitative and quantitative data analysis,
To determine the existing pastoralist adaptation mechanisms in the Somali region of Ethiopia.	Cross-sectional with qualitative and quantitative data	Both Primary and secondary	Household survey (questionnaires) FGD, Key informant, Observation	quantitative data analysis (Descriptive statistics and Binary logistics regression model) and qualitative insights
To examine the extent to which existing institutional interventions complement pastoralists' adaptation mechanisms.	Cross-sectional with qualitative and quantitative data	Primary and secondary	Household survey, FGD, Key informant, Observation	Qualitative and quantitative data analysis
To suggest ways through which pastoralists can effectively adapt to the impact of climate change in the study area.	Cross-sectional with qualitative and quantitative data	Primary and secondary	FGD, Key informant, Observation and Household survey	Qualitative with quantitative support with data analysis

Source: Own survey result (2024).

The data analysis process was involved the arrangement of qualitative and quantitative analysis procedures, utilizing various data collection methods and sources to address the research objectives and provide comprehensive insights into the bearing of climate change on pastoralist communities in the Somali region of Ethiopia.

4.6.3. Variable Measurement and analysis

Variable measurement and analysis are essential components of conducting rigorous research. In the context of climate change, adaptation can be measured using a binary dummy variable, where a value of 1 indicates that household was adapted, and 0 signifies that household was not adapted. This variable captures whether adaptation measures have been implemented to mitigate the impacts of climate change and enhance resilience.

The classification of households adapted' is determined based on several criteria. These may include the adoption of climate-smart agricultural practices, diversification of livelihoods, and implementation of water management strategies, use of early warning systems, infrastructure improvements, and participation in community-based adaptation initiatives.

More specifically, adaptation to climate change serves as a dependent variable influenced by various independent factors such as socio-economic characteristics, climate variability, adaptive capacity, and the presence of climate change intervention strategies. These was followed many sub-factors that influence household adaptation strategies. However, it is important to recognize that measuring adaptation solely through a binary variable may fail to capture the complexity and evolving nature of the adaptation process. Adaptation is dynamic and context-specific, varying across geographical regions, temporal scales, and social settings. Therefore, it is advisable to complement binary measurements with qualitative data and indicators that are more detailed. This mixed-methods approach enables a more comprehensive understanding of adaptation efforts, their effectiveness, and the contextual factors that influence them. By integrating both quantitative and qualitative analyses, researchers can more accurately capture the multifaceted nature of climate change adaptation.

Table 6: Description of independent variables and Expected hypothesis

Explanatory Variables	Variable codes	Nature	Expected relationship
Socio-economic Factors			
Sex of the respondent	1=Male, 0=female	Dummy	+/-
Age of respondent	Year	Continuous	-
Marital status of the respondents	1= single 2= married 3= divorce 4= widowed	categorical	+/-

Family size	Number	Continuous	-
Educational level of respondent	Can read and write or not	dummy	+/-
Income source of respondent	1.Agriculture, 2 non agriculture 3 both	categorical	+
Distance from the market	Km	Continuous	-
Climate Change variability Factors			
Drought Occurrence	1 yes, 0= otherwise	Dummy	-
Floods Occurrence	1 yes, 0= otherwise	Dummy	-
Rainfall variability	1=yes, 0= otherwise	Dummy	+
Change of Temperature	1 high 0= low	Dummy	-
Disease Outbreak	1 yes 0 = otherwise	Dummy	-
Range/grass land based conflict	1 yes 0 otherwise		-
Climate Change Interventions Strategy			
Livelihood Diversification	1= Yes 0 otherwise	Dummy	-
Value of local knowledge	1= Yes 0 otherwise	Dummy	+
locally based coping mechanism	1= Yes 0 otherwise	Dummy	+
Capacity of Pastoralists to known Upcoming Seasons	1= Yes 0 otherwise	Dummy	+
Access to Early Warning Information	1= Yes 0 otherwise	Dummy	+
Climate Change Intervention Policies	1= Yes 0 otherwise	Dummy	+
Knowledge and Skills of community	1= Yes 0 otherwise	Dummy	+
Adaptive Capacity			
Identification of Local Problems	1= Yes 0 otherwise	Dummy	+
Livestock holding capacity	TLU	Continuous	+
Experience on climate change	1= Yes 0 otherwise	Dummy	+
Indigenous knowledge on cc intervention	1= yes 0 otherwise	Dummy	+

Source: Own survey result (2024).

4.7. Ensuring Rigour: Validity and Reliability

Validity is best achieved through watchful and purposeful planning, consistent and continuous utilization of researcher flexibility, as well as honest and forthright interaction between investigator and the audience regarding the study and its conclusions. This research was explicitly intensive and supported by a conceptual framework for long-term sustainable living. Well-formulated research questions was aid in the selection of appropriate research techniques, improving the trustworthiness of the study and reducing researcher bias, which is prevalent in qualitative methodology (Johnson et al., 2020).

Additionally, it is important to note that the concept of validity is significant, and if it is not handled wisely and applied to research outcomes, it can lead to problems. The development of a solid theoretical framework enables the selection of appropriate research methods to reduce the bias inherent in qualitative research. This helps ensure the internal consistency of participants during data gathering, analysis, and interpretation. Internal validity contributes to the confirmation of meaning and information obtained from the population, which is endorsed by the researcher. Reliability and validity are concepts used to assess research quality and demonstrate how methodological approaches measure what they claim to measure (Middleton, 2019). For instance, reliability refers to a measure's dependability, whereas validity refers to a measure's correctness. It is imperative to reflect dependability and correctness when

researchers generate their own study method and develop a way of interpreting results. The researcher attempted to use data triangulation by employing various mechanisms, such as gathering convergent information and events of investigation and depending on various theories as well as empirically stated climate change and adaptation by pastoralist communities.

Source triangulation, such as combining data from various qualitative and quantitative methods of research analysis and theory integration, provides the blueprint for adaptation mechanisms used by pastoral communities. Discussing the data verification model that was employed to verify the collected data from different stakeholders of the research about adaptation mechanisms used by pastoral communities and how findings are implemented. In this study, to ensure different standards of rigor, mixed methods were used for analysing the output. To verify the real measurement of what researchers are anticipating gaining and magnitude to which the outcomes are measured under circumstances of pastoral community's livelihood systems.

4.8. Ethical considerations

Ethical considerations was the top priority in confirming the validity and trustworthiness of the data collected in the research proposal, both during data collection and throughout the entire research process. These steps were guided by researcher supervision, and the university's policy on research proposals and the thesis or dissertation was followed ethically. In order to present information in a logical sequence, the researcher must select the best research methodology to employ and determine the relevant methods for collecting data and interpreting the research findings (Akaranga & Makau, 2016).

These concerns include the violation of participants' rights, anonymity, and sensitivities, preventing any damage that might occur as a result of their participation in the study, and providing them with accurate knowledge about the research objectives. The researcher was schedule structured and unstructured interviews in advance of the people's availability. The researcher was considered cultural norms, experience and local knowledge in order to get accurate results of adaptation to climate change. Consequently, to protect respondents' privacy and improve their relationships with investigators during research findings, transparency and confusion free questionnaire development is essential. Finally, the investigator was ensured confidentiality during the fieldwork by keeping the secrets of interviewees and minimizing research bias in the data gathering through explanation, and responding community inquiry as possibly by regularly triangulating the interviews, observation, group discussions, and literature review throughout the entire project.

Conclusion

This chapter has comprehensively outlined the methodological framework engaged to accomplish the intentions of this study, which investigates climate change adaptation among pastoral communities in the Somali Regional State of Ethiopia. The chapter began by detailing the description of the study area,

emphasizing the socio-economic, environmental, and climatic characteristics of the area. This contextual background is essential, as it highlights the ecological fragility, the dependence on pastoral and agro-pastoral livelihoods, and the increasing vulnerability to climatic variability. The section on livelihood activities and climatic conditions illustrated how pastoral communities' reliance on livestock and natural resources makes them particularly susceptible to enhancing temperature, erratic rainfall, and recurrent droughts.

The research paradigm and design established the philosophical and methodological foundations rooted in pragmatism approach allowed flexibility and methodological pluralism, combining the objectivity of quantitative analysis with the depth of qualitative inquiry. The mixed-methods design facilitated triangulation, thereby improving the validity, reliability, and comprehensiveness of the findings. In detailing the study population, sampling procedures, and data collection methods, the researcher described a systematic and ethical process for selecting respondents from the population. The multi-stage sampling techniques were employed to select representativeness across different zones, to capture numerical data. The study also elaborated the data analysis strategies applied to interpret qualitative data from FGD, KII and field observation. Qualitative information was analysed thematically to identify major patterns and perspectives, guided by relevant theoretical frameworks, such as Sustainable Livelihoods Approach, Afrocentric theory, and Capability theory. Moreover, quantitative data analysis was employed descriptive statistics and a Binary Logistic Regression Model (BLRM) to examine determinant factors influencing pastoralists' adaptation decisions. The integration of these analyses strengthened the credibility and interpretive power of the research outcomes. Consequently, the validity, reliability and ethical considerations were a central concern of this research finding.

In conclusion, this chapter provided a detailed account of how the research was conceptually framed, empirically designed, and ethically implemented to meet its objectives. By integrating qualitative and quantitative approaches under a pragmatic paradigm, the study ensures that its findings are both scientifically sound and socially meaningful. The methodological framework sets a solid foundation for the subsequent chapter, which presents the analysis, interpretation, and discussion of the study's results, exploring how pastoral communities in the Somali Region are adapting to the on-going and intensifying impacts of climate change.

Chapter Five: The Extent and the impact of Climate Change on Pastoralist Communities in the study area.

Introduction

This chapter presents and analyses the primary data collected on the extent and impact of climate change on pastoralist communities in the Somali Regional State, building on the mixed-methods design described in the methodology chapter. By using the survey, focus group discussion (FGD), and key informant interview (KII) findings as self-evident, the chapter's purpose is interpretive. It asks not only what proportion of respondents reported a given experience, but also why these patterns emerge, what they mean for adaptive capacity and policy, and how far community perception corresponds with independently verified climatic and ecological evidence. Descriptive statistics are therefore presented as a starting point for analysis rather than as conclusions in themselves, and each major finding is examined against the theoretical and empirical literature it's actual and policy implications.

The chapter have interrelated themes, which serve as the framework for interpreting the collected data such as Demographic information of the participants, Patterns and Influence of Climate change on Pastoral Communities, Accessibility and Utilization of Climate Information and Early Warning Systems, Changes in weather patterns (rainfall and temperature), Climate change effects on livestock and grazing land productivity, Influence of Climate Dynamics on Agricultural and Pastoral Productivity, Extents of Climate Change on Pastoralist Communities and Consequences of Climate Change on Natural Resources. Triangulating local knowledge with survey data and with the wider scientific literature is central to this analysis, because adaptive responses are shaped as much by how communities interpret and internalize environmental change as by the change itself. Without attention to this interpretive layer, the chapter would document the existence of impacts without explaining the mechanisms through which perception, vulnerability, and adaptive capacity with analytical rigors.

In general, the chapter examines how climate change affects pastoralist and agro-pastoral practices, while situating these effects within the broader socio-cultural and policy consequences of environmental variability. The impacts documented with evidence of how climate change is reshaping pastoral livelihoods, community identity, and institutional capacity in the Somali Region, and what this implies for adaptation policy and future research.

5.1. Theoretical Framework for Interpreting the Findings

Before presenting the study findings, it is necessary to make explicit the theoretical lenses through which the data are interpreted. Three complementary frameworks structure the analysis in this chapter: the Sustainable Livelihoods Approach (SLA), Adaptive Capacity Theory, and Afrocentric theory. Each addresses a different analytical gap that purely descriptive reporting cannot fill. The SLA explains why particular demographic and asset profiles translate into particular vulnerabilities; Adaptive Capacity

Theory explains why high levels of perceived exposure do not automatically translate into effective adaptation; and Afrocentric theory provides the epistemological grounding for treating pastoralist knowledge, proverbs, and oral testimony as legitimate evidence rather than as illustrative alongside “real” scientific data.

5.1.1. The Interpreting of Sustainable Livelihoods Approach (SLA) with the Findings

The Sustainable Livelihoods Approach conceptualizes livelihoods as a function of five capital assets, human, social, natural, physical, and financial that interact with a vulnerability context (shocks, trends, and seasonality) and transforming structures and processes such as institutions and policy. In this study, by integrating SLA with findings to connected outcomes. Education and literacy levels are indicators of human capital such as household size, labor availability and marital status. The control of livestock describe social and natural capital; and access to early warning systems and health infrastructure describe physical capital and institutional “transforming structures. The SLA makes clear that the recurring high exposure to climate hazards combined with constrained capacity to respond, is not an incidental pattern but the predictable outcome of a livelihood system in which capital assets are simultaneously aligned with finding variables.

5.1.2. Interpreting of Capability Theory with Findings

The integration findings with capability theory by distinguishes between exposure (the degree to which a system is exposed to climatic stimuli), sensitivity (the degree to which it is affected by that exposure), and adaptive capacity (the ability of a system to adjust, moderate harm, or exploit opportunities). A central proposition of this framework, directly relates to the interpretation of findings, is that high exposure and high awareness of a hazard do not by themselves constitute adaptation and adaptive capacity but it depends on the availability of resources, information, and institutional support that convert awareness into effective response. This distinction is essential for this study because, as the data will show, near-universal recognition of drought, rainfall variability, and disease outbreaks coexists with persistently low access to early warning systems, low literacy, and weak health and infrastructure. Therefore, supplies the analytical bridge between “what people perceive” and “what people can do about it,” a distinction that descriptive statistics alone cannot establish and that is applied explicitly in the discussion of each major finding outcomes.

5.1.3. Interpreting of Afrocentric Theory with Findings

Afrocentric theory is associated with social phenomena that analyzed from a standpoint from centers African agency, cosmology, and epistemology, than treating African experience solely through externally derived theoretical categories. For this study, Afrocentric theory justifies and structures the treatment of pastoralist proverbs (e.g., Meel uu dad joga ayey duunya imaada and Maal baddil raas), Quranic education status (Culumo/caamo), and indigenous methods of forecasting climatic cycles (the elders'

belief in 15–50-year rotations) as primary analytical data rather than as decorative ethnographic illustration. Afrocentrically, the indigenous forecasting knowledge is not merely a quaint cultural detail to be contrasted with “real” science; it is itself a long-standing community-based early warning system whose erosion (acknowledged by elders as no longer reliable) constitutes a measurable loss of adaptive capacity pastoralist communities. This theoretical stance is applied throughout the finding to ensure that qualitative testimony is interpreted into epistemological terms by triangulating with scientific climate data. Throughout this chapter, each major empirical finding is examined in three analytical steps. First, the magnitude and pattern of the finding are reported. Second, the finding is read through the most relevant of the three frameworks such as SLA for demographic/asset findings, Adaptive Capacity Theory for the gap between perception and response capacity, and Afrocentric theory for indigenous knowledge and testimony. Third, the finding is set against independent scientific or secondary evidence so that the distinction between what residents perceive and what has been independently measured is explicit, and the policy implications of that distinction are drawn out.

5.2 Demographic Information of the Participants

The demographic profile of respondents is analyzed here as background description on the bases of the human-capital and social-capital foundation on which adaptive capacity is built, following the Sustainable Livelihoods Approach. Each demographic indicator is therefore interpreted in terms of what it implies for households' practical ability to respond to climate stress.

The sex distribution of respondents shows that 61.2% of households were male-headed, while 38.8% were female-headed (Table 4). This imbalance reflects the broader socio-cultural context of pastoralist communities, where men traditionally control decision-making, livestock, land, and mobility, and where cultural and religious norms constrain women's participation in income-generating and asset-owning activities. For instance, the SLA is also, social-capital and natural-capital asymmetry with direct consequences for adaptive capacity of female-headed households. They are simultaneously exposed to climate shocks (because they retain primary responsibility for water and firewood collection, which become more arduous as resources degrade) and less able to convert labor or social networks into climate-resilient livelihood diversification, because asset ownership and mobility decisions sit outside their control. This pattern is consistent with (Amare and Belayneh, 2013), who found a higher proportion of male-headed households in their study of livelihood diversification as a coping strategy for climate change, and it implies that gender-blind adaptation programming risks reinforcing rather than reducing vulnerability among female headed households.

The age distribution of household heads indicates that 77.0% fall within the economically productive age range of 31–64 years, 11.9% are aged 20–30, and 10.9% are above 65 years (Table 4). In aggregate, 88.9% of the sample belongs to the productive age group. This demographic structure is consistent with

what Ethiopia's national planning literature terms a demographic dividend window which is the period of high proportion of working-age individuals creates economic growth potential. According to discussions at the Ethiopian Economic Forum Workshop held in December 2024 at Kebri Dehar University, Ethiopia is currently at the peak of this demographic dividend, yet has not been able to convert this potential into tangible benefit due to limited employment opportunities, internal conflict, and weak governance. Applying Adaptive Capacity Theory to this finding clarifies the policy implication of working -age population is a necessary but not sufficient condition for adaptive capacity. The adaptive capacity works only when it is matched by investment in skills, infrastructure, and markets demand, but the employment opportunities represents underused capacity rather than realized resilience, and policy attention should not aware to focus on the structural employment and improve governance barriers identified at the Kebri Dehar workshop to enhance favorable economic development. This finding is also broadly consistent with (Dary and Kuunibe, 2012), who found age to be a key determinant of livelihood decision-making, since younger and middle-aged household heads tend to be more receptive to adopting new adaptation practices than older heads.

Educational attainment is the demographic indicator most directly relevant to human capital and, by extension, to adaptive capacity. In this sample, 45.3% of respondents were illiterate, 22.9% can read and write without formal schooling, and 31.8% had completed some level of formal education (Table 4). Functionally, this means that less than one in three respondents possesses the literacy needed to interpret written early-warning bulletins, extension materials, or market information without intermediation. This is not a minor descriptive detail. It is the single demographic variable most likely to explain why, pastoralist were not following schooling, due to unavailability of education access or lack of interest. For instance, the SLA, low literacy constitutes a deficit in human capital that constrains the conversion of available natural and social capital (livestock, land, kinship networks) into diversified, climate-resilient livelihoods. Moreover, linking to Adaptive Capacity Theory, the low level of education attainment can lead sensitivity-amplifying factor of the practical difficulty of translating awareness of climate risk into preparedness behavior of pastoralist communities. This finding aligns with (Ali, 2015), who found that illiteracy among pastoralist communities constrains the diversification of livelihoods and the ability to cope with environmental shocks.

As mentioned in a focus group discussion (FGD) was the importance of Quranic education among pastoralist communities. Those who completed Quranic education are known as Culumo, and they are highly respected, while individuals without it are called caamo and are considered illiterate, reflecting how religious education complements or substitutes for formal schooling. For instance, in most families young children attend a Quranic School (dugsi) mainly during the rainy season. In the dry seasons these children are likely to withdraw when their families split in search for grazing areas.

However, pastoralists' livelihoods remain highly vulnerable because their well-being is inseparably tied to livestock and the natural environment, as expressed in the local saying *nole lone ku nool*, which means the living lives with the living. This interdependence highlights how climate variability directly impacts both herds and human survival. Strengthening both formal and non-formal education represents a vital strategy to break cycles of vulnerability, enhance awareness, and foster adaptation pathways that support the resilience and dignity of pastoralist communities.

Pastoralists' livelihoods depend not only on livestock but also on social networks, shared resources, and collective knowledge passed down through generations. It underscores the communal nature of resilience, where one's survival is deeply connected to the health, support, and sustainability of others including humans, animals, and the land on which they live. The policy implication is that conventional, fixed-location schooling models are structurally mismatched to a mobile pastoral population, and that mobile communities need boarding-school models, to address the illiteracy deficit and the disruption caused by seasonal mobility. Quotation from one of the focus groups.

Pastoralists' livelihoods remain inseparably tied to livestock and the natural environment, captured in the local saying nole lone ku nool ("the living lives with the living"). This proverb is treated here, consistent with the Afrocentric, as a primary statement of the community's own theory of vulnerability: human and livestock survival are understood as a single interdependent system, so that any climatic shock to pasture or water is simultaneously a shock to household welfare. This indigenous framing anticipates, in vernacular form of exposure sensitivity logic formalized in Adaptive Capacity Theory, and its persistence across generations suggests that strengthening of formal and non-formal education is not simply a developmental achievement but also reinforce an adaptive logic that communities already hold.

To speak frankly, we are uneducated people who have not gone to school, but we know very well that education is very important for life and development. However, the circumstances we live in do not allow us to educate our children, because we live in rural areas where there are no schools. If we wanted to send our children to the city for education, there would be no one to take care of them or provide for them. The government has not established boarding schools where nomadic families can send their children to study. Among us, some individuals send only one or two children who have had education opportunities, usually because they have relatives in town who can care for them. (FGD, 2025)

Marital status plays a significant role in household responsibilities and influences livelihood strategies. In this study about 66.1% of the respondents were married, 16.7% were divorced, 13.0% were single, and 4.2% were widowed (Table 4). Being married often involves greater responsibility for daily expenses and income generation activities. Consequently, married household heads are expected to be more likely to bear the responsibility and diversify their livelihoods to ensure food security and sustain their families, to the adverse climate events such as drought. In contrast, divorced and widowed women possess greater

independence in decision-making; but they face limitations in cultural views and access to essential resources such as land ownership and force needed labor works, which enhance negatively to climate-induced shocks. This finding aligns with (Michael, 2015), who emphasized that marital status significantly influences exposure to economic pressures and influences the capacity for livelihood diversification. The result, consistent with both the SLA and Adaptive Capacity Theory, is that divorced and widowed women occupy a structurally ambiguous position: freer to act, but with fewer assets to act upon a combination that the data suggest leaves them disproportionately exposed to climate-induced economic and psychosocial stress.

Focus Group Discussions (FGDs) revealed that widowed and divorced women are often more proactive in seeking livelihood options. This increased initiative is largely attributed to the absence of spousal influence, which can limit decision-making autonomy due to family influence. This means that the divorced are vulnerable to climate change by experiencing greater psychological and social stigma, restricting them to explore diverse income-generating activities. However, despite this proactive attitude, unmarried women's ability to fully engage in diverse livelihood activities is still significantly moderated by prevailing cultural norms and asset ownerships. In many pastoral communities in SSA including Somali Region, societal structures tend to favor male ownership of productive assets such as livestock, thereby limiting women's access to asset ownership and decision-making. Asset ownership is a key determinant of economic empowerment, and without sufficient control over these resources, widowed and divorced women often face economic and structural barriers that hinder their adaptive capacity.

Direct quotation: - As We pastoral communities we believe that assets can be acquired through marriage. We have a saying: Maal bacdil raas ("Wealth replaces the head"). This means that if you want to become wealthy, you should first marry and then begin building assets with your wife. This reflects deep-rooted values where social harmony is prioritized over the accumulation of wealth, because a truly rich person is someone who has children, not someone who has accumulated many assets. The saying does not suggest that money is unimportant, but highlights the societal mechanisms established to maintain peace, dignity, and community continuity through inheritance, especially in cases of loss from conflict or accidental death. (FGD, 2025)

Household size further mediates adaptive capacity. Most households (67.2%) have 6–10 members, 19.5% have 3–5 members, and 13.2% have more than ten members (Table 4), with a mean household size of 7.5 higher than the regional average of 6.8. Larger households can deploy more labor across diversified, spatially separated livelihood activities (migration, wage labor, livestock herding). The SLA frames as an expansion of effective human capital through internal labor diversification improves adaptation the mechanism pastoralist communities. Furthermore, a cultural belief exists that sometimes a poor household may become prosperous after the birth of a new child due to the baby's luck, as it is

believed that children born on certain days of the year possess good fortune. However, beyond fortune, large family sizes are critical during times of displacement and drought outbreaks. A larger family can endure and adapt to climate change impacts by splitting family members: some members search for alternative livelihoods or migrate, while others remain to keep and care for the essential livestock assets. Key informant Interview at Bolkolmanyo district Liban zone stated that most pastoralists' communities believe that medium-to-large households always have more opportunities to adapt to a challenging climate. The reason is that large household members improve labor-intensive livelihood activities which are required for climate change adaptation strategies, but they also face challenges when the dependency ratio (children and elderly) is high, as they are part of the household. Quotation:

Finally, livelihood occupations is important for pastoralist communities' vulnerability and adaptation to climate change. In this study, about 51.3% of them rely on pastoralism, and 40.4% cultivate crops in addition to raising livestock (agro-pastoralism). Another 6.3% depend on wage labor, whereas 1.6% and 0.5% depend on salaried employment and business activities respectively (Table 4). This highlights the strong dependence of communities on climate-sensitive livelihoods and their vulnerability to adverse climate change. Pastoralism and agro-pastoralism are highly susceptible to rainfall variability, recurrent droughts, and rangeland degradation. The reliance on these sectors underscores the need for mitigating climate risks by improving education and access to market information, thereby enabling a transition toward more resilient and non-farm livelihood options. This concentration of livelihood strategies in climate-sensitive sectors is the structural precondition for the high exposure levels documented pastoralist communities. It indicates that the diversification toward wage labor, salaried employment, and business activities together still under 10% of the sample respondents. This remains the most under-developed component of household livelihood portfolios, and consequently the most policy-relevant lever for reducing climate vulnerability remain ineffective.

Table 7 Demographic information of the participants

No	Characteristics	Parameters	Respondents	
			Frequency (n= 384)	Percent
1	Sex of the household head	Male	235	61.2
		Female	149	38.8
		Total	384	100.0
2	Marital status of the household head	Single	50	13.0
		Married	254	66.1
		Divorced	64	16.7
		Widowed	16	4.2
		Total	384	100.0
3	Respondent's education level	Illiterate	174	45.3
		Read and write	88	22.9
		Primary school	42	10.9

		Secondary school	51	13.3
		Diploma	26	6.8
		Degree and above	3	.8
		Total	384	100.0
4	Household size	3-5 Family member	75	19.52
		6-10 family member	258	67.18
		11-14 family member	51	13.2
		Total	384	100.0
5	Age of the respondent	20-30	46	11.9
		31-64	296	77.017
		>65	42	10.93
		Total	384	100.0
6	Occupation of household head	Pastoralism	197	51.3
		Agro-pastoralism	155	40.4
		salary takers	6	1.6
		Labour	24	6.3
		business activities	2	.5
		Total	384	100.0

Source: Own survey result (2025).

5.3. Patterns and Influence of Climate change on Pastoral Communities

Pastoralist communities in tropical and semi-arid regions are among the most climate-sensitive populations globally, because their livelihoods depend directly on climate-determined natural resources rangeland, surface water, and seasonal rainfall. This section reports the prevalence of six climate-related hazards as perceived by respondents (drought, flooding, rainfall variability, livestock disease, human disease, water scarcity, and grazing-land conflict). This interrogates what these prevalence figures mean by triangulating against independent climatological evidence and adaptive-capacity theory, to strengthen and improve validity of the results.

Pastoralist communities are highly vulnerable to climate change because their livelihoods depend directly on climate-sensitive natural resources such as grasslands, water sources, and seasonal rainfall that are increasingly affected by shifting climatic patterns. This study revealed that all respondents (100%, n = 384) reported experiencing drought events in their locality in recent years (Table 5). This high prevalence of drought occurrences highlights the central role of this climatic stressor in shaping pastoralist livelihoods. The complete agreement among respondents indicates that drought is not an isolated or irregular phenomenon, but a systemic challenge that has become embedded in the socio-ecological fabric of the study area. In addition, pastoralists in the Somali Region encounter numerous challenges

that undermine the sustainability of their traditional way of life. This study is aligned with earlier results showing that climate change-related factors such as frequent droughts, floods, unpredictable rainfall patterns, and rising temperatures have significantly complicated pastoralist livelihood systems (Stark & Terasawa, 2011).

Drought events lead to reduced biomass production and consequent forage depletion, reduced rangeland carrying capacity, and increased livestock mortality. This undermines household food security due to people's dependence on milk and meat as staples of daily nutrition. Furthermore, drought-induced livestock losses diminish household economies, erode asset bases, and weaken the overall resilience of families to future shocks. From an ecological perspective, recurrent droughts reduce the regenerative capacity of rangelands by accelerating land degradation, intensifying soil erosion, and diminishing biodiversity. Collectively, these impacts create a negative feedback loop that weakens ecosystem resilience and heightens the vulnerability of livestock and human populations to ongoing climatic stresses. Socially, drought intensifies migration pressures, as households are forced to move in search of water and pasture. This mobility has historically been used as a key adaptive strategy in pastoral systems, but it is constrained by shrinking grazing lands, administrative boundaries, and competition with agricultural expansion. Consequently, in Ethiopia, climate impacts have played a significant role in increases in temperature and decreases in rainfall which results in the decline of production where the primary sources of food production depend on agriculture, mainly rain-fed agriculture (Kassaye et al., 2021). The effects of climate change on future crop yield sensitivities, we utilized projected climate outputs from the UQAM-CRCM5 and SMHI-RCA4 models, as presented by Liersch et al. (2018). These projections provided daily mean temperature and precipitation data, which were subsequently aggregated into decadal averages. For the period 2021–2045, the models project an average temperature increase of 1.3°C and 1.4°C, and a corresponding rise in annual precipitation of 54 mm and 85 mm, respectively. These climatic changes are associated with a reduction in sorghum yield losses by 2.9 and 2.4 quintals per hectare relative to the baseline average. Further projections indicate a consistent increase in mean annual temperature across three upcoming decades 2031–2040, 2041–2050, and 2051–2060. The decade of 2051–2060 is expected to experience the highest temperature increases. Specifically, under the UQAM-CRCM5 model, temperatures are projected to rise by 2.11°C (RCP4.5) and 2.91°C (RCP8.5), while the SMHI-RCA4 model forecasts increases of 2.15°C (RCP4.5) and 2.65°C (RCP8.5), all relative to the baseline period of 1988–2018. These projections suggest that mean annual temperatures could reach up to 28.01°C (RCP4.5) and 28.81°C (RCP8.5) in the UQAM-CRCM5 model and 28.05°C (RCP4.5) and 28.55°C (RCP8.5) in the SMHI-RCA4 model by the mid-century (Kassaye et al., 2021).

The scientific consensus also suggests that climate change is increasing both the frequency and intensity of drought events across East Africa and particularly the Horn of Africa, where pastoralism is the predominant livelihood (Butera, 2012).

The analytical task is therefore not merely to report the 100% figure as evidence of drought severity, but to recognize that community perception and independent evidence are substantially aligned. The long-term rainfall record presented in the climatological section demonstrates a measured decline in Gu-season rainfall and repeated drought years most severely in 2011 and 2017 consistent with the documented, La Niña-linked suppression of the Indian Ocean moisture system (NMA, 2025; Wesenu, 2022). This triangulation matters analytically: it allows the 100% perception figure to be read as a reasonably reliable proxy for an independently verifiable climatic trend, rather than as an artifact of survey framing alone. A purely descriptive presentation of the 100% figure obscures this important methodological qualification. Furthermore, it cautions against treating perception data and instrumental data as interchangeable evidence of the same phenomenon, even when they point in the same direction. Adaptive Capacity Theory supplies the analytical bridge between perception and outcome. It posits that while exposure and awareness are necessary, they are not sufficient for adaptation; they require testable data to understand how they translate into action. In this way, the 100% drought statistic is not a conclusion about drought itself. Instead, it serves as the opening premise of an argument explaining why awareness alone has not translated into resilience in this study area an argument that substantiates that institutional support, such as early-warning systems, literacy, and infrastructure, remains mandatory for achieving successful adaptation outcomes. This drought recognition is effectively universal, awareness campaigns yield little benefit but it needs policy intervention. The binding constraint is access to actionable information and resources policy must shift from teaching that a hazard exists to providing tools to respond to it.

About 65.9% of respondents reported that they experienced flood events, while the remaining 34.1% had not encountered such occurrences (Table 5). This finding highlights the presence of significant climate variability and the complex challenges it poses to pastoralist livelihood systems. Over the past century, floods in sub-Saharan Africa have affected 38 million people, claimed thousands of lives, and caused substantial economic losses across the region (Boamah et al., 2015). Therefore, higher temperatures act as a double-edged sword which aggressively strip moisture from the land, leading to prolonged droughts, while simultaneously loading the atmosphere with excess water vapor that eventually falls as torrential, flood-inducing rain. Floods can destroy infrastructure such as roads and shelters, limiting access to markets and essential services, and contaminating drinking water sources thereby increasing the risk of

water-borne vectors. Flooding often results in the displacement of families and livestock, loss of pastures, and interruptions to social and economic activities. Collectively, these impacts not only compound the adverse effects of drought but also weaken the adaptive capacity and long-term resilience of pastoralist communities, rendering them more vulnerable to future climatic shocks.

Flood effect at shilabo district



Pastoralist communities in the Horn of Africa remain among the most politically and economically marginalized populations, a condition that has contributed significantly to widespread household-level poverty. This marginalization limits access to essential social and physical infrastructure, leaving pastoralists below the national development averages of their respective countries' regions. Climate change further compounds these structural inequalities by introducing additional complex challenges. The region is projected to experience more frequent and intense extreme weather events, including floods and droughts, which threaten to destabilize pastoral livelihood systems (Butera, 2012). The coexistence of these opposing climatic extremes underscores the need for integrated and forward-looking adaptation strategies aimed at safeguarding livelihoods, reducing vulnerability, and enhancing the adaptive capacity and preparedness of pastoralist communities.

Variability in rainfall exerts a direct influence on forage quality and livestock nutrition, both of which are fundamental to the livelihoods of pastoralist communities. In this study, about 96.4% of respondents reported experiencing noticeable changes in rainfall patterns compared to the previous decade, whereas only 3.6% perceived no significant variation. This overwhelming majority underscores the growing unpredictability of rainfall and its far-reaching implications for livestock health, household food security, and overall livelihood stability among pastoralist populations (Table 5). Such local perceptions align with climatological studies indicating that arid and semi-arid ecosystems are becoming increasingly exposed to erratic precipitation regimes as a result of climate change (Ngetich et al., 2022).

Sub-Saharan Africa and Ethiopia in particular has experienced a notable rise in climate variability over recent decades, characterized by the increasing frequency and intensity of floods and droughts (Grossi & Dinku, 2022). Given that a large proportion of Ethiopia's population depends on agriculture for its livelihood, fluctuations in rainfall and temperature not only disrupt food production but also reduce households' access to financial and natural resources, thereby constraining their capacity to recover from climatic shocks (Mekuyie & Mulu, 2021). Consequently, climate variability undermines both food availability and income security among smallholder farmers. Furthermore, erratic rainfall and rising temperature adversely impact livestock productivity, intensifying livelihood insecurity among pastoralists who rely heavily on rangeland resources. These findings are consistent with broader scientific assessments, including those of the Intergovernmental Panel on Climate Change (IPCC, 2014), which confirm a growing trend of rainfall variability across Sub-Saharan Africa, particularly within arid and semi-arid regions:

According to our findings from Focus Group Discussions (FGDs) and Key Informant Interviews (KIs), pastoralists have historically relied on traditional ecological knowledge to predict wet and dry seasons, guiding livestock migration and grazing strategies. However, these indigenous forecasting methods have become increasingly unreliable due to shifting climate patterns. Over the past several decades, there has been a noticeable decline in total rainfall, adversely affecting forage quality and livestock nutrition. According to the participants' recollection, prolonged dry periods often result in high livestock mortality rates, and animals that survive the drought frequently face increased vulnerability at the onset of the rains due to their weakened physical condition. These environmental stressors have significant socio-economic repercussions, including increased uncertainty in herd management, reduced livestock market stability, and heightened vulnerability to food insecurity.

Livestock disease outbreaks are a critical challenge to pastoralist livelihoods, significantly undermining food security and reducing household income, thereby exacerbating the vulnerability of affected communities. In this study, approximately 98.4% of respondents reported experiencing disease outbreaks among their livestock, while only 1.6% indicated the absence of such issues, marking a notable increase in disease incidence compared to previous decades (Table 5). The primary outcome of climate change is the loss of livestock (97%) which is followed by food shortages (91%), decreased income (84%), feed scarcity (83%), water scarcity (80%), and crop failure 79% (Tofu et al., 2025). This is a major issue because of the central role of livestock in pastoralist systems, where animals function not only as primary economic assets but also as integral components of cultural identity and social status.

The rise in disease outbreaks is closely associated with weakened animal immunity and deteriorating nutritional status, both of which are consequences of prolonged droughts, poor forage quality, and unreliable water availability. These challenges are emblematic of broader systemic issues faced by pastoralist communities across Africa, including the impacts of climate variability, socio-political marginalization, and limited integration into national policy frameworks. Environmental degradation, particularly the deforestation of dryland forests, further compounds these vulnerabilities. Dryland forest ecosystems, which are critical to climate regulation and biodiversity preservation, have been steadily declining at global, regional, and local scales (Mugambi, 2025). In East Africa, drylands constitute approximately 47% of the region's total land area and support the livelihoods of nearly 20 million people, most of whom are pastoralists. However, the viability of pastoralism in these areas is increasingly affected by a combination of demographic pressures, environmental degradation, and climate-induced disease dynamics (Githae & Mutiga, 2021).

Human disease outbreaks occur when infectious agents such as viruses, bacteria, or parasites spread rapidly within a population, resulting in illness rates that exceed normal expectations. In the present study, approximately 94.8% of respondents reported the occurrence of human disease outbreaks in their area over recent decades, compared to earlier periods, while only 5.2% reported no such experience (Table 5). The twenty-first century has witnessed a wave of severe infectious disease outbreaks, like COVID-19 pandemic, which has had a devastating impact on lives and livelihoods around the globe. The 2003 severe acute respiratory syndrome coronavirus outbreak, the 2009 swine flu pandemic, the 2012 Middle East respiratory syndrome coronavirus outbreak, the 2013–2016 Ebola virus disease epidemic in West Africa (Baker, et al. 2022). This high level of reported incidence reflects growing community awareness and suggests an increasing burden of disease in the region. Most respondents about 94.8% agreed the associated the rise in disease outbreaks with climate variability poses both direct and indirect threats to human health. These outcomes are compatible with research directed by (Davoudi et al. 2014), which demonstrated that climate variability, particularly extreme weather events such as droughts and floods, has been a key driver of increased disease outbreaks in sub-Saharan Africa. Their study found that temperature and rainfall anomalies were significantly associated with epidemics of viruses such as Rift Valley fever, cholera and malaria, particularly in pastoralist and agro-pastoralist regions. This underscores the considerable strain placed on local health systems, which often lack the capacity to effectively monitor, prevent, and respond to emerging health threats. This was expressed in one of our focus group discussions:

There is no doubt that human health is a key component of human capital and plays a vital role in enabling sustainable livelihoods and adaptation to climate change. Good health determines individuals' capacity

to participate productively in the economy and to secure adequate food and nutrition. However, the high incidence of human disease outbreaks caused by climate change in the study area reflects the weakness of existing health facilities which many of them existed in name only and fail to provide the expected level of healthcare services. Moreover, health posts and health extension workers assigned to kebeles are not functioning effectively; when one staff member leaves, it is often difficult to find a replacement due to poor follow-up and weak accountability systems across the Somali Region (FGD, 2025). This was most likely not a common farmer, but some kind of official or professional in the FGD.

Such sentiments were stated frequently as in this key informant interview: *The long distance between pastoralist settlements and hospitals ranging from 60 to 150 kilometres, combined with poor transportation and infrastructure of the Somali region, severely limits providing access to timely medical care. As a result, inadequate infrastructure services have contributed to poor sanitation and hygiene conditions, leaving pastoralist communities highly vulnerable to disease outbreaks. Furthermore, the mobile lifestyle of pastoralists, who frequently move in search of water and pasture for their livestock, hinders consistent access to health education and preventive services (KII, 2025).*

Water scarcity is a dynamic and complex challenge affecting livelihoods as a result of climate change. This study revealed that about 97.9% of respondents reported they are experienced water scarcity as compared in the past as they are recently experiencing more water and livestock feed scarcity, while only 2.1% of them indicated that they had not faced such difficulties (Table 5). The findings highlight that water scarcity is one of the most serious challenges confronting pastoralist populations in the study region. It poses a serious threat not only for survival but also to the productivity and health of livestock, which are central to pastoral livelihoods. The widespread acknowledgment of this problem underscores its severity, reflecting a broader global concern, mainly in developing nations where adaptive capacity and water managing methods remain inadequate. Similar findings were reported by (Mekonnen and Hoekstra, 2016), who noted that nearly two-thirds of the global population experiences severe water scarcity at least one month per year, with the impacts being most pronounced in regions characterized by fragile ecosystems and limited adaptive capacities.

Findings from our focus group discussions indicated that water scarcity is a major driver of human migration, inter-community conflict, and livelihood insecurity, thereby exacerbating socio-economic vulnerability in the affected regions. Filtu Town, of Liban zone, currently lacks boreholes and pipeline water source by costing 20 litter of normal water 100-150 birr by November 2025. However, the government has initiated a major project to supply water to the town and surrounding settlements through

a pipeline from the Genale River, located approximately 70 kilometers away. During the dry season, local pasture becomes depleted and land degraded, forcing herders to divide their livestock herds. Stronger animals are often moved over long distances in search of grazing and water resources. Camels typically access water points every 10–25 days, often requiring one to two days of travel, while sheep and cattle need watering every three days or less (FGD and KII, 2025).

Grassland-based conflict in pastoralist communities is frequently rooted in competition for limited grazing resources, which are fundamental to sustaining the livestock that form the backbone of their livelihoods. In arid and semi-arid environments, characterized by unreliable precipitation and low land productivity, access to pasture is a significant source of tension. In this study about 82.3% of respondents reported experiencing conflicts over grazing land, while the remaining 17.7% did not report such disputes (Table 5). Resource-based conflicts can be understood as a socio-political manifestation of climate-induced stress. The scarcity of essential resources like pasture and water, driven by recurrent droughts and unpredictable rainfall, intensifies competition among pastoralist groups, often escalating into violent clashes.

A pertinent example can be found in the conflicts between the Somali-Oromo and Somali-Afar communities, which are primarily rooted in disputes over the allocation and use of pasturelands and water sources. These tensions are significantly aggravated by compounding factors such as drought, famine, poverty, and external geopolitical interventions. Historically, groups like the Somali, Oromo, and Afar engaged in traditional practices such as cattle raiding and resource competition, but the state restructuring in Ethiopia in 1991 transformed these interactions into more entrenched frontier conflicts (Mohamed, 2018). The persistence of these disputes is also influenced by broader political contexts within Ethiopia. Debates have pointed to the system of ethnic federalism as a contributing factor, which can accentuate conflicts over regional borders. Furthermore, the conflict dynamics are exacerbated by weak local political leadership and administrative authorities, who often lack the capacity to effectively resolve disputes within their jurisdictions.

Table 5: Patterns and Influence of Climate change on Pastoral Communities

No	Characteristics of Variable	Parameters	Respondents	
			Frequency (n=384)	Percent
1	Do you observed the drought occurrence in your locality recently?	Yes	384	100.0
		No	0	0
		Total	384	100.0
2		Yes	253	65.9
		No	131	34.1

	Is there any Floods Occurrence recently in your area?	Total	384	100.0
3	Does Rainfall variability occurred over recent decade as compared in the past?	Yes	370	96.4
		No	14	3.6
		Total	384	100.0
4	Does Livestock disease Outbreak recently happened in your district?	Yes	378	98.4
		No	6	1.6
		Total	384	100.0
5	Does Human disease Outbreak recently happened in your locality?	Yes	364	94.8
		No	20	5.2
		Total	384	100.0
6	Is there water scarcity for livestock and drinking in your area?	Yes	376	97.9
		No	8	2.1
		Total	384	100.0
7	Did you observed grass land based conflict in your area	Yes	316	82.3
		No	68	17.7
		Total	384	100.0

Source: Own survey result (2025).

Policy Implications of Near-Universal Drought Perception

1. Shift Policy Focus from Risk Targeting to Resource Provision

Because the recognition of drought is effectively universal across the sampled population, geographically or demographically targeted awareness campaigns would yield negligible additional benefits. The binding constraint in this system is not a lack of knowledge that drought exists, but rather a lack of access to actionable information and material resources. Consequently, policy interventions must shift from teaching communities that a hazard is occurring to providing the tools necessary to respond to it.

2. Prioritize Early Warning Infrastructure Over Hazard Messaging

Public investment must be redirected from basic hazard-awareness creation toward robust early warning systems (EWS). Given the stark divergence between near-universal hazard recognition and the limited 46.4% access rate to early warning data (Section 5.3), of this study. This dictates efficiency closing of structural access gap. Interventions should prioritize localized forecast dissemination using radio networks, mobile platforms, and trusted intermediaries such as traditional elders and religious leaders—rather than redundant messaging about well-recognized risks.

3. Address Literacy Barriers Through Tailored Communication Channels

Given that 45.3% of respondents are illiterate and existing water and health infrastructure is functioning in name only across multiple kebeles (Section 5.8), of this study. It means the basic literacy and institutional capacity must be treated as prerequisites rather than parallel tracks to adaptation programming. Any early warning or adaptive framework built exclusively around written or digital information channels will systematically exclude the most vulnerable households. To prevent this, policy implementations must bypass literacy barriers by embedding oral communication, intermediary networks, and Quranic-school delivery channels into their dissemination strategies, aligning with the contextual realities.

4. Co-Produce Knowledge by Integrating Rather than Displacing Indigenous Forecasting

Elders' traditional methods of anticipating climatic cycles (Section 5.7) of this study represent a pre-existing, deeply trusted, and locally legitimate early-warning framework. The erosion of this traditional knowledge base compounds the formal early-warning deficit rather than resolving it. Policy frameworks should therefore adopt a co-production model that integrates, rather than bypasses, indigenous forecasting. Combining scientific meteorological data with local indicator-based knowledge enhances the community uptake and perceived legitimacy of modern early-warning messages.

5.2.2 Rainfall Dynamics and Climatic Extremes in the Shabelle Zone, Ethiopia (1985–2025)

The rainfall record for 1985 – 2025 shows that 1997 and 2019 recorded 780 mm and 820 mm, respectively values that are higher than in other years on record (NMA, 2025). These peaks are associated with a positive Indian Ocean Dipole (pIOD), which acts as a moisture conveyor belt, funneling humid air from the warm waters near the East African coast into the Shabelle lowlands. In 2019, this phenomenon was so strong that it effectively “supercharged” the Deyr (October–December) rainy season, producing rainfall totals nearly three times the seasonal norm. These years represent a climatic surplus, in which the atmosphere’s high water-holding capacity supports intense convective storms that can recharge deep aquifers but may also trigger widespread fluvial flooding across the Shabelle River basin.

In contrast, the minimum rainfall years 2011 (320 mm) and 2017 (340 mm) signify periods of severe moisture deficit linked to the La Niña phase of the ENSO cycle. During these years, typical moisture-bearing winds are diverted away from the Horn of Africa toward the western Pacific. This results in a catastrophic failure of the Gu (April–June) rains, which are vital for pastoral and agro-pastoral livelihoods in the Shabelle Zone. These troughs are often exacerbated by high potential evapotranspiration: because the air is dry and temperatures remain high, any limited rainfall that does occur is quickly returned to the

atmosphere before it can infiltrate the soil. This produces meteorological drought that can rapidly intensify into agricultural drought.

According to reports from Famine Early Warning Systems Network (FEWS NET), rainfall peaks in Shabelle in 1997 often occurred while the northern and western Ethiopian highlands were experiencing rainfall deficits, due to the differing impacts of El Niño across the country (Wesenu, 2022). Conversely, the 2011 and 2017 droughts were more uniform in their impacts across the Somali and Oromia regions and are widely cited in Ethiopian literature as among the most severe dry spells of the 21st century.

Average annual rainfall change is projected to range from -11.36% to $+10.38\%$ under RCP4.5 and from -12.91% to $+53.28\%$ under RCP8.5. Moreover, climate model projections indicate changes ranging from -16.00% to $+6.18\%$ under RCP4.5 and from -12.30% to $+85.14\%$ under RCP8.5, relative to the baseline period (1971–2000), for the near-term (2021–2050) and mid-term (2051–2080) periods (Wesenu, 2022). These deficits are compounded by high potential evapotranspiration, which returns the limited rainfall that does occur to the atmosphere before it can infiltrate the soil, converting a meteorological drought rapidly into an agricultural drought. This mechanism provides the independent climatic basis for the 100% drought-Overall, these projections indicate that stream flow will likely decrease from October to November under both emission scenarios, and from April to October in the mid-term under both emission scenarios. While the highlands benefit from the Kiremt (main) rains, Somali Region's reliance on the bimodal Indian Ocean rainfall system makes its maxima and minima far more volatile and extreme than those observed in the more temperate central regions of Ethiopia. These deficits are compounded by high potential evapotranspiration, which returns the limited rainfall that does occur to the atmosphere before it can infiltrate the soil, converting a meteorological drought rapidly into an agricultural drought. This supports the finding results that provides the independent climatic basis for the 100% drought of respondents' feedback.

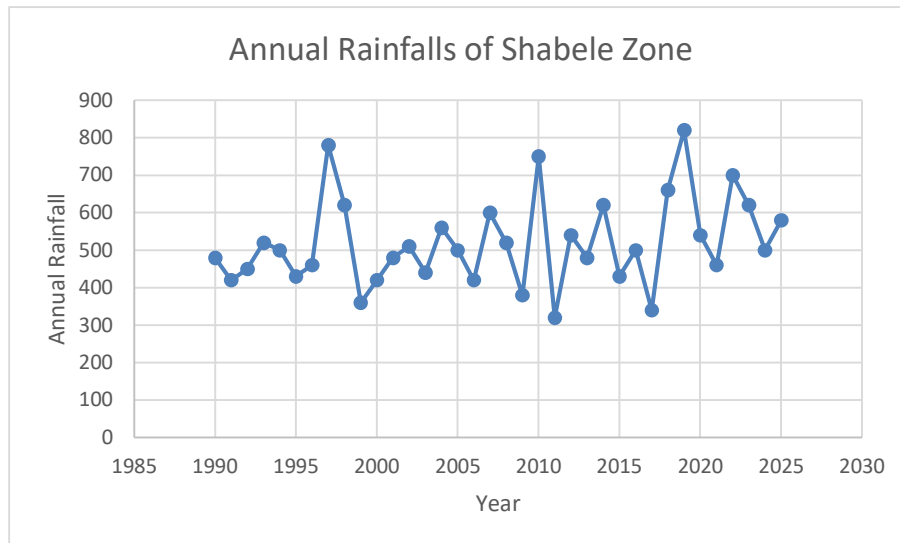


Figure 6:- Annual Rainfalls of Shabelle Zone

5.2.3 Rainfall Dynamics and Climatic Extremes in the Korahey Zone, Ethiopia (1985–2025)

Rainfall patterns in the Korahey Zone of south eastern Ethiopia, within the semi-arid Somali Region, exhibit pronounced inter-annual variability. This variability is driven by complex ocean–atmosphere interactions, primarily the Indian Ocean Dipole (IOD) and the El Niño–Southern Oscillation (ENSO), which strongly influence the seasonal distribution of rainfall across the Horn of Africa. Analysis of rainfall records from 1985 to 2025 highlights recurring and extreme fluctuations between anomalously wet and exceptionally dry years. Notably, 1997 and 2019 were among the wettest years, while 2011 and 2017 were among the driest, marked by severe drought (NMA, 2025).

The peak rainfall year of 1997, (480 mm) coincided with one of the most intense El Niño events of the 20th century. In south eastern Ethiopia, El Niño conditions often enhance the Deyr (October–December) rainy season by warming sea surface temperatures (SSTs) in the western Indian Ocean. These warmer SSTs promote moisture convergence and convection over the Horn of Africa, resulting in above-average rainfall. The year 2019 (520 mm) recorded the highest rainfall in the region, largely driven by an exceptionally strong positive IOD. This "super" IOD phase significantly elevated SSTs in the western Indian Ocean, intensifying the inflow of humid south-easterly winds. As a result, the Korahey Zone received rainfall exceeding twice the climatological average during that period.

In contrast, the extreme lows of 2011 (140 mm) and 2017 (150 mm) reflect the region's vulnerability to drought conditions linked to adverse oceanic influences. The year 2011, the driest on record, coincided with the well-documented Horn of Africa drought, primarily associated with a strong La Niña event. Cooling SSTs in the western Indian Ocean suppressed convective activity over eastern Africa and severely weakened the Gu (April–June) rains. Similarly, 2017 received only 150 mm of rainfall, far below expected levels, as part of a prolonged drought period. Scientific assessments suggest that successive

failures of seasonal rains reduce soil moisture, limit evaporative cooling, and contribute to rising surface temperatures. Consequently, the Korahey Zone experienced a critical moisture deficit that led to widespread livelihood losses among pastoral communities.

Overall, the observed rainfall patterns in the Korahey Zone align with broader climatological findings across the Somali Region of Ethiopia, which point to a long-term decline in annual rainfall since 1997, particularly between 2015 and 2017. Comparable regional dynamics of rainfall variability have also been documented in the Borana Zone and other southern pastoral areas. While temperatures show a consistent upward trend, rainfall has become increasingly unpredictable, often characterized by delayed onset and shortened rainy seasons. These ecological and livelihood impacts are compounded by an increased frequency of extreme dry events occurring roughly every two years since 2014 which has contributed to ongoing ecosystem degradation.

In summary, rainfall dynamics in the Somali Region, particularly the Korahey Zone, over the past four decades underscore the area's sensitivity to large-scale oceanic drivers and the broader impacts of climate variability. Alternating patterns of rainfall surplus and deficit affect water availability and carry profound implications for food security, pastoral livelihoods, and ecological sustainability. Understanding these dynamics is essential for strengthening early warning systems, improving adaptive planning, and supporting climate-resilient development strategies in Ethiopia's semi-arid regions.

This acceleration in drought frequency is consistent with and provides an independent explanation for the 100% of respondents' agreement that elders perceive the traditional 15–50-year climatic rotation cycle to have broken down into an "unspecified" and less predictable pattern. The instrumental record confirms that drought recurrence intervals have genuinely shortened, indicating that the erosion of indigenous forecasting confidence reported by community elders tracks a real, measurable change in climatic periodicity, rather than reflecting a loss of cultural knowledge alone. Moreover, while rainfall has become less predictable, temperatures show a consistent upward trend, indicating that the region's vulnerability is being shaped jointly by reduced and more erratic precipitation and by rising thermal stress a compounding combination examined directly in the following section.

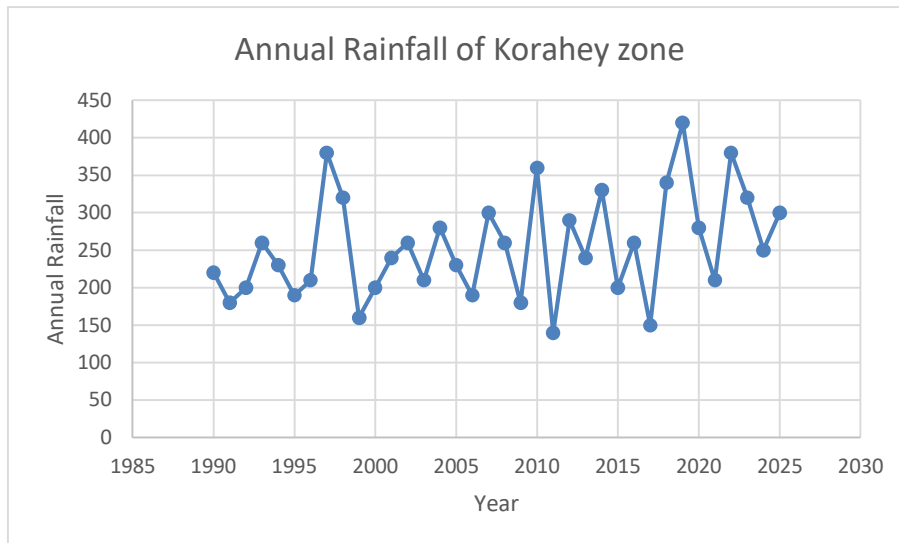


Figure 7:- Annual Rainfall of Korahey zone

5.2.4 Temperature Peaks and Troughs in the Shabelle Zone (1990–2025)

Maximum temperature values, observed most prominently in 2019 and 2022, indicate years of extreme thermal stress associated with the same positive IOD and El Niño conditions that drove the rainfall peaks. The same atmospheric conditions that suppressed rainfall reduced cloudiness and limited evaporative cooling also increased net surface radiation, intensifying heat extremes in arid and semi-arid lowlands (Saji et al., 1999; Nicholson, 2017; IPCC, 2021). The persistence of high temperatures further increases evaporative demand, reinforcing drought stress. This means that, mechanistically, the warmest years and the driest years in this record are not independent phenomena but are generated by overlapping ocean–atmosphere conditions. This is analytically important because it explains why respondents' lived experience of drought, water scarcity, and heat stress tend to co-occur in the same calendar years rather than as unrelated hazards.

Minimum temperature years, such as 2000 and 2011, represent periods of comparatively lower cumulative thermal energy, generally aligning with La Niña conditions or enhanced regional moisture transport that suppress daytime heat extremes through increased humidity and cloud cover (Nicholson, 2017). Notably, 2011 records both the minimum temperature and the minimum rainfall of the year. This illustrates that drought in this context is not simply a function of heat but can also occur under comparatively cooler conditions when atmospheric moisture transport fails a nuance that reinforces the earlier point that respondents' broad use of the term "drought" captures a composite hydro-climatic experience rather than a single, easily defined meteorological threshold.

In comparison with other Ethiopian climatic zones, a clear contrast emerges between lowland (Kolla) and highland (Dega) climates. Ethiopian climate summaries consistently show that lowland areas maintain higher mean and maximum temperatures, while the central highlands (e.g., around Addis Ababa) are cooler, primarily due to elevation and the environmental lapse rate (NMA, 2025; Barry & Chorley, 2009).

This altitudinal control on temperature is a well-established physical relationship in mountain climatology (Barry & Chorley, 2009).

Further, the Afar Region provides a distinct "maximum" context: the Danakil Depression is internationally documented among the hottest inhabited places on Earth, with extreme heat linked to its very low elevation and regional desert climatology (NMA, 2025; IPCC, 2021). Conversely, conditions in pastoral areas of Ethiopia can yield maximum temperatures similar to those in Shabelle but with substantially higher humidity, which elevates the heat index (apparent temperature) and changes the human-perceived heat stress relative to drier lowland environments (NMA, 2025).

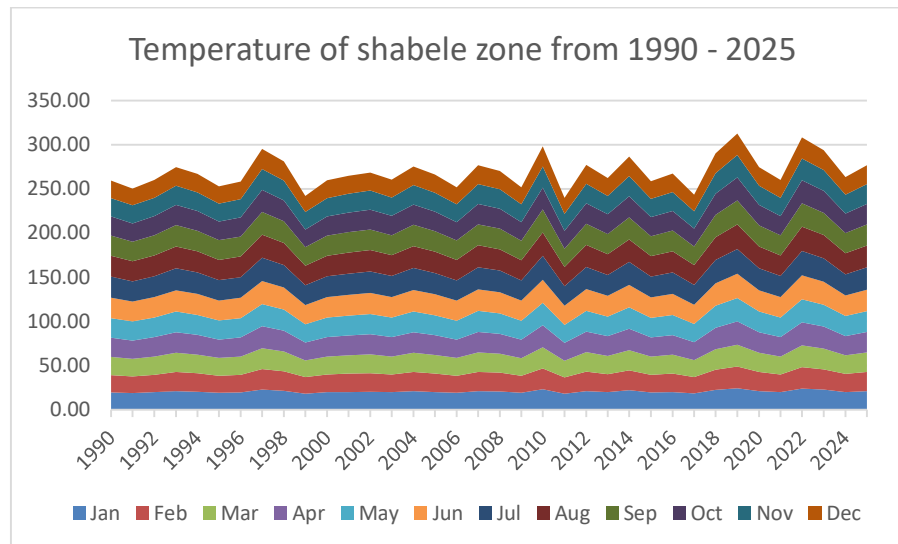


Figure 8: Temperature of shabele zone from 1990 - 2025

5.3. Accessibility and Utilization of Climate Information and Early Warning Systems

Access to early alert systems is critical for strengthening the adaptive ability and endurance of communities, particularly those who rely on ecologically sensitive occupations like pastoralism and agriculture. Early warning systems (EWS) provide timely, accurate, and actionable climate-related information such as forecasts of droughts, floods, extreme temperatures, or seasonal rainfall patterns which enables individuals and communities to prepare for, respond to, and recover from potential climate-related hazards. In this study out of the total respondents, 46.4% reported they got access to early warning information on climate change, while 53.6% reported they do not get (Figure 9). This highlights a significant communication gap in climate change preparedness. The accessibility and utilization of climate information and early warning systems (CIEWS) critically determine the adaptive capacity of climate-vulnerable populations, such as pastoral communities, as these systems provide the scientific basis for anticipatory action against hazards like drought (UN, 2015; Coughlan de Perez et al., 2015). Effective CIEWS function across four integrated pillars: risk knowledge, monitoring/forecasting, dissemination, and preparedness is essential. However, their practical utility is frequently undermined by

infrastructural constraints in remote areas and socio-demographic barriers like low literacy and gender disparities, which impede equitable access. These issues are critical because early warning information plays a vital role in adaptation planning, disaster preparedness, and mitigating the negative impacts of climate on livestock and productivity. However, mostly in Somali region district level does not have climate record rather than short-term weather forecasts on a time scale of days, while climate change can only be observed when records extend over several decades and cannot be used to forecast short-term climatic events.

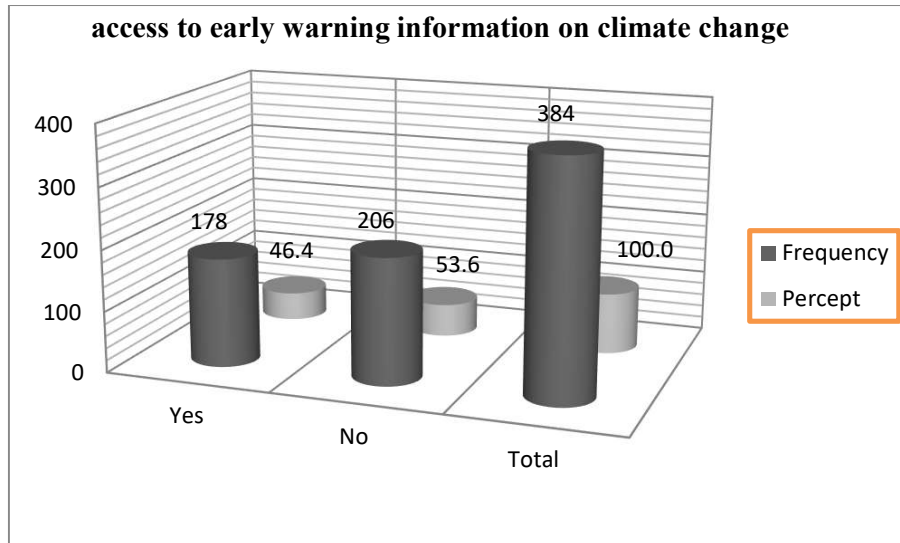


Figure 9: Access to early warning information on climate change

Source: Own survey result (2025).

5.4. Changes in weather patterns (rainfall and temperature)

Climate change is making changes to the world's weather patterns more noticeable, especially in terms of temperature, precipitation and rainfall which come intense and unpredictable as a result of the climate cycle that exacerbated by rising global temperatures brought on greenhouse gas emissions. These changes underline the pressing need for climate adaptation and mitigation measures as they not only impair agricultural output but also compromise the livelihood as whole. This study indicated the majority of respondents (77.3%) reported to observe changes in weather patterns such as rainfall and temperature over the past 10–15 years (Figure 10). This means that most community members are experiencing and perceiving shifts in climatic conditions, which causes increasing rainfall variability, rising temperatures and irregular seasonal patterns. Such perceptions are important because they reflect experiences on climate variability and needs for scientific knowledge and policy intervention on climate change adaptation.

In contrast, about 22.7% of respondents stated they had not noticed any significant changes, while a smaller proportion gave uncertain or other responses (Figure 10). This minority could represent individuals whose livelihoods are less directly affected by weather changes, or who have limited access to long-term climate information, making it harder to perceive gradual shifts. Nonetheless, the overwhelming majority noticing changes highlights a strong local consensus that climate variability is a pressing issue.

Overall, the findings suggest that communities are not only aware of changing weather patterns but may also be vulnerable to their effects, especially in climate-sensitive areas. This widespread recognition of change underscores the importance of integrating local knowledge into climate adaptation strategies, as perceptions can guide interventions in agriculture, water management, and disaster preparedness. The intensifying variability of climate patterns across the globe particularly in vulnerable regions is increasingly supported by scientific evidence. In agriculture based economies, and pastoralist livelihood system often affects weather shocks makes them off-take of their productive livestock as a key risk-coping strategy (Gebrekidan et al., 2019). However, such distress-driven asset off-take can undermine households' ability to recover after the shock, potentially prolonging economic stagnation. Moreover, the macroeconomic performance of developing countries heavily reliant on subsistence agriculture which remain inactive for providing livelihood and development needs of the communities.

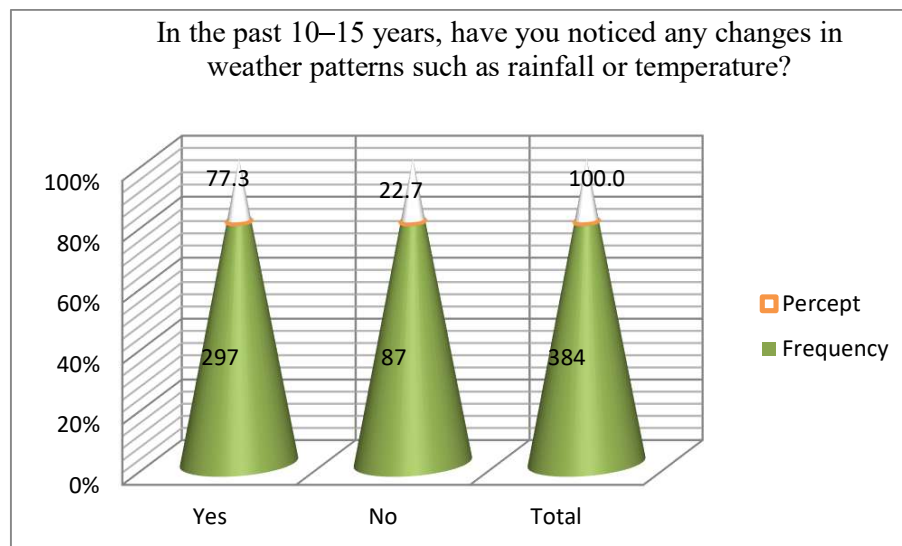


Figure 10: Changes in weather patterns (rainfall and temperature)

Source: Own survey result (2025).

5.5. Climate change effects on livestock and grazing land productivity

Climate change has significantly affected livestock and grazing land productivity, particularly in pastoralist regions of Ethiopia, where communities rely heavily on natural rangelands. These impacts include rising

temperatures, irregular rainfall forms, and continued droughts, all of which diminish the availability and quality of pasture and limit livestock access to adequate nutrition. Consequently, pastoralist herds experience weight loss, reduced milk production, poor animal health, and increased mortality rates. This study illustrates how climate variability has influenced livestock and grazing land productivity among pastoralist communities. Findings show that about 56% of respondents experienced a severe impact from climate change, while another 25.8% reported a moderate impact. In total, 81.8% of respondents perceived climate change as having significant consequences on their livelihoods (Figure 11). This means that the most community are vulnerable to climate variability, such as declining forage availability, water scarcity, and reduced livestock productivity, due to their dependence of livestock in livelihood activities. On the other hand, about 14.3% of respondents responded that climate change effects on livestock and grazing can slight impact whereby only 3.9% of them reported that there is no impact on livestock and grazing (Figure 11). This small minority suggests that some households may have access to adaptive strategies, such as mobility, feed storage, or diversified income sources, which buffer them from the full effects of climatic changes. However, the overwhelming majority reporting serious consequences highlights the limitations of traditional coping strategies under increasingly unpredictable weather conditions.

Rising temperatures, variations in rainfall circulation, and an increasing frequency of extreme weather events are predicted to have a negative impact on global livestock output and productivity, both directly through heat stress and lower water availability (Mutengwa et al., 2023). The data clearly demonstrates a strong link between perceived climate change and the deterioration of livestock and grazing land productivity. These findings highlight the urgent need for targeted climate adaptation strategies, such as sustainable rangeland management, water harvesting, and livelihood diversification. Without such measures, ongoing climate variability is likely to intensify food insecurity, increase livestock losses, and heighten the overall vulnerability of pastoral communities.

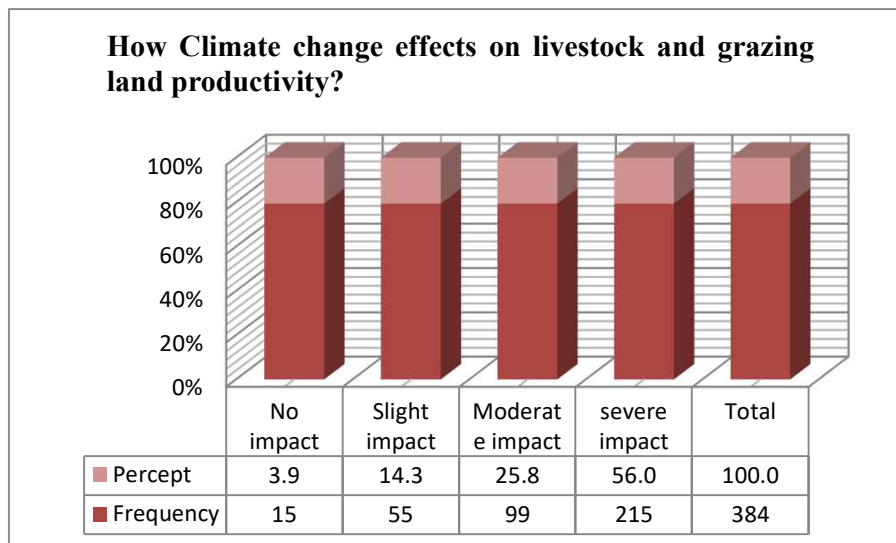


Figure 11: Climate change effects on livestock and grazing land productivity

Source: Own survey result (2025).

5.6. Influence of Climate Dynamics on Agricultural and Pastoral Productivity

The influence of climate dynamics on agricultural and pastoral productivity constitutes a substantial global threat to food security, particularly in arid and semi-arid lands where livelihoods are overwhelmingly dependent on rain-fed systems and are thus acutely susceptible to hydro-meteorological variability (Habte et al., 2022). Specifically, the observed climate dynamics characterized by increasing temperatures, a rising incidence and concentration of extreme weather events (primarily droughts), and more erratic precipitation patterns which have negative effects across production. The data indicate that 55.5% of respondents agree that climate change has negatively impacted agriculture through reduction of productivity, soil fertility loss, and increased pest and crop diseases. Meanwhile, about 24.2% of them identified that reduced productivity as the main effect, while 17.2% of them also mentioned that soil fertility loss as the primary concern of agricultural production loss (Figure 12). A smaller proportion, 3.1%, perceived the major impact to be the increased prevalence of pests and crop diseases.

This distribution of responses demonstrates that climate change is felt as a multifaceted and interconnected threat to agriculture rather than a single, isolated problem. The majority selection of “all of the above” suggests that farmers recognize the compounding and reinforcing effects of these challenges. For instance, declining soil fertility can exacerbate yield reduction, while higher pest and disease incidence further undermines already stressed crops. Together, these impacts interact to create a downward spiral that erodes the resilience and sustainability of agricultural systems.

The findings also imply that local societies have higher degree of awareness for the systemic nature of climate change impacts. Rather than viewing them in isolation, respondents acknowledge that productivity loss, soil degradation, and biotic pressures (pests and diseases) are interlinked stressors that threaten food security, rural livelihoods, and long-term agricultural sustainability. This perception underscores the need for integrated climate adaptation strategies such as soil fertility restoration, pest management, and climate-smart agriculture to address the complex challenges posed by climate change.

According to IPCC (2022), rising temperatures, altered rainfall amounts, and higher climate events reduce crop yields and increase the prevalence of pests and diseases. These changes also degrade soil health, making agricultural lands less productive over time (FAO, 2016). This aligns with the participants' perception that climate change is not causing a singular impact but a synergistic degradation of agricultural viability.

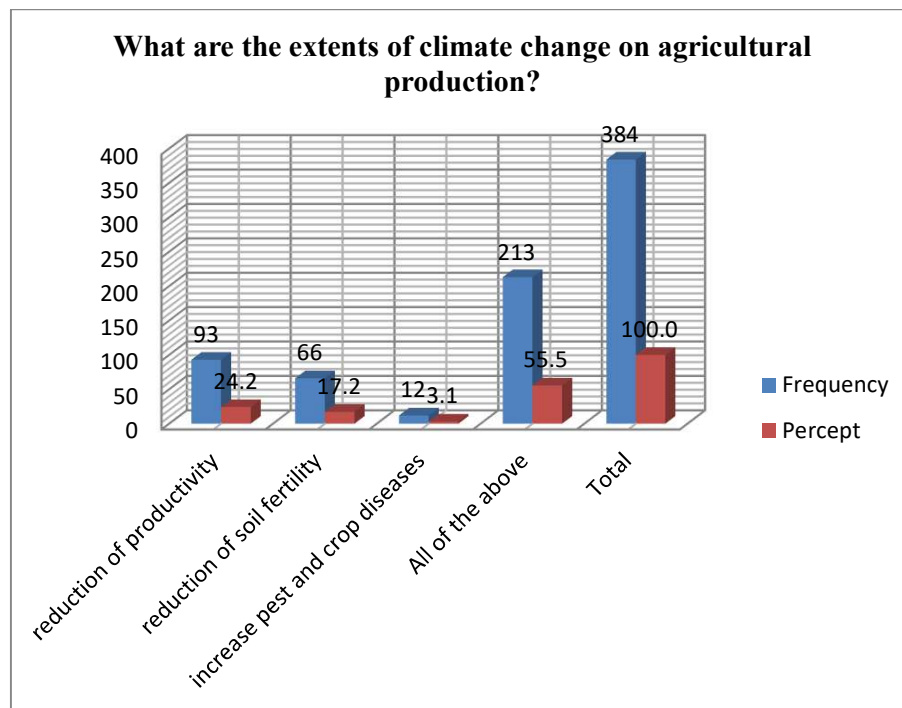


Figure 12: Extents of Climate Change on Agricultural Production

Source: Own survey result (2025).

5.7. Extents of Climate Change on Pastoralist Communities

Pastoralist communities are inherently vulnerable to climate variability, climate change and climatic extremes because their traditional livelihoods depend on climate-sensitive natural resources (Uddin & Kebreab, 2020). Key climatic drivers such as rising mean temperatures, amplified rate and intensity of droughts, and erratic rainfall directly degrade the core assets supporting pastoralism. This manifests as

rangeland degradation, diminished forage quality and acute water scarcity, which collectively lead to significant livestock mortality and a substantial loss of livelihood capital (Kimaru et al., 2022).

This study established understanding and illustrating the multifaceted nature of the threat. A significant majority of respondents, 80.2%, reported that climate change impacts their communities through a combination of increased human and animal diseases, reduced production and productivity, decreased household income, and heightened poverty. These local communities use to measure the climate change different dimensions such as experience on accounting past 15 to 50 years of believing that every 15 years' climate change will fluctuate, traditional astronomies, winds direction and magic. However, this knowledge is concentrated little people among the communities but they are not willing to share others due to religious issue and knowledge patent right keeping. Furthermore, individual impacts were also noted: 1.6 % of respondents cited high disease incidence as the primary issue, 1.3% pointed out reduced production, 10.4% identified diminished household income, and 6.5% highlighted increased poverty as the main consequence (Figure 13). The dominant response, however, underscores that climate change is perceived not as a singular issue but as a complex and compounding threat where multiple stressors interact to undermine pastoralist livelihoods.

These results are consistent with broader findings that climate change in arid and semi-arid regions can exacerbate both direct and indirect vulnerabilities (IPCC, 2022, Dzvene et al., 2025), the Arid and semi-arid regions are most vulnerable, where water scarcity and erratic weather patterns already challenge agricultural productivity. Therefore, understanding the climate challenges and the adaptive measures being implemented is essential to ensure long-term agricultural sustainability. For instance, during drought outbreak disease prevalence rise as increased temperatures and erratic rainfall, which expand the geographic range of vectors and pathogens affecting both humans and livestock (FAO, 2018). Similarly, recurrent droughts and heat stress reduce forage availability, leading to declining livestock productivity, which directly translates into lower household income (Thornton et al., 2014). The fact that nearly nine out of ten respondents acknowledged this combination of impacts reflects a sophisticated, holistic understanding of climate change as a systemic risk. This lived experience aligns with scientific assessments that emphasize the compound and cascading effects of climate change, where stressors rarely occur in isolation but instead reinforce one another (IPCC, 2022). For pastoralists, this means climate change simultaneously threatens ecological stability (rangeland health), economic viability (household income), and social well-being (human health), thereby compromising their long-term resilience. Therefore, the elders' pastoralist believes that climate change events rotation was very long

and will turn every 15 years or 50 years previously but nowadays fluctuates every unspecified time period by drying-up of rivers, water wells and pasture lands.

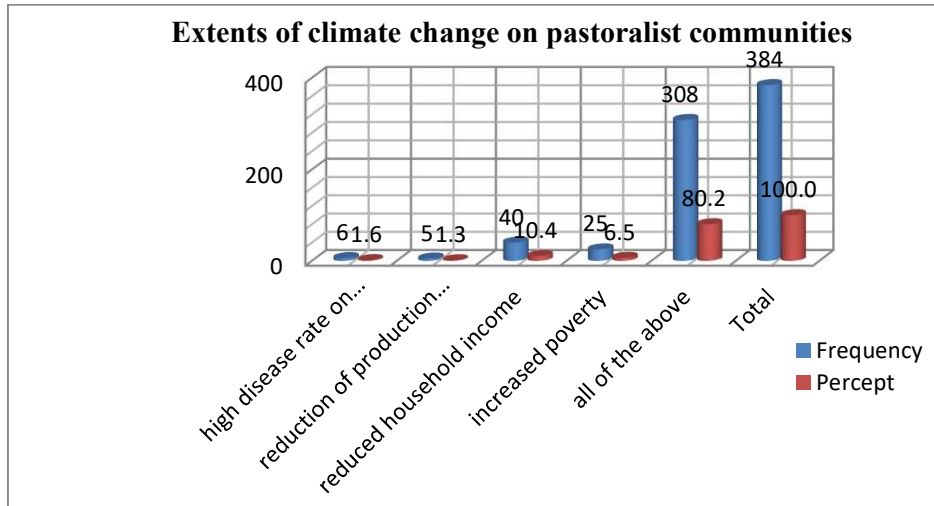


Figure 13: Extents of Climate Change on Pastoralist Communities

Source: Own survey result (2025).

5.7.1. Severity Level of Climate Change in the Study Area

The severity level of climate change refers to how widespread and intense the impacts are felt across pastoralist communities in the Somali Region of Ethiopia. In this study, about 75.8% of them perceived the high severity level of climate change, which impacted the environment and livelihood of pastoralist communities. These severities significantly reduce pastoralists' capacity to cope and threaten the long-term sustainability of livelihood systems. Furthermore, about 21.6% of respondents perceived medium severity levels, whereby, only 2.6% of respondents perceived low severity levels of climate change (Figure 14). This proposes that climate-induced aspects such as drought, rainfall variability, rising temperatures, and disease remain challenges in the area. This distribution underscores that virtually all community members recognize the presence and impacts of climate change, with the high-to-medium severity consensus (97.4%) aligning with findings from broader Sub-Saharan Africa, where rural and pastoral communities consistently report a high concentration of climate variability due to their direct dependency on natural resources (Menghistu et al., 2020). The high sensitivity of these livelihoods is further confirmed by scientific assessments, which validate that arid and semi-arid regions are inherently vulnerable to rising temperatures, erratic rainfall, and recurrent droughts, amplifying climate change effects (Richard, 2025). This notable convergence between community perceptions and scientific evidence (Bekele et al., 2020) validates the critical role of indigenous knowledge in monitoring climate variability and reinforces the urgent requirement for context-specific adaptation measures. Consistent with findings among smallholder farmers (Asefa Bogale, 2024; Tessema & Simane, 2019), who adopt strategies such as changing crop variety, improving crop and livestock management, and implementing soil and water conservation practices, the perceived high severity in the Somali Region signals an imperative for strengthening local adaptation capacities. Therefore, the results necessitate immediate and targeted interventions focused on enhancing institutional support and developing long-term resilience-building programs to safeguard the pastoralist communities of the Somali regional state.

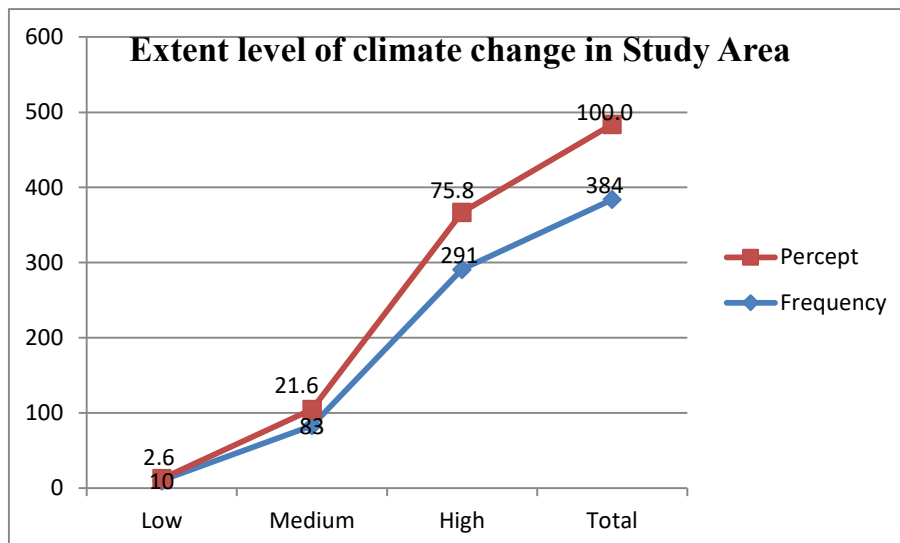


Figure 14: Extent and Severity of Climate Change

Source: Own survey result (2025).

5.8. Consequences of Climate Change on Natural Resources

The consequences of climate change on natural resources encompass a cascade of negative ecological impacts, including the degradation of rangelands, reduced water availability, and loss of vegetation cover. Rangeland degradation remains a serious impediment to improve pastoral livelihoods in the lowlands of Ethiopia (Mussa et al., 2016). Evidence suggests that Ethiopia has experienced a significant increase in aridity and environmental stress, driven by a 1.3 °C rise in average temperature since 1960 (McSweeney et al., 2010; Teku, & Eshetu, 2024). These changes directly affect the accessibility of crucial pasture land and water sources for pastoralist groups. Consequently, the sustainability of traditional pastoral livelihoods is increasingly threatened, contributing significantly to food insecurity and greater economic vulnerability. In this study, a large majority (77.9%) of respondents reported that climate change has affected natural resources through the combined stresses of soil erosion, water shortages, deforestation, and rangeland reduction. This pattern indicates a broad recognition of climate change's multiple impacts. In contrast, when respondents were asked to identify specific, single primary impacts individually, the percentages were much lower: 0.5% cited soil erosion, 8.1% mentioned water shortages, 11.7% identified deforestation, and 1.8% reported rangeland reduction (Figure 15). This study is aligning with the study stated that Ethiopia's vulnerability to climate change is exacerbated by high poverty rates, rapid population growth, increasing prevalence of vector-borne diseases, and heavy reliance on rain-fed agriculture (Teku, & Eshetu, 2024). The dominance of the collective answer over the individual categories suggests that respondents view these issues as interconnected consequences of climate-related stress rather than isolated problems that can be ranked individually. The high selection of the "all of the above" option strongly indicates a perception of holistic, compounded environmental degradation

caused by climate impacts. This warming has intensified the hydrological cycle, leading to a 15–20% decline in seasonal rainfall in parts of the southern and eastern lowlands (Tofu et al., 2023) and an increase in potential evapotranspiration that depletes groundwater recharge and surface water levels. The resulting soil desiccation has exacerbated land degradation, with the Ethiopian highlands losing approximately 1 billion tons of topsoil annually, reducing overall land productivity by 2.2% each year (Moges, & Tegbaru, 2025).

This perception aligns with scientific literature; climate-induced deforestation and rangeland degradation often arise from the synergistic effects of prolonged drought, overgrazing, and land-use shifts driven by changing weather patterns (UNCCD, 2020). Moreover, water shortages, intensified by declining rainfall and increased evaporation, further strain ecosystems and local economies (WWAP, 2015). These climatic shifts have profoundly impacted natural resources, shrinking arable land and deteriorating livestock feed quality, leading to reduction in national GDP in the country as highly depends on agriculture. Actually, in many parts of Africa, forests are spreading as part of the “greening of the Earth” effect (carbon fertilization from increased atmospheric carbon dioxide), but in the more densely populated regions forests are shrinking because people cut the trees down in charcoal production and other temporally livelihood earnings which can enhance frequency repetition of droughts.

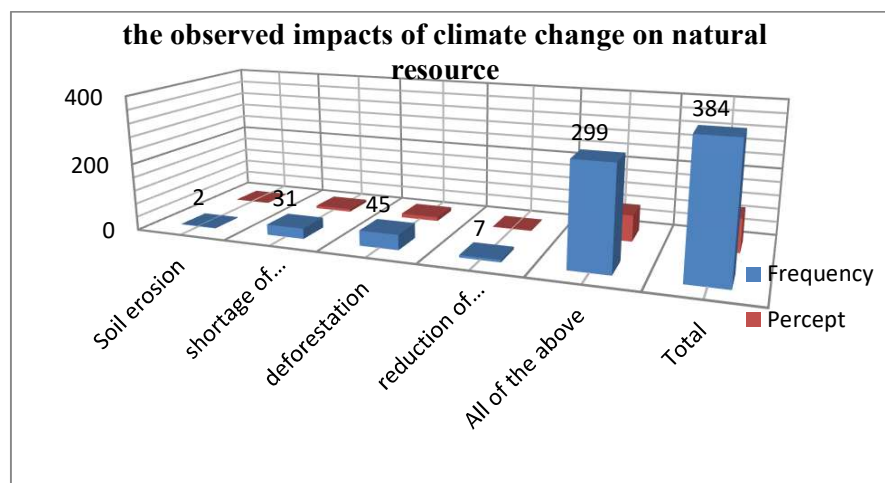


Figure 15: Observed Impacts of Climate Change on Natural Resources

Source: Own survey result (2025).

Conclusion

The findings clearly demonstrate that many people in the Somali Regional State perceive climate change as profound and multifaceted challenges to their pastoralist communities. Climate variability, manifested through recurrent droughts, erratic rainfall, and widespread water scarcity, has disrupted both ecological and socio-economic systems. Nearly all respondents reported experiencing drought and rainfall

irregularities, which have led to severe livestock losses, declining grazing lands, and increased outbreaks of human and animal diseases. Consequently, household incomes have diminished, poverty has deepened, and vulnerability has intensified across communities. Overall, the 1985–2025 climate record for Shabelle and Korahey Zones reveals a highly volatile hydroclimate shaped primarily by Indian Ocean–ENSO teleconnections and amplified by rising temperatures, producing alternating extremes of flood-generating wet years and livelihood-threatening drought years. Exceptional rainfall peaks in 1997 and especially 2019 align with strong El Niño/positive IOD conditions that intensify the Deyr season through enhanced western Indian Ocean moisture transport, increasing convective storm activity and elevating Shabelle River flood risk even as such events can temporarily recharge aquifers. In contrast, the severe lows of 2011 and 2017 correspond to La Niña–linked suppression and failure of the Gu rains, compounded by high potential evapotranspiration that rapidly converts meteorological drought into agricultural drought, with regionally widespread impacts across Somali and adjacent pastoral areas. Temperature evidence from Shabelle (notably peaks around 2019 and 2022) indicates escalating thermal stress that heightens evaporative demand, reduces effective rainfall, and worsens drought impacts, while cooler trough years are associated with relatively increased moisture and cloud cover.

Demographically, the majority of pastoralists in our sample fall within the productive age group but possess limited formal education, a factor that significantly constrains their adaptive capacity. Gender and marital dynamics further exacerbate this vulnerability; female-headed, divorced, and widowed households face distinct physical and social barriers to resource access and livelihood diversification.

Furthermore, evident natural resource degradation manifested as soil erosion, deforestation, and shrinking rangelands reflects the severe ecological toll of climate stress. Compounding these environmental issues are critical institutional and informational gaps, most notably the absence of early warning systems and a lack of awareness regarding adaptive strategies. Connectivity remains a major hurdle, where most pastoralists in the study areas lack smartphones and internet access. Even in many district towns within the Somali Region, standard telecommunications network coverage is unavailable, leaving communities isolated from vital early warning information. Ultimately, these findings illustrate that climate change in the Somali Region is not merely an isolated environmental problem but a systemic crisis undermining economic stability, ecological balance, and cultural integrity. Strengthening resilience, therefore, requires an integrated approach that enhances education, promotes gender equity, and builds institutional capacity while safeguarding the social and ecological foundations of pastoralist livelihoods.

Chapter Six: Existing Pastoralist Adaptation and Coping Mechanisms.

Introduction

Pastoralist communities are among the most climate-sensitive populations due to their heavy reliance on livestock and rangeland resources. Increasing climate variability, recurrent droughts, water scarcity, and rangeland degradation have forced households to employ diverse adaptation and coping mechanisms to sustain their livelihoods. However, the ability to adopt such strategies is not uniform; it varies across households and is shaped by multiple socio-economic, environmental, and institutional determinants. A systematic understanding of these determinants is critical for informing evidence-based interventions that can strengthen resilience and adaptive capacity among pastoralists.

This chapter engaged a quantitative and qualitative research approach to examine the determinants of existing pastoralist adaptation and coping mechanisms. Specifically, descriptive statistics are used to summarize and present patterns of household responses, highlighting the prevalence, frequency, and distribution of different strategies. This provides an overview of how pastoralist communities respond to climate-related and livelihood shocks. In addition, a binary logistic regression model is applied to identify the key factors that significantly influence the likelihood of households adopting specific adaptation or coping mechanisms. Explanatory variables considered in the analysis include demographic characteristics (such as age, gender, and education of the household head), resource endowment (livestock herd size, land access, and income level), institutional factors (extension services, credit access, and membership in cooperatives), and environmental conditions (water availability, rangeland quality, and climate variability).

By integrating descriptive, modeling analysis with qualitative insights, this study moves beyond general observations to statistically validate the determinants of adaptation and coping mechanisms. The result was provided robust evidence for policymakers, development practitioners, and researchers to design targeted interventions that enhance adaptive capacity and ensure the sustainability of pastoralist livelihoods in the face of climate and socio-economic challenges.

6.1. Pastoralists Adaptation and Coping Mechanisms

The practice of adaptation and coping mechanisms is involving various strategies that individuals, households, and communities adopt to respond the effects of climate change, particularly in vulnerable pastoral and agro-pastoral areas. In this study show that a majority of respondents has practiced adaptation and coping mechanisms in response to climate change impacts. Specifically, about 67.7% of

households reported that they had implemented adaptation and coping strategies, while 32.3% of households reported that they had not implemented coping strategies (Figure 16). This demonstrates that most households in the study area are actively responding to climatic shocks and stresses, by using different adaptation and Coping strategies such as abortion of livestock, migrating to other area, livestock selling and tolerating and managing of resource. The high proportion of adopters showed they have awareness, knowledge, and skill on climate change impacts. This is consistent with findings from, Kenya, on climate shock responsiveness, where pastoral and agro-pastoral communities have developed a range of adaptation measures, including livestock mobility, herd diversification, fodder storage, water harvesting, and engagement in alternative income sources (Fortnam et al., 2020). The adoption of such mechanisms demonstrates both the resilience and the reliance on indigenous knowledge systems that have historically enabled to survival in harsh and variable environments (IPCC, 2012). Moreover, respondents who reported not practicing any adaptive measures face a range of barriers linked to limited awareness and knowledge of climate change impacts and adaptation strategies. These constraints are compounded by structural limitations such as inadequate access to productive resources, weak institutional support, high levels of poverty, low educational attainment, and restricted access to climate information services. Similar findings have been reported across the Horn of Africa, where pastoralist households often lack timely meteorological information, institutional coordination, and extension support necessary for proactive adaptation (Bryan et al., 2009).

In the Somali Region specifically, limited formal education and poor infrastructure constrain information dissemination and reduce awareness of alternative livelihoods and adaptive innovations. Social and cultural dynamics also play role gender inequalities, traditional norms, and barriers to accessing decision-making processes further reduce adaptive capacity among vulnerable groups, particularly women and marginalized households (Abebe et al., 2022). Consequently, these interlinked barriers result in dependence on reactive or traditional coping mechanisms rather than planned, forward-looking adaptation strategies. Addressing these barriers therefore requires targeted interventions in climate education, institutional strengthening, and inclusive resource governance to enhance community adaptive capacity in the Somali pastoral context. Also study conducted in East Africa shows that the socio-economic and institutional constraints often hinder households from adopting to basic coping strategies, thereby leaving them more vulnerable to climate-induced shocks (Herrero et al., 2016). These finding results indicated that while the majority of households are making efforts to adapt, but significant numbers of the population remain unprepared, which has important implications for policy and development interventions. For instance, strengthening access to financial resources, awareness

creation, extension services, institutional intervention and climate-smart technologies could be important to reduce vulnerability of climate change.

According to data from Focus Group Discussions (FGDs) and Key Informant Interviews (KIs), pastoralist communities have developed a wide range of adaptation and coping mechanisms to manage the impacts of climate variability, recurrent droughts, and related socio-economic challenges. These strategies are deeply rooted in indigenous knowledge systems and are increasingly complemented by modern approaches introduced through development interventions.

1. **Mobility and Herd Diversification:** Mobility remains the cornerstone of pastoral adaptation. By moving livestock seasonally in search of water and pasture, pastoralists reduce pressure on degraded rangelands and maintain overall herd productivity. In addition to mobility, many households diversify their livestock species raising camels, goats, and cattle which differ in drought tolerance, grazing behavior, and market value. Such diversification spreads risk and ensures income stability under variable climatic conditions.
2. **Social Networks and Resource Sharing:** Strong kinship ties and reciprocal social support systems serve as vital coping mechanisms. During droughts or crises, pastoralists rely on traditional institutions such as clan-based redistribution, livestock loans, and food-sharing networks to sustain household food security. These social mechanisms strengthen community cohesion and enhance collective resilience in the face of environmental stress.
3. **Livelihood Diversification:** To reduce dependence on livestock-based livelihoods, pastoralists increasingly engage in alternative income-generating activities such as petty trade, charcoal production, wage labor, and seasonal migration to urban centers. In addition, some communities participate in government safety-net programs and collaborative development projects, which provide supplementary sources of income and buffer households against climate-induced economic shocks.
4. **Water Harvesting and Rangeland Management:** Local innovations in water storage and management including the construction of berkads (underground water reservoirs) and shallow wells enable communities to cope with increasing water scarcity. Likewise, community-based rangeland management practices, such as rotational grazing and enclosure systems, have emerged as effective strategies for restoring vegetation cover and reducing land degradation.
5. **Integration of Modern Knowledge:** In some areas, pastoralists have begun integrating scientific knowledge and modern technologies into their traditional systems. The adoption of improved livestock breeds, veterinary services, early warning information, and weather forecasting tools has strengthened community resilience. When harmonized with indigenous practices, these modern

approaches enhance the adaptive capacity of pastoral systems and promote sustainable livelihood transformation.

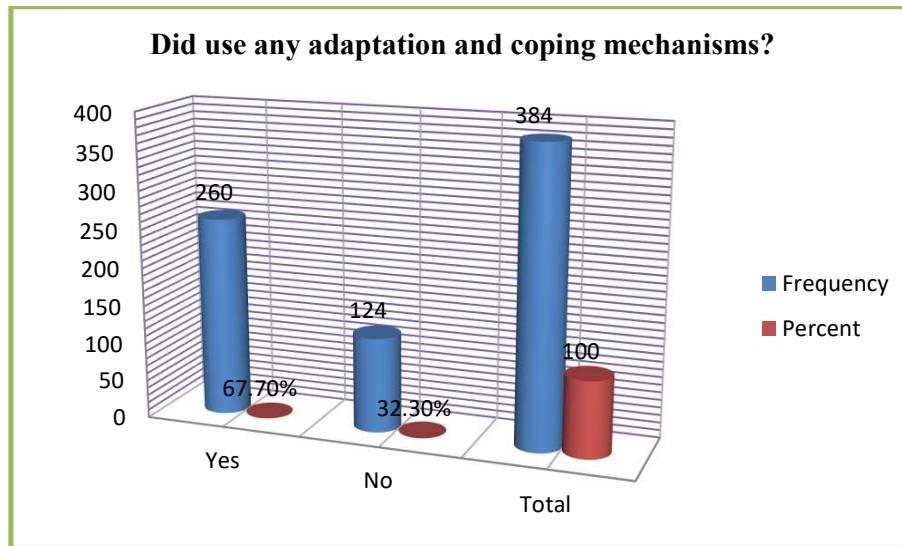


Figure 16: Did you ever practice adaptation and coping mechanisms

6.1.1. Effectiveness and Limitations of Adopted Strategies

The adaptation and coping mechanisms practiced by pastoralists play a significant role in sustaining their livelihoods by helping them manage challenges arising from climate variability, economic fluctuations, and shifting political conditions. However, these strategies often face major limitations due to inadequate access to timely climate information, poor infrastructure, and limited financial resources. Mobility is one of the most traditional and effective coping mechanisms have increasingly been constrained by land fragmentation and resource-based conflicts. Additionally, weak institutional support and the absence of inclusive policies further undermine the effectiveness of local adaptation efforts, reducing the overall resilience of pastoralist communities to climate-related shocks.

According to researcher observations and information gathered from FGDs, mobility remains a highly effective strategy, enabling pastoralists to access dispersed natural resources and minimize livestock losses during droughts. Complementing this, strong social networks continue to serve as vital safety nets, helping prevent destitution and maintain social cohesion within communities. Livelihood diversification also plays a critical role by stabilizing household income and enabling families to meet basic needs when livestock productivity declines. Moreover, improved rangeland and water management practices contribute to resource conservation and strengthen community resilience against environmental and economic shocks.

Despite these strengths, pastoralists' adaptive strategies face several significant constraints that undermine their long-term effectiveness. Restricted mobility is driven by agricultural expansion, land

privatization, conflicts, and administrative boundaries have reduced access to essential grazing areas and water sources. At the same time, traditional social networks are weakening due to urbanization, increasing market dependence, and recurrent shocks, eroding communal support systems that once ensured collective resilience. Some households also engage in unsustainable livelihood diversification activities, such as charcoal production, which may provide temporary income but contribute to environmental degradation and resource depletion. Furthermore, limited access to modern technologies, infrastructure, and institutional support continues to constrain the potential of contemporary adaptation measures. Increasing climate unpredictability, characterized by more frequent and severe droughts, has overwhelmed traditional coping mechanisms, resulting in widespread livestock losses and, in extreme cases, the collapse of pastoral livelihoods. In general, pastoralists' adaptation and coping mechanisms are multifaceted, combining long-standing traditional practices with emerging modern strategies. However, their effectiveness depends on supportive policies, secure access to grazing lands and water, functional social networks, and integration into broader climate adaptation frameworks. Strengthening these areas is essential for sustaining pastoral livelihoods amid escalating environmental and socio-economic pressures.



6.1.2. Coping Mechanisms Used by Pastoralist communities in study area

Pastoralist communities use a variety of traditional coping mechanisms to manage the immediate impacts of climate shocks. Out of the total respondents, 67.7% of respondents reported that they involved adaptation and coping mechanisms, whereby about 47.1% of them used migration to other areas (Figure

17). This highlights the crucial role of herd mobility in pastoralist systems as a traditional and immediate response to drought and climate variability, finding for water and pasture land. Meanwhile, 7% of them used livestock selling, as coping mechanisms, which provides short-term relief. In addition, 7.3% of the respondents adopted tolerating and managing with existing resources as coping mechanisms, which reflects households' reliance on controlling and adjusting consumption and expenditures of resources. Moreover, in extreme circumstances, approximately 6.3% of respondents used livestock abortion as a coping strategy during severe droughts; to survive the life of mother animal when essential resources for sustaining were critically scarce (Figure 17). This finding aligns with study in Ethiopia, which shows that migration remains the most critical resilience strategy among pastoralists (Opiyo et al., 2016). The adoption of reliance on mobility reflects both the strength of pastoral indigenous systems and vulnerability of households to control limited resource. For instance, migration alone cannot safeguard shocks and distress of climate change also households often resort livestock sales to purchase food, and fodders (Herrero et al., 2016). Beyond livestock sales, some households practice other adaptation mechanisms based on pastoralist indigenous knowledge in local context, which enables survival during crises but does not build sustainable adaptive capacity as it an erosive strategy (Eriksen & Marin, 2011). Moreover, in the most severe drought outbreak, some pastoralist communities were used livestock abortion to preserve the life of the mother animal when resources are critically scarce as adaptation strategy. Traditionally Pastoralists relied on different adaptation and copying mechanisms based on geographical contexts, and resilience-building interventions capacity but it seems deficient to meet the growing requirements of pastoralist groups. As a result of climate policy initiatives and agriculture investments, pastoralists are experiencing unprecedented levels of social divergence and vulnerability. Institutional interventions on climate change and requests to enhance resilience require new incentive for pastoral development, since climate policy measures and pastoral initiatives result in new forms of social difference and insecurity among pastoralists (Campbell, 2022). Taking together, these coping mechanisms is essential to response, where households begin with traditional adaptive practices such as migration and progressively shift toward more erosive and extreme strategies as resource scarcity intensifies.

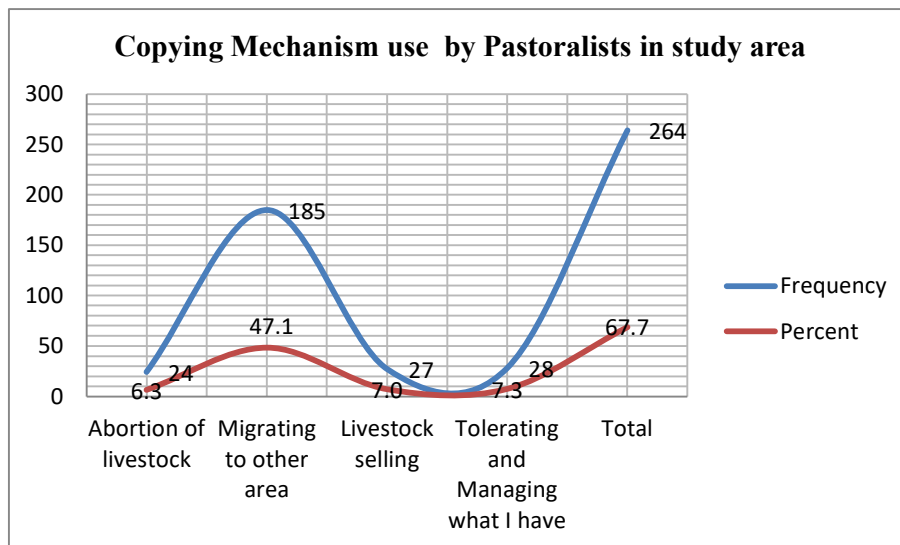


Figure 17: Pastoralists Adaptation and Coping Mechanisms

Source: Own survey result (2025).

6.2. Qualitative Insights into Pastoral Adaptation and Coping Mechanisms

Pastoral communities are inherently exposed to a variety of environmental and livelihood stresses, such as drought, livestock disease outbreaks, and scarcity of natural resources such as water and pasture. Understanding how these communities adapt and cope with such stresses requires an in-depth exploration of their behaviors, strategies, and decision-making processes. In this regard, the Focus Group Discussions (FGDs) and Key Informant Interviews (KIs) stated the context-specific responses of pastoral households to environmental variability. These qualitative approaches provide a rich understanding of the ways in which pastoralists maintain their livelihoods by complementing and supporting the descriptive statistical findings obtained from quantitative surveys.

FGDs and KIs mentioned that pastoral households employ a diverse set of adaptive strategies which derived from indigenous knowledge and contemporary interventions mechanisms. Mobility and migration still remains the cornerstone of pastoral climate change adaptation mechanism. Households often relocate livestock to access better grazing areas, seasonal water sources, and areas less affected by disease outbreaks. This strategy is particularly important during periods of prolonged drought when local resources are insufficient to sustain livestock herds. Beyond mobility, households also diversify their income sources, engaging in small-scale agriculture, trade, and casual labor to buffer against climate shocks. Such diversification reflects an understanding among pastoralists that dependence on a single livelihood source is vulnerability than diversified households.

Disease management and veterinary interventions emerged as another critical aspect of adaptation mechanism. KIs highlighted that pastoralists actively monitor livestock health and, where accessible, utilize both traditional medicines and modern veterinary services. Community-based animal health programs, including mobile veterinary clinics, facilitate timely responses to outbreaks, minimizing livestock mortality. Moreover, drought mitigation strategies, such as water harvesting, construction of small dams, and maintenance of boreholes, are widely adopted practices that indicate an integration of traditional knowledge with contemporary resilience-building approaches. These strategies not only support the immediate survival of community but also sustain household livelihoods during prolonged periods of scarcity.

The socio-economic context of pastoral households plays a vital role in determining adaptive views. FGDs agree that households with greater access to financial resources, social networks, and educational opportunities are more likely to implement diverse and effective coping mechanisms. Likewise, low income households are constrained with weak institutional support, and social marginalization they may secure short-term survival but undermine long-term resilience. Furthermore, cultural and belief systems influence decision-making processes of adaptation choices, such as grazing and eating patterns, livestock abortion, herd composition and source management, are guided not only by environmental considerations but also by local norms and beliefs. These findings underscore that adaptive capacity is not uniform across communities and is mediated by a complex interchange of environmental, socio-economic, and cultural aspects.

The qualitative discussion also provides context-specific narratives by illuminating why certain households adopt specific strategies and how these practices vary across households with different resource endowments. This means that household can be “adaptor” or “non-adaptor based on their awareness, resource availability, social capital, and knowledge and availability of support services. These insights ensure that adaptation of climate change is linked with sensitivity to the real-world conditions and decision-making processes of pastoral communities. Moreover, qualitative analysis highlights the effectiveness and limitations of traditional and modern strategies. Traditional practices, such as seasonal migration and herd diversification, have proven resilient over generations but may be increasingly constrained by modern challenges, including land fragmentation, changing climate patterns, and policy restrictions. On the other hand, modern interventions, such as veterinary services and water infrastructure, enhance resilience but may be unevenly accessible due to logistical, financial, or institutional barriers. FGDs and KIs thus provide a nuanced understanding of how pastoral communities negotiate old and new strategies, making adaptive choices that are practical and culturally acceptable. This integrated perspective is vital for policymakers and development practitioners seeking to strengthen pastoral livelihoods, as it highlights the importance of aligning interventions with local knowledge and

socio-economic realities. The qualitative findings show how environmental, socio-economic, and cultural factors collectively shape pastoral coping and adaptation. By capturing lived experiences, they complement quantitative analysis and reveal the diversity of strategies, the significance of resource access, and the central role of local knowledge. These insights are essential for designing active interventions, enhancing adjustments, and ensuring the long-term sustainability of pastoral livelihoods in an increasingly unpredictable environmental context.

FGD data Collection and observation



6.3. Nature of the Dependent Variable with adaptation and coping mechanism

The dependent variable of this study is a binary, or dichotomous, variable, specifically designed to capture whether a household has practiced adaptation and coping mechanisms in response to the impacts of climate change. In this study, households were asked, “Did you ever practice adaptation and coping mechanisms?” Responses to this question were coded as “Yes” (1) for households that reported adopting strategies, and “No” (0) for those that did not. The dichotomous nature of this variable makes it particularly suitable for binary logistic regression analysis, which is widely used to estimate the probability of a specific outcome based on a set of explanatory factors. Other commonly applied modeling approaches for such outcomes include the probit regression model and the Linear Probability Model (LPM), but binary logistic regression remains the most frequently employed method due to its ability to provide interpretable odds ratios for the likelihood of adoption.

In the context of pastoral communities, adaptation and coping mechanisms are essential strategies for managing the unpredictable and often harsh impacts of climate change, such as drought, livestock disease outbreaks, and pasture degradation. Pastoral households rely heavily on these strategies to maintain the productivity of their livestock and to secure their livelihoods in environments that are increasingly vulnerable to climatic variability. By framing the adoption of such mechanisms as a binary outcome, the study can statistically examine the factors that influence whether a household decides to implement adaptive strategies or not. As descriptive statistics finding of this study found that about 67.7% of respondents responded were adapted to climate change which indicates that a household is actively engaging in different adaptation and coping mechanisms to use supplementary livelihood activities. Conversely, a response of “No” identifies households that are not yet adopted strategies, highlighting there are potential gaps in awareness, resources, knowledge, or institutional support.

Analyzing this binary dependent variable allows researchers to explore the different determinants that influence pastoral adaptation and coping mechanisms, such as socio-economic factors, climate change interventions strategy, climate change variability factors, and adaptive capacity of pastoralists. Logically the factors such as household size, livestock holdings, access to extension services, adaptive strategy, proximity to water sources, and exposure to climate shocks can significantly affect the likelihood of adopting adaptive measures. Understanding these relationships is critical for designing effective interventions that enhance the resilience of pastoral households. By quantifying the probability of adaptation, logistic regression models provide insights into which factors most strongly encourage or constrain the implementation of coping strategies. Ultimately, this approach contributes to a deeper understanding of how pastoral communities respond to climate change, highlighting areas where policy support, capacity building, and resource allocation can strengthen resilience and sustain livelihoods under increasingly climate change conditions.

6.4. Binary Logistic Regression Analysis

Binary logistic regression is best suited for modeling the occurrence probability of a categorical reaction variable with two outcomes. These means the chance of occurrence must be between 0 and 1, it is impossible to describe probabilities using linear regression techniques, because the linear regression model permits the dependent variable to take values greater than 1 or less than 0. The logistic regression model is a form of modified linear model that expands on the linear regression model by connecting the actual numerical range to the 0-1 range.

For instance, the Scientific Interpretation of significance Variables is judged by the Sig. (p-value) column, where the p-value < 0.05 which means the variable is statistically significant at the 5% significance level. However, sometimes researchers used at 10% significance level based on P-Value when they don't get at 1% and 5% significance level.

Table 8: Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	339.673 ^a	.312	.435

a. Estimation terminated at iteration number 6 because parameter estimates changed by less than .001.

According to the table 9, results of using binary logistic regression analysis with dependent variable which is weather used adaptive strategies or not, four independent variables were found statistically significant such as age of the respondents, main income source of household head, educational level of household head and Adaptive Strategies.

Table 9: Explanatory Variable Analysis for Binary Logistic Regression

Binary Logistic Regression (Sample HH = 384)						
Dependent variable (does HH practiced adaptation and coping mechanisms or not)						
Explanatory Variables	B	S.E.	Wald	df	Sig.	Exp(B)
Sex	-.358	.307	1.362	1	.243	.699
Marital Status	.104	.237	.191	1	.662	1.109
Age	.030	.014	4.565	1	.033**	1.030
Family size	-.025	.058	.189	1	.664	.975
Livestock	-.001	.010	.018	1	.893	.999
Main income	.597	.197	9.203	1	.002	1.816
Degradation	.693	.602	1.327	1	.249	2.000
Conflict	.940	.567	2.745	1	.098*	2.561
Before Drought	-.144	.129	1.250	1	.264	.865
Effect CC	.223	.156	2.032	1	.154	1.250
Adaptive Strategies	2.696	.413	42.531	1	.000	14.822
Equal Value	.014	.499	.001	1	.977	1.014
Problems	-.116	.428	.073	1	.787	.891
Hear Policies	.263	.340	.598	1	.439	1.301
Symptoms	-.098	.308	.101	1	.750	.907
Indigenous Knowledge	.231	.404	.328	1	.567	1.260
Education	.250	.122	4.170	1	.041	1.284
Constant	-10.746	1.938	30.750	1	.000	.000

a. Variable(s) entered on step 1: sex, Marital status, Age, Family size, Livestock, main income, degradation, conflict, before Drought, effect CC, adaptive Strategies, equal Value, problems, hear Policies, symptoms, indigenous Knowledge, Education.

Source: Own survey result (2025).

Age of Household Head: It is a constant variable measured in number of years for household head completed during the data collection time. As expected, age was found to be significant at 5% probability

level that influenced adaptation to climate change positively. As age increase by additional of one year, the probability of adaptation to climate change increase by factors 1.030 holding other factors constant. The possible reason is that after one of additional experience household head will learn the past treats and adapts the new coping mechanism by accepting better technologies and search alternative livelihood strategies to promote the well-being. The age was positively associated with adaptation, where each additional year of age increased the probability of adopting coping mechanisms which means the older household heads may possess greater indigenous knowledge, social network, and experiential learning accumulated through recurrent exposure to droughts and climate shocks. Such experience is critical in shaping perceptions of risk and in guiding adaptive decision-making (Bryan et al., 2009). However, it is worth noting that while age enhances experiential capacity, very old household heads may also face physical limitations that constrained adaptation, suggesting a nonlinear relationship that could be further explored in future studies.

Main income source of household head: It is a categorical variable measured whether the Main income source of household depends on Agriculture, pastoralism (livestock), Salary, Labour or Trade. The model results indicate that Main income source of household-head significantly and positively influence adaptation strategies at 1%, holding other factors constant.

As main income source increase by one unit of additional source, the probability of adaptation strategies to climate change increase by factor of 1.8 odd ratios, remaining other factors constant. Main income source of household emerged as another significant determinant indicating that when household involve one additional activity the income source was 1.8 times more likely to employ climate change adaptation and coping strategies. By enhancing the economic capacity of households, allowing them to purchase livestock feed, water storage, veterinary care, as well as other livelihoods activities. This aligns with the sustainable livelihoods framework (Chambers & Conway, 1992), which emphasizes financial capital as a cornerstone of adaptive capacity. Households with limited income sources are often locked into reactive coping strategies, such as distress livestock sales or migration, which may undermine long-term resilience.

Educational level of household head: Its continuous variable measured in number of years involved education by the household head. The regression model result shows, education was found significant at 5% probability level that influenced adaptation strategies to climate change. As education increase by one level, the possibility of adaptation strategies to climate change raises by factor of 1.284, holding other factors constant. For instance, highly educated people are engaged to search new adaptation strategies to survive their life and protect the effect of climate change by involving different activities. This finding is similar with (Kassie *et al.*, 2017), who stated the educational attainment of farm households had a detrimental influence on diversifying their incomes because educated farmers may specialize in on-farm

activities by using better farm technology. This results contradict the prior expectation of education which was positively to influence household's adaptation, and others authors findings this variables has high probability of positively influenced livelihood options due to possibility of educated person's ability to gain better skill, experience, knowledge and capability to adaptation to climate change.

Adaptive Strategies: It is a dummy variable measured in weather household used adaptive strategies or not. The model results revealed that the coefficient for adaptive strategies was positive and statistically significant at the 1% level, confirming the prior expectation. Specifically, as pastoralist households adopt one additional formal adaptation strategy, the probability of strengthening adaptation and coping mechanisms increases by a factor of 14.82, holding other factors constant. This demonstrates a strong positive association between multiple adaptive behaviors and the likelihood of effective climate resilience.

The findings further suggest that pastoral households employing diverse adaptive strategies often grounded in indigenous knowledge systems are more likely to develop new coping mechanisms than non-adopters. The adaptation process among pastoralists appears to be cumulative and reinforcing in nature. Once households acquire experience in adaptive practices such as herd mobility, livestock diversification, or early destocking, they build a foundation of knowledge, skills, and social networks that facilitate further innovation in adaptation (Thornton & Herrero, 2015). This indicates that adaptation is not a one-time event but a dynamic, path-dependent process in which prior experience significantly enhances the probability of future resilience-building actions. The results underscore that pastoralist adaptation is shaped not only by environmental conditions but also by human, social, and financial capital. Adaptive strategies function as a gateway through which income provides the material means for action, while age and experience contribute to informed decision-making. These interactions highlight the importance of designing integrated interventions that simultaneously strengthen economic capacities and reinforce local knowledge systems. Such an approach can enhance the long-term resilience of pastoral households to the mounting challenges of climate variability and livelihood insecurity.

Finally, the analysis revealed that certain variables such as sex, family size, livestock holdings, and indigenous knowledge were not statistically significant at the 5% level. Although these factors exhibited either positive or negative relationships with the dependent variable, their influence was not strong enough to serve as primary predictors of climate change adaptation in this model. However, their subtle associations may still contribute to household-level adaptation decisions in indirect ways and warrant further qualitative and contextual investigation.

Conclusion

The findings of this study provide strong evidence that climate change is widely perceived as a severe challenge in the study area, with 75.8% of respondents mentioning high extent and severity. This recognition aligns closely with Sub-Saharan Africa, realities of climate visibilities and alarming impacts of recurrent droughts, rainfall variability, and rising temperatures on pastoralist livelihoods. Such climatic stressors significantly undermine households' coping capacities and threaten the sustainability of pastoral production systems.

Despite these high levels of pastoral vulnerability, the results demonstrate that a majority of households 67.7% have adopted adaptation and coping mechanisms to resist the impact of climate change. These strategies include migration, livestock selling, resource controlling, and in extreme cases, and livestock abortion. Migration was especially emphasized, reflecting the traditional reliance of pastoralists on herd mobility as a resilience strategy. However, findings also highlighted the erosive nature of distress sales and livestock abortion, which is short-term relief and not fostering long-term adaptive capacity. This indicates that while pastoralist involves coping mechanisms it remain deeply rooted in indigenous knowledge, institutional interventions are urgently needed to strengthen sustainable resilience pathways. The qualitative findings show how environmental, socio-economic, and cultural factors collectively shape pastoral coping and adaptation. It provides a nuanced understanding of how pastoral communities negotiate old and new strategies, making adaptive choices that are practical and culturally acceptable. This integrated perspective is vital for policymakers and development practitioners seeking to strengthen pastoral livelihoods, as it highlights the importance of aligning interventions with local knowledge and socio-economic realities.

The binary logistic regression model confirmed that age, education, main income source, and adaptive strategies were the key determinants of adaptation. Specifically, older household heads were more likely to adopt coping mechanisms, reflecting the importance of experiential knowledge. Educations also had a positive influence, indicating that even limited literacy helps households' access information and develop alternative livelihood practices. Consequently, households dependence on pastoralism were nearly twice as likely to adopt adaptation strategies compared to those with other income sources, highlighting the centrality of livestock-based livelihoods activities. The most experienced households were engaged in adaptive strategies by involving different livelihood activities. This underscores the cumulative and path-dependent nature of adaptation needs experience and immediate action to enhance resilience.

In general, the convergence of descriptive, regression model and qualitative results points that climate change is not only highly visible and severe in the study area, but it is also reshaping livelihoods, knowledge systems, and adaptation practices. The pastoralist communities are actively responding through migration and other coping mechanisms, yet their strategies remain predominantly short-term and reactive, often constrained by limited resources, poverty, weak institutional support, and inadequate access to climate information services. Therefore, while pastoralist households demonstrate remarkable adaptive capacity based on traditional knowledge and practices, without enhanced institutional and structural support, their adaptation mechanisms risk remain inadequate to control the escalating severity of climate change.

Chapter seven: Institutional Interventions and Pastoralists' Complement of Adaptation Mechanisms.

Introduction

Pastoralist communities are among the most climate-vulnerable populations globally, with their complicated livelihoods which is dependent on climate-sensitive resources. In recent decades, the magnitude and frequency of climate-related stressors such as prolonged droughts, erratic rainfall patterns, and land degradation have significantly increased which posing severe threats to the socio-economic fabric and ecological sustainability of pastoralist systems. The extent of climate change impacts on these communities has been profound, often resulting in reduced livestock productivity, food insecurity, and increased livelihood fragility.

In response to these challenges, various institutional actors including governmental interventions, non-governmental organizations (NGOs), and international development allies have initiated involvements targeted at attractive the adaptive aptitude of pastoralists. These institutional supports range from early warning systems and climate-resilient infrastructure to water resource development, agricultural extension services, and capacity-building programs. However, the accessibility, effectiveness, and appropriateness of these interventions in addressing the unique needs of pastoralists remain a subject of ongoing debate.

This chapter examines the extent to which existing institutional interventions complement pastoralists' adaptation mechanisms. By assessing how these interventions align with and strengthen local coping strategies. It critically evaluates the degree to which institutional efforts complement traditional knowledge and indigenous resilience mechanisms, rather than undermining them. Furthermore, the chapter identifies the main institutional actors involved in climate change adaptation in the study area and analyzes the scope and level of their interventions. By examining both the formal and informal dimensions of adaptation support, this chapter aims to provide a nuanced understanding of whether existing institutional interventions are effectively integrated into pastoralists' lived realities and adaptive practices.

7. 1. Climate Change Intervention on Pastoralist Communities of Somali Region

The results from the participants clearly indicate that the majority of respondents have a strong need for climate change interventions to support their livelihood development. Strong institutional presence takes a vital role in assessing pastoralists' efforts to cope with and adapt to the impacts of climate change. In this study, out of total respondents, 82.3% reported the need for climate change intervention as important

for pastoralists' way of life, while only 17.7% disagreed with the effectiveness of such interventions due to the lack of clear policies and the political marginalization of pastoralists (Figure 18). This overwhelming majority reflects the urgent need for intervention arising from climate change-induced challenges such as prolonged droughts, erratic rainfall, declining pasture availability, and increasing livestock diseases, which pastoralists widely acknowledge. The report suggests that climate change is not viewed as a distant or abstract phenomenon, but as an immediate and pressing threat to pastoralist livelihoods, requiring collaborative intervention among stakeholders.

These findings are consistent with those highlighting pastoralists' vulnerability in conjunction with environmental changes that demand policy intervention. According to Cuni-Sanchez et al. (2019), over 80% of pastoralists in northern Kenya perceived climate variability as a significant threat to their survival, requiring governmental and policy interventions. Similarly, (Deressa and Ringler, 2011) argue that local perceptions of climate change strongly influence adaptation choices, with farmers and pastoralists emphasizing the importance of long-term policy responses to the changing weather patterns that undermine agricultural productivity. The agreement between the current findings and previous studies underscores that pastoralists' perceptions are grounded in their lived experiences of climate-related shocks and the need for effective climate interventions.

Furthermore, the existence and diversity of adaptive capacities within the community can effectively help pastoral societies to sustain their livelihood activities. This aligns with the findings of (Lemma, 2016), who emphasized that adaptive capacity among rural populations depends heavily on access to natural resources, institutional support, and livelihood diversification. For instance, pastoralists with access to irrigation, alternative income-generating activities, and stronger social networks experience less immediate pressure from climate variability than purely pastoral communities, as reflected by respondents in this survey.

According to the FGDs and KIs, different stakeholders such as government agencies and NGOs are involved in climate change intervention activities targeting pastoral communities by providing resilience and relief-based support. However, these interventions have not been fully effective because they often lack community consultation and are not guided by research-based evidence. The interventions were largely designed and implemented by the central government through a top-down policy approach, imposing a predetermined understanding of how climate change is perceived within pastoralist societies and what constitutes appropriate intervention strategies. This approach frequently fails to consider the community's contextual understanding, indigenous knowledge, and adaptive capacities. The widespread

acknowledgment of climate impacts highlights the urgent need to design and implement adaptation strategies for affected communities. In particular, Somali Region pastoralists and other pastoral communities in Eastern Africa face climate-induced disruptions that often lead to declining livestock productivity, food insecurity, and conflict over scarce grazing resources. Therefore, integrating pastoralists' knowledge with scientific knowledge in adaptation planning and policy intervention is essential to provide context-specific insights that can strengthen the resilience of vulnerable populations.

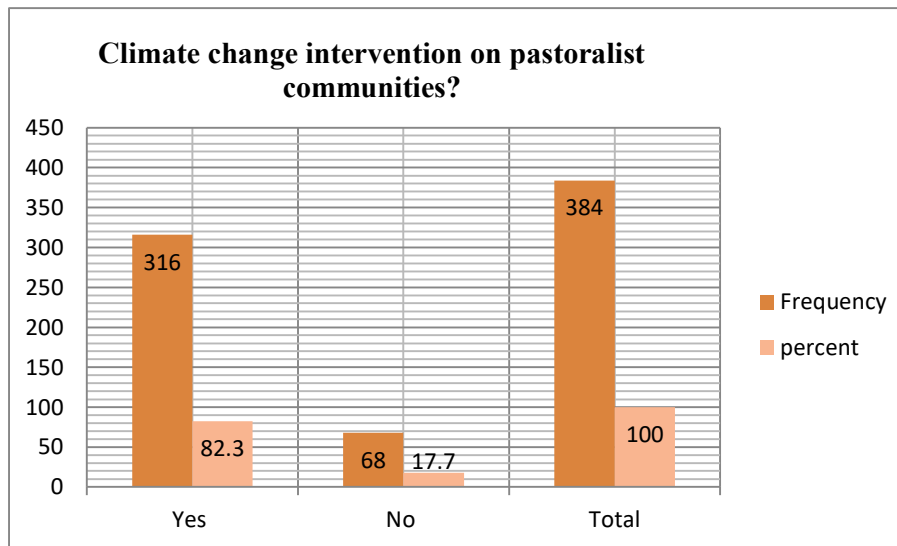


Figure 18: Climate change intervention on pastoralist communities

Source: Own survey result (2025).

7.2. Received support on climate change adaptation in study area

Pastoralist communities need intervention support on climate change adaptation, such as training, early warning systems, awareness creation, and capacity building. However, the effectiveness of these support systems remains uneven due to the lack of inclusive and sustained interventions. In this study, about 60.9% of respondents reported that they received some form of support from government or non-governmental organizations (NGOs) on climate change adaptation strategies. This support included drought relief, construction of water points, and training on adaptive practices. However, a significant number of respondents, around 39.1%, did not receive any form of intervention support (Figure 19). This suggests that although adaptation support reaches the majority of pastoralist households, a considerable portion of the population remains underserved, making them more defenceless to the waves of climate change. This finding is consistent with a study that highlighted the uneven reach of externally supported climate adaptation interventions (Tessema & Simane, 2019).

Pastoralist communities in Ethiopia are widely recognized as among the most vulnerable to climate variability and change. This high level of vulnerability stems primarily from the country's dependence on

a climate-sensitive agricultural sector, which is severely affected by risks associated with rainfall variability. This study is supported study conducted Aboriginal and northern communities in Canada face distinct climate-related challenges that require a comprehensive assessment of their vulnerabilities, including careful consideration of how community-level interventions can strengthen their resilience (Furgal & Seguin, 2006). These communities are experiencing significant climatic shifts that have adverse effects on their livelihoods, health, and overall well-being, highlighting the urgent need for context-specific adaptation strategies across regions. The accessibility of adaptation resources often depends on institutional presence, geographic location, and the strength of community networks that can facilitate effective interventions. According to (Ogundeji, 2022), climate change is predicted to have a significant negative impact on smallholder subsistence farmers, posing a serious threat to household food security. Government and NGO interventions in Africa often struggle with limited funding, weak institutional coordination, and inadequate integration of local knowledge. These gaps reduce the effectiveness of interventions, leaving many vulnerable households without assistance suited to their needs. In the context of pastoralist communities, where livelihoods highly depend on climate-sensitive resources, the absence of external support can significantly exacerbate risks, leading to food insecurity, livestock losses, and livelihood crises. The fact that the majority of respondents received some form of support for climate change adaptation emphasizes that adaptation is increasingly facilitated through multilateral and local partnerships that bridge government and NGO interventions. The presence of these interventions helps enhance the awareness, knowledge, and skills of pastoralists. In general, institutional interventions present both achievements and limitations in adaptation support systems within pastoralist communities. These interventions have improved access to water sources, veterinary care, early warning systems, livelihood support, and capacity-building initiatives that enhance community resilience. However, their effectiveness is often constrained by top-down implementation approaches, weak coordination among stakeholders, policies that remain largely theoretical and limited consideration of indigenous knowledge and local priorities, all of which reduce the sustainability and relevance of adaptation support systems.

According to focus group discussions (FGDs) and key informant interviews (KIs), pastoralist communities possess a deeply rooted indigenous culture of mutual assistance during periods of climatic hardship. This integration includes both voluntary and obligatory social networks based on food sharing, loans, and productive assets to mitigate challenges such as daily food shortages and livestock losses. Vulnerable households typically seek support from relatives, friends, and clan members when their livelihoods are disrupted by climate-related factors. This assistance often takes the form of livestock transfers, such as the gifting of animals as charity and the provision of lactating animals temporarily. This community-based intervention is important for addressing temporary livelihood needs but cannot provide a permanent

solution to the challenges posed by climate change. These practices of asset sharing are deeply embedded in community cultural norms and collective social responsibilities, serving as effective traditional coping strategies in the face of climate change (FGDs and KII, 2025).

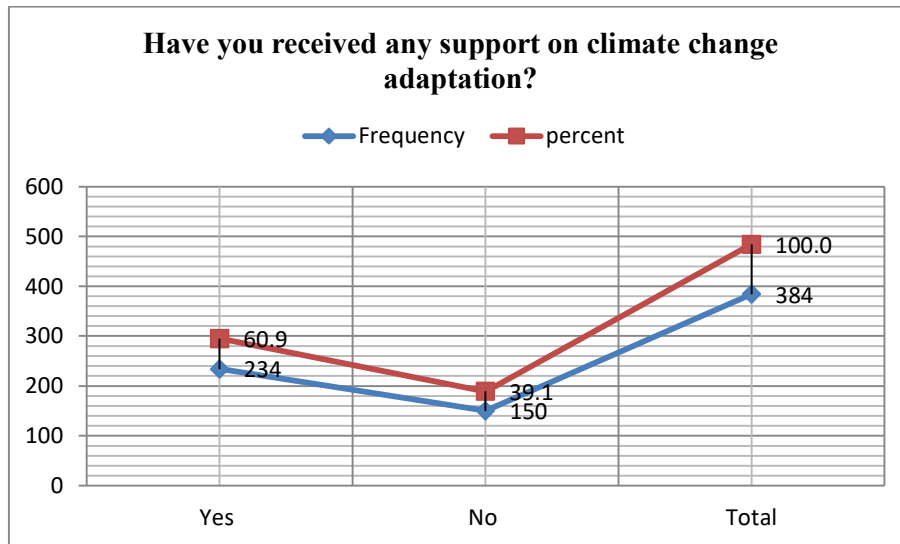


Figure 19: Received support on climate change adaptation

Source: Own survey result (2025).

7.2.1. Magnitude of Intervention Support for Climate Change Adaptation

The scale and effectiveness of institutional intervention support for climate change adaptation in pastoralist communities remain limited and inconsistent, particularly across developing countries. Strengthening community-based and sustained interventions is therefore crucial to enhancing the resilience and adaptive capacity of these populations (Tessema & Simane, 2019). According to the findings of this study, out of total respondents 60.9% reported they received some form of support from government or non-governmental organizations (NGOs) on climate change adaptation. Among these, only 15.4% described the interventions as fully supportive, whereby 42.4% confirmed as partially supportive, and 3.1% mentioned as not supportive at all (Figure 20).

This distribution reveals that although intervention support is available, most respondents perceive it as only partially effective in promoting resilience to climate change impacts. Two key insights emerge from these findings. First, the relatively low proportion of respondents who considered interventions fully supportive suggests that most programs are short-term in nature primarily focused on immediate relief measures such as drought assistance, food aid, or emergency water trucking. These initiatives, while valuable in crisis mitigation, are insufficient to address the systemic vulnerabilities of pastoralist communities.

Second, the high proportion of respondents expressing partial satisfaction indicates that beneficiaries recognize some benefits of government and NGO-led initiatives but remain concerned about their limited contribution to long-term self-reliance and sustainability by enhancing dependence rate of communities. Many adaptation programs in East Africa have been criticized for being fragmented, donor-driven, and top-down in design, rather than genuinely participatory or community-led (Cuni-Sanchez et al., 2019). Consequently, these programs often struggle to align with the socio-cultural realities, livelihood systems, and indigenous coping mechanisms that are central to pastoralist adaptation.

Moreover, the lack of supportive local policies, inadequate institutional coordination, and minimal integration of indigenous knowledge systems further undermine the success of adaptation efforts. Empirical evidence from Ethiopia and Kenya suggests that interventions that disregard local knowledge tend to generate dependency and fail to build long-term capacity (Lemma, 2016). Therefore, integrating indigenous knowledge with scientific and policy frameworks enhances contextual relevance and promotes adaptive learning, enabling communities to strengthen their resilience against climate-induced shocks. The policymakers and development partners are urged to move beyond short-term relief approaches toward comprehensive, participatory, and sustainable adaptation frameworks that reinforce pastoralists' existing coping systems. Addressing these gaps requires inclusive, multi-stakeholder engagement to design interventions that are not only technically sound but also socially and culturally appropriate. By fostering collaboration among government institutions, NGOs, and local communities, it is possible to shift interventions toward the "fully supportive" category one characterized by co-production of knowledge, institutional continuity, and long-term livelihood security for pastoralist populations. Overall, while adaptation interventions are reaching target communities, they remain inadequate or only partially effective. This underscores the urgent need for more context-specific, long-term, and beneficiary-driven solutions that recognize pastoralists not merely as recipients of aid but as active agents in sustaining ecological and livelihood resilience in the face of climate change.

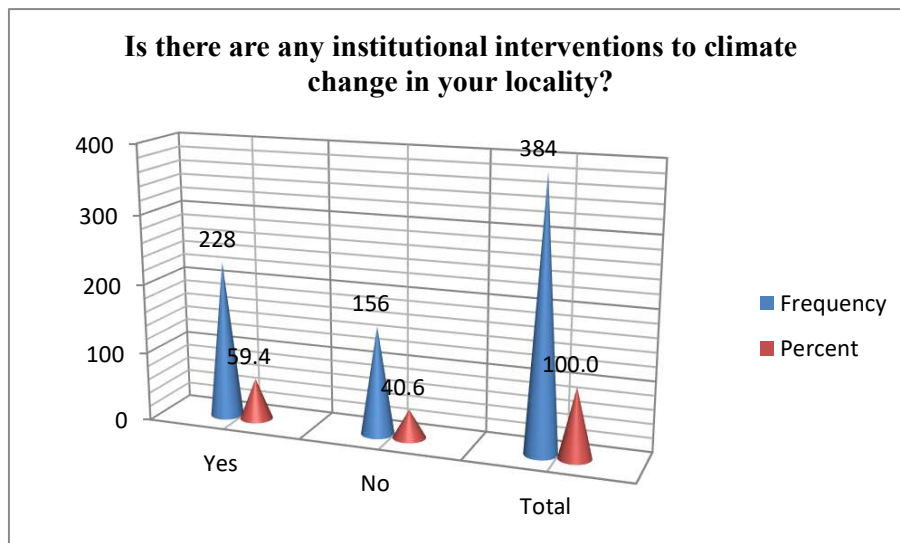


Figure 20: Extent Level of Interventions Support on Climate Change

Source: Own survey result (2025).

7.3. Key actives of institutional intervention to cope with climate change.

Institutional interventions play a crucial role in helping vulnerable communities, particularly pastoralists and smallholder farmers to cope with the effects of climate change. These interventions must implemented by various actors, including national and local governments, non-governmental organizations (NGOs), and research institutions. In this study, the findings indicated that only 9.9% of respondents reported having access to credit services, while about 90.1% did not receive such support (Table 9). This means that most households lack financial resources to invest in adaptive strategies such as agricultural inputs, water harvesting technologies, and livelihood diversification. This finding is in line with the study on climate change insight and alteration among agro-pastoral societies in Kenya (Silvestri et al., 2012), which stated the major challenges to adaptation are a lack of financing or money, coupled with inadequate access to farming land and commodities. Farmers' adaptability as breeders is hampered by a lack of markets, notably for the procurement of extra stock and innovative types, which require financial capital.

Safety net programs are designed to prevent vulnerable households from falling deeper into poverty during periods of shock or chronic hardship such as drought, food insecurity, or loss of livelihood assets. In this study about 31.8% of respondents indicated the presence of such programs in their district, while 68.2% did not benefit from any safety net support (Table 9). Safety net programs, which provide monthly cash transfers, food aid, or public works payments, are indispensable mechanisms for assisting vulnerable households adapt to climate shocks such as droughts and floods. The relatively low coverage

highlights gaps in institutional outreach and suggests that large sections of the population remain exposed to risks without formal social protection. Extension services also play a crucial role in transferring knowledge and best practices to pastoral communities. In this study, only 19.8% of respondents reported receiving extension support in the past 12 months, while 80.2% did not (Table 9). This indicates gaps in institutional interventions aimed at promoting the uptake of improved farming techniques, sustainable rangeland management, and climate-smart agricultural practices. The low delivery of extension services demonstrates the existence of weak institutional capacity in rural areas, which exacerbates climate vulnerability.

Training and awareness creation to help pastoralists to cope with climate change have shown relatively better performance. In this study more than half of the respondents 55.5% reported that they received training and awareness-creation activities, while 44.5% indicated that they had not (Table 9). This suggests that awareness-raising initiatives have achieved broader outreach compared to credit and extension services. However, the fact that nearly half of the pastoral population remains unexposed to such programs indicates the need to ensure that climate change knowledge and capacity-building activities reach all communities. The results indicate that although interventions have made progress, particularly in awareness creation, significant gaps remain in areas such as financial support, social safety nets, and extension services. These institutional interventions are essential for enhancing community resilience and ensuring that households have access to the financial, technical, and informational resources required to adapt effectively to the growing challenges posed by climate change.

Table 10: Key Institutional intervention to cope with climate change

No	Institutional intervention to cope with climate change	Parameters	Respondents	
			Frequency (n= 384)	Percept
1	Do you receive Credit services providing access?	Yes	38	9.9
		No	346	90.1
		Total	384	100.0
2	Does Exist Safety Net Program in your area?	Yes	122	31.8
		No	262	68.2
		Total	384	100.0
3	Do you receive Extension service in the last 12 months?	Yes	76	19.8
		No	308	80.2
		Total	384	100.0
4	Did you Receive Training and Awareness Creation on Climate Change Adaptation?	Yes	213	55.5
		No	171	44.5
		Total	384	100.0

Source: Own survey result (2025).

According to the Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) revealed that institutional interventions to cope with climate change remain limited and irregularly. FGD mentioned that as namely the government provide support on safety net programs, agricultural extension services, and awareness facilities which were inadequate to meet the needs for growing climate-induced challenges. They emphasized that safety net programs is temporary relief which is not enough to livelihood needs of pastoral communities, also it does not ensure long-term resilience. Moreover, Key Informant Interviews (KIIs) mentioned that agricultural extension services such as training on improved farming practices, distribution of drought-tolerant crop varieties, and the promotion of water harvesting technologies are crucial for enhancing pastoral and agro-pastoral livelihoods. However, the effectiveness of these services has been constrained due to limited resources, lack of actors' involvement, weak institutional capacity, and low levels of community participation, which have collectively hindered the sustainability and impact of such interventions. For instance, FGDs and KIIs stressed that interventions were often reactive rather than preventive, leaving communities vulnerable to recurrent climate shocks. This indicates the urgent need for scaling up institutional support with a stronger focus on sustainable rangeland management, livelihood diversification, and inclusive climate adaptation strategies.

Consequently, government initiatives have focused on establishing drought early warning systems, promoting sustainable rangeland management, expanding water infrastructure, and implementing social protection programs such as the Productive Safety Net Programme (PSNP) to reduce vulnerability. Policy frameworks at national and regional levels must recognize the important of pastoralism as a viable livelihood system, emphasizing resilience building, mobility, and market integration. Local and international organizations have complemented these efforts through livelihood diversification projects, capacity-building programs, veterinary and extension services, and the introduction of climate-smart technologies. However, pastoralists need mixed interventions to improved access to services and market opportunities, also there are need to change top-down programs implementation to botton-up approach, to define the needs and existing challenges of pastoralists. This means that externally driven interventions have inadvertently disrupted local coping mechanisms, grazing access, and enhance dependency. Overall, institutional efforts have contributed positively to enhancing adaptive capacity, but their long-term effectiveness depends on aligning policies and programs with indigenous knowledge, local priorities, and the dynamic nature of pastoral livelihoods.

The Stakeholder Perspectives of this study need to involve the government officials, researcher, budget custodians, and policy implementers to solve the critical gap by linking the Afrocentric, capacity-theoretic, and Sustainable Livelihoods Approach (SLA). The Afrocentric theory asserts an epistemic identity of the marginal and peripheral of African people, purposes, and positions, laying down the cultural identity and historical context rather than peripheral standpoint (Asante, 1998). This means climate research must lay

the agency of affected communities in dialogue with policy development, rather than treating as a silent backdrop.

Capability theory clarifies that the stakes of social factors such as institutions, perceptions, and social capital were determined the society capacities to adapt to climate change (Gupta et al., 2010). This empirical integration shows how institutions financial capacity, alongside physical and human resources is mandatory for adaptation despite adequate awareness and knowledge were existed (Khan, Gao, & Abid, 2020). Therefore, neglecting institutional actors leaves budget and capacity constraint, which lead decisive implementation outcomes. Moreover, the SLA situates the transforming structures and processes which deals with the formal and informal institutions that formulate policies, legislation, and other measures shaping livelihoods (DFID, 1999). Without institutional data, the study cannot assess how governance structures enable or constrain community resilience. Together, these frameworks indicate that research inquiry were achieved with incorporation of key informant interviews with institutional actors to examine political-economic constraints, staffing capacity, and budgetary decision-making as integral not peripheral dimensions of climate intervention effectiveness.

7.4. Awareness, Dissemination, and Implementation of Climate Change Policies among Pastoralist Communities in Ethiopia

The findings of this study indicated that 63.0% of respondents were haired the climate change policies, while 37.0% remain unaware (Figure 21). This means that even-though high number of pastoralists have awareness for climate change policy but still there are persistent gaps in policy communication among Ethiopia's pastoralist communities. This uneven distribution of awareness reveals a significant challenge in the dissemination and accessibility of institutional information that limits the capacity of pastoral communities to effectively engage with and benefit from national climate frameworks. The fact that nearly two-thirds of respondents are aware of such policies reflects some success of top-down government efforts, such as information spread through development programs, disaster risk management (DRM) frameworks, or local administrative channels. Moreover, the considerable portion that remain uninformed underscores disconnect between policy formulation and reality on the ground. This gap is partly rooted in the fragmentation of dissemination mechanisms. Information channels often fail to reach the most mobile and remote pastoralist groups due to poor communication infrastructure and the absence of systems that align with mobile livelihoods.

Administratively Ethiopia Government has implemented policy and strategies such as Community-based Early Warning Systems (CIEWS) strategy, which aware pastoralist and agro-pastoralist, though media radio broadcasts, leaflets, and administrative circulars limits outreach to groups whose seasonal movement patterns. This awareness giving does not necessarily translate into actionability, but knowing

that a policy existence also does not guarantee that communities can access or utilize the policy objective. The misalignment between the timing, location, and management of interventions and community priorities further dilutes policy impact.

Ethiopia's institutional approach to climate change policy, has stated ambitious, illustrates theoretically but practical implementation outcomes still has remained question mark. Theoretically, the country has two national strategies for climate adaptation framework concerned pastoralist areas which are the Climate-Resilient Green Economy (CRGE) Strategy (developed in 2011) and the National Policy and Strategy on Disaster Risk Management (DRM). The CRGE aims to balance economic growth with environmental sustainability, seeking to enhance livestock productivity, rangeland management, and infrastructure resilience (FDRE, 2011). Complementarily, the DRM policy promotes a paradigm shift from reactive aid toward proactive disaster risk reduction through early warning systems and social safety nets (Coughlan de Perez et al., 2015). These frameworks express clear priorities aligned with building resilience in pastoralist regions. However, it faces implementation challenges due to budget and stakeholder collaboration limitations. For instance, the interventions in water and rangeland management to mitigate drought vulnerability, and rangeland restoration needs budget allocation, ownership and stakeholders' collaboration. Furthermore, the static infrastructures inadvertently encourage overgrazing near boreholes creating land degradation" that undermine rangeland sustainability (Nori & Scoones, 2023). Similarly, livelihood diversification and sedentarization programs intended to stabilize pastoralist livelihoods often conflict with the mobility-based adaptive logic that underpins pastoral resilience. This marginalization and biased implementation policy among pastoralist and urban areas excludes mobile populations for participation and decision-making of resource (Nori, 2022).

The disconnection between formal policy goals and local realities is further reinforced by a lack of institutional integration and participatory processes. The national frameworks emphasize inclusivity, actual interventions tend to be top-down, with limited involvement of pastoralist communities in decision-making and project design. This indicates that while local communities often express awareness of climate policies, they remain uncertain about how to access the associated benefits, suggesting that information dissemination is partial and largely non-operational. Moreover, findings from (Nkuba et al., 2023) demonstrate that government communication channels rarely intersect with trusted traditional social networks, leaving a significant number of mobile pastoralists unreachable.

Consequently, persistent shortfall lies in the utilization of Indigenous and Local Knowledge (ILK). While national documents recognize the value of ILK in forecasting rangeland stewardship and adaptation of climate change but integrating for policy planning remain weak (Tafesse, 2021). Solving this gap requires not only recognition but institutionalization embedding ILK systematically within climate early warning, resource allocation, and adaptation planning frameworks.

In conclusion, the high level of partial awareness (63%) contrasted with significant unawareness (37%) underscores a systemic challenge in Ethiopia's climate policy landscape: translating policy existence and general recognition into contextually relevant, actionable information. For policies to meaningfully enhance resilience among pastoralist communities, communication strategies must become mobile-friendly, culturally resonant, and participatory, aligning dissemination with pastoral movement patterns and social networks. Moreover, policy implementation must evolve from rigid, top-down planning to flexible, co-designed interventions that combine scientific and indigenous knowledge. Only through such integrated, grounded approaches can climate change policies move from nominal awareness to tangible, equitable resilience on the ground.

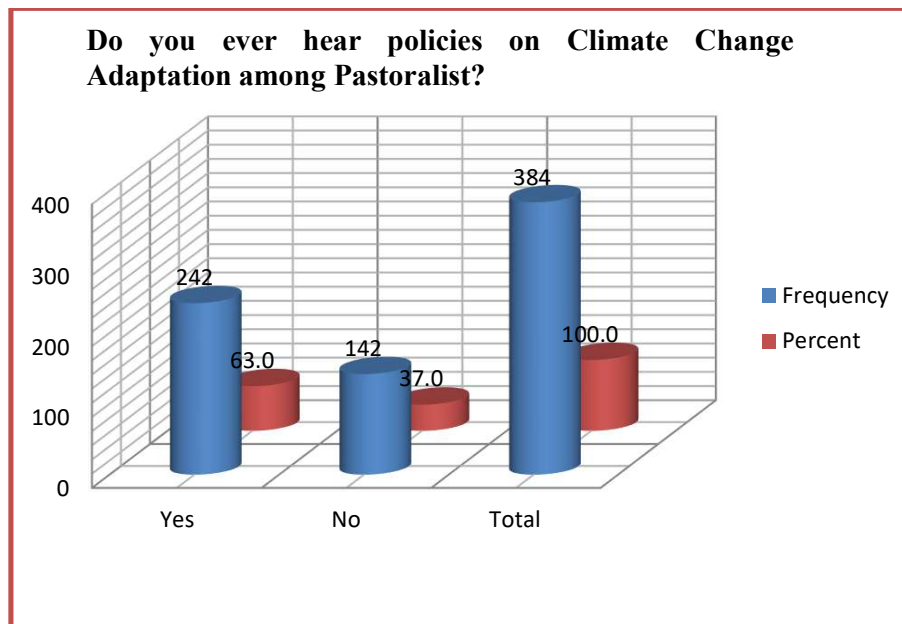


Figure 21: Awareness, Dissemination, and Implementation of Climate Change Policies among Pastoralist

- ✚ Direct quotation from pastoralists: - The effectiveness of government interventions in supporting pastoralist communities is contingent upon the alignment between stated national policies, such as the Climate-Resilient Green Economy (CRGE) Strategy and the Disaster Risk Management (DRM) Policy, and their operational execution on the ground, revealing a complex intersection with community-led coping mechanisms. While interventions like borehole construction are quantitatively aligned with policy goals to support drought resilience and complement the pastoral strategy of transhumance. "The new borehole built by the government in our area saved our whole herd last drought but they frequently result in ecological disconnection by promoting localized rangeland degradation (as per Participant P12). These means the government gives us water with one hand and loses our grazing land with the other." Furthermore, interventions for livestock health often suffer from quality gap and poor timeliness (as per Participant P08). The

government brings the vaccines, but they come too late making them reactive rather than proactive, and structural projects can actively undermine resilience by blocking crucial migration corridors (as per Participant P21). Ultimately, the government must develop successful institutional support, like cash transfers, acts as a crucial safety net that allows communities to preserve their adaptive assets (as per Participant P03). It meant during drought period we did not able to sell our livestock to buy food and other basic needs, so demonstrating that resilience is maximized when interventions are flexible, timely, and strategically reinforce, rather than conflict with, the fundamental principle of pastoral mobility.

Conclusion

This chapter has demonstrated that institutional interventions play a vital role in enhancing the adaptive capacity and resilience of pastoralist communities in the face of accelerating climate change. The findings reveal that while numerous governmental and non-governmental efforts have been initiated ranging from safety net programs, extension services, and training initiatives to the construction of water points and relief-based assistance their effectiveness remains uneven across the study area. A considerable proportion of the population continues to experience limited or inconsistent access to adaptation support, particularly in critical areas such as credit services, social protection, and extension support systems.

The analysis further suggests that the presence of institutional interventions has improved pastoralists' awareness and contributed to short-term relief from climatic shocks. However, the predominance of top-down approaches, inadequate community consultation, weak institutional coordination, and limited incorporation of indigenous knowledge has collectively constrained their sustainability and inclusiveness. Pastoralists' lived realities, cultural contexts, and traditional coping mechanisms have not been fully integrated into the design and implementation of adaptation strategies, thereby reducing the long-term resilience of these interventions. Evidence from both survey data and qualitative discussions (FGDs and KIs) underscores that while some progress has been made in awareness creation and capacity building, structural constraints including poor access to finance, weak institutional capacity, and policy fragmentation continue to undermine the impact of adaptation programs. Furthermore, interventions that remain reactive and relief-driven provide only temporary solutions to deep-rooted vulnerabilities, instead of addressing the systemic causes of climate-induced livelihood insecurity. To ensure lasting impact, institutional interventions must transition from fragmented, short-term support toward a comprehensive, participatory framework that strengthens local adaptive systems. This includes aligning formal interventions with indigenous knowledge, promoting bottom-up planning processes, and investing in sustainable rangeland management, livelihood diversification, and market integration. Effective adaptation requires multi-stakeholder collaboration, where government, NGOs, and local communities work synergistically to co-produce knowledge and design context-appropriate solutions.

In summary, institutional interventions have made notable contributions to enhancing the adaptive capacities of pastoralist communities, yet significant gaps remain in achieving equitable, sustainable, and culturally grounded adaptation outcomes. Bridging these gaps demands a paradigm shift toward inclusive, knowledge-integrated, and community-empowered climate governance that recognizes pastoralists not merely as beneficiaries of aid but as active agents of resilience and environmental stewardship. While some progress has been made in raising awareness of climate risks and providing short-term relief measures, much remains to be done to strengthen the adaptive capacity of pastoral communities. Building resilience requires moving beyond fragmented aid responses toward comprehensive, community-driven, and sustainable climate adaptation strategies. Therefore, holistic, long-term, and participatory approaches can help pastoralist communities' transition from recurring vulnerability to sustainable resilience in the face of climate change.

Chapter eight: Suggesting ways pastoralists can effectively cope with the impact of climate change.

Introduction

Pastoralists can effectively cope with the impact of climate change by diversifying their occupations, adopting climate-resilient activities, accessing early warning information, and strengthening community-based resource management systems. However, climate change has emerged as one of the most pressing challenges confronting pastoralist communities, particularly in arid and semi-arid regions. The recent decades, these communities have experienced increasingly unpredictable climatic conditions, marked by rising temperatures, erratic rainfall, and frequent droughts. This Chapter explored suggesting ways pastoralists can effectively cope with the impact of climate change. Drawing more on qualitative data from Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs), alongside quantitative survey results was provided a comprehensive overview of existing and suggested adaptation mechanisms.

The chapter begins by examining observed changes in temperature and rainfall patterns as perceived by community members and stakeholders, highlighting the challenges faced on pastoral livelihood activities. It evaluates the role of government and development partners in supporting effective adaptation and extent of community awareness of climate change. Additionally, the analysis integrates perspectives on the value of combining indigenous and scientific knowledge systems and key constraints that hinder the implementation of effective adaptation strategies. By comparing qualitative insights with empirical survey for suggesting pragmatic, community-driven, and policy-relevant pathways to reinforce the adjustment ability of pastoralists to climate change.

8.1. Qualitative aspect of Climate Variability and Its Implications used by Pastoralist

Qualitative data from Key Informant Interviews (KIIs) reveal that pastoralist communities observe profound, escalating shifts in localized climate conditions, primarily characterized by rising temperatures, prolonged periods of extreme heat, and severe rainfall multi-variability over the past two decades. Informants emphasize that historically distinct seasonal cycles have become increasingly blurred, which severely disrupts traditional livelihood systems by making it difficult to determine optimal timelines for grazing, migration, or opportunistic cultivation. Rainfall unpredictability has emerged as the most critical threat to regional stability; rains now arrive later than expected and are highly erratic, often manifesting as extended dry spells interrupted by sudden, destructive downpours. This volatility has not only undermined the reliability of natural water points and weakened the strategic mobility patterns traditionally used to cope with climatic stress, but it has also intensified localized competition and resource conflicts over dwindling water sources. Conversely, when precipitation does occur, it frequently triggers flash

floods that cause immediate property damage, degrade fragile rangelands, and hinder essential pasture regeneration.

Crucially, while pastoralists intimately recognize the severity of these shifting environmental baselines, many remain hesitant to adopt new technologies due to systemic uncertainties. This indicates that accelerating climate volatility has fractured community confidence in historical coping mechanisms alone, leaving pastoralists in urgent need of structured external support systems to supplement their indigenous knowledge. To address this vulnerability, there is a clear necessity to integrate modern meteorological forecasting, proactive government advisories, and targeted extension services to strengthen localized decision-making and long-term livelihood planning. Future pathways to resilience must leverage climate-smart interventions, such as mobile-based early warning systems for drought and rainfall tracking, which empower communities to make timely, informed mobility decisions. Furthermore, promotional strategies must emphasize the adoption of drought-tolerant livestock breeds such as camels and Somali goats alongside early-maturing, drought-resistant crop varieties like sorghum and maize. Ultimately, these qualitative insights underscore the critical need for blended, multi-dimensional adaptation approaches that harmonize localized cultural knowledge with modern scientific data to systematically improve the adaptive capacity of pastoralist and agro-pastoral communities (KII, 2025).

The hesitation of pastoralists to adopt new climate-smart technologies (such as mobile-based early warning systems or drought-tolerant livestock breeds) is best understood through Capability Theory. This framework posits that raw awareness of a hazard does not equate to the capability to act unless an individual possesses the fundamental freedoms, resources, and institutional support to do so. The qualitative data highlights that structural un-freedoms including high illiteracy, missing credit markets, and top-down policy neglect (the implementations gap) deprive pastoralists of the agency required to convert climate information into sustainable livelihood choices. Therefore, bridging these theoretical domains is essential. To expand pastoralist capabilities, future adaptation policies must reject top-down implementation. Instead, they must design a hybrid framework that restores the cultural legitimacy of IKS via modern science, systematically dismantling the structural barriers that trap vulnerable households in maladaptive cycles.

Researcher Field Observation: - The researcher was observed the pastoralist realities to get an essential data for directly examining the ground realities of climate change impacts and adaptation among pastoralist households. By visiting the six study districts, the researcher systematically observed livelihood activities, rangeland conditions, and water resource management practices, which closely aligned with the results obtained from respondents, focus group discussions (FGDs), and key informant interviews (KIIs). Observations also focused on infrastructure quality and the functionality of institutions

supporting the pastoral system an area that had been called into question by respondents. Moreover, visible signs of environmental degradation and the rate of grazing land recovery were observed, and when contrasted with other findings, these observations pointed in the same direction, reinforcing the overall pattern of results. This method provided firsthand evidence of how climate change influences pastoral livelihoods, enabling a realistic assessment of adaptive capacity and resilience by comparing field-based evidence with actual ground conditions including available resources, climate-induced challenges, and the physical condition of both livestock and people. During data interpretation, insights from field observations were triangulated with findings from household surveys, FGDs, and KIIs, contributing to a comprehensive and coherent understanding of the multi-dimensional challenges faced by pastoralists in the Somali Region.

Live in pastoral



8.1.1. Role of Government in Supporting Pastoral Communities

The government plays a vital role in support pastoral communities through various interventions, including veterinary services, livestock marketing support, seed distribution, and the development of water infrastructure. According to the KIIs, mobile animal health units have been deployed to reach remote areas, while additional government initiatives focus on promoting water harvesting technologies and introducing drought-resistant crop varieties as core adaptation strategies (KII, 2025). Strengthening community resilience, however, requires continued investment in capacity building and awareness creation, particularly through the expansion of boreholes and small dams to ensure reliable water access. The establishment of permanent animal health posts and the extension of veterinary outreach services to remote settlements are also essential for sustaining herd productivity under increasing climatic stress.

Beyond these measures, agricultural offices support pastoralists by providing veterinary care, and fodder distribution during drought periods. They further complement this assistance with the provision of seeds, farming tools, and soil conservation training such as terracing to mitigate erosion. Despite these efforts, the support remains insufficient compared to the scale of challenges faced by pastoral households. The FGD emphasized that the need for establishing community-based fodder banks would significantly enhance preparedness by allowing surplus feed to be stored for use during dry seasons. Building the capacity of farmers in integrated farming systems combining livestock, crop production, and water management can further diversify household income and stabilize food production (FGD, 2025). Conservation agriculture practices, including minimum tillage and crop rotation, were also highlighted as essential approaches for reducing soil erosion, improving soil fertility, and enhancing moisture retention. Collectively, these interventions contribute to more sustainable and climate-resilient livelihoods for pastoral and agro-pastoral communities.

8.1.2. Suggesting Adaptation and Coping Mechanisms

Pastoralist communities in developing counties engage different adaptation and coping mechanisms such as livestock diversification, seasonal migration, and water harvesting to manage the impacts of climate change. A current strategy used pastoralist's community in Somali Region includes seasonal migration, herd size reduction, water storage, and Livelihood diversification and so on. The Key Informant Interviews (KII) highlighted that pastoralists are moving to neighbouring zones in search of food and water for their animals. Moreover, they suggested adaptation and coping mechanisms such as selling weak animals early, livestock diversification and transforming, children educating, saving, establishing other livelihood source and cultivating of land to resist climate variability. These coping mechanisms, communities can develop rotational grazing plans supported by local customs and laws to prevent overgrazing and ensure grassland regeneration. The communal rangeland management committees would further promote equitable and sustainable use of pasture resources. Supporting community-based awareness that preserve and share climate-resilient crop varieties can enhance agricultural resilience followed by promotion of small-scale irrigation schemes using river sites for solar-powered pumps machines.

In addition, the FGD and KII suggested the need for livestock transformation programs and diversifying income sources would help pastoralists to mitigate the financial burden of animal losses during climate shocks by shifting to other assets. Consequently, diversifying income sources to other livelihoods alternative such as beekeeping, business, or handicrafts would reduce dependence on climate-sensitive activities by providing greater stability for livelihood source (FGD and KII, 2025).

8.1.3. Awareness and Effectiveness of Pastoralist Communities on Climate Change

Awareness and effectiveness of climate change adaptation strategies determine how well pastoralist communities can respond to climate impacts and enhance their long-term resilience. According to Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) discussion demonstrated that the strong awareness of pastoral communities on climate change is important. The participants frequently mentioned that the reduction of pasture availability, disease outbreak, recurrent droughts, and crops failure are indicators of shifting climatic patterns. The KIIs suggested that strengthening awareness requires structured interventions of climate education to build long-term understanding of communities. Similarly, FGDs suggested the use of local radio and community meetings to disseminate timely information on climate trends and adaptation practices is important. In addition, we suggested youth and women's groups training in climate-smart agriculture and livestock management to strengthen community-level capacity building.

For instance, the awareness and effectiveness of climate change adaptation of communities and institutions are not sufficient to support the livelihood of pastoralists. The FGDs noted that migration was reliable coping strategy used pastoralist during scarce pasture and water resources from residential area. Likewise, rainwater harvesting initiatives were not sufficient to support the small-scale farms households among communities. To address these gaps, participants recommended scaling up water harvesting technologies, including underground cisterns and rooftop collection systems, to serve larger populations. Both FGDs and KIIs emphasized the need for developing policy on regional cooperation between neighbouring zones to establish shared grazing and water use agreements, thereby reducing conflict and ensuring more equitable access. Furthermore, promoting agro ecological zone mapping was suggested as an important tool to guide decisions on suitable crop varieties and livestock investments based on local environmental conditions.

The interviews reveal that pastoralists involved various adaptation strategies but their awareness and effectiveness of adaptation is sufficient. Therefore, there is a need for strengthening institutional support, promoting climate-resilient practices, and investing in local capacity-building are essential to enhance the effectiveness of their coping mechanisms by using collaborative approach, to ensure that pastoral communities can thrive in the face of a changing climate (FGD and KII, 2025).

8.1.4. Challenges and Institutional Responses Complementing Community Strategies

Challenges play critical role for institutional responses in complementing community-based strategies by addressing resource gaps, policy limitations, and capacity constraints in climate change adaptation. According to Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) discussion mentioned that there are several challenges faced by service providers in supporting pastoral and agro communities.

These challenges include poor infrastructure, cultural issue, lack weather and climate data, limited human resources, and inadequate tools for farming. These constraints were noted to limit the effectiveness of service delivery and weaken the impact of community-led adaptation efforts. Pastoral community need for better road infrastructure, education facilities, water, good communication networks and awareness creation to ensure timely access to information and services deliveries. The participants also pointed out need for partnerships with NGOs and research institutions to strengthen technical capacity, and mobile extension services were recommended as a way to reach underserved areas with essential inputs and climate information.

Despite these challenges, institutional actors are already making efforts to complement community strategies, though with different stakeholders' engagement. For instance, KIIs suggested that need for improving pastoralist development by focussing infrastructure development, education access, wells, health facilities and livelihood options. However, developing countries stressed due to lack of financial for infrastructural development undermines community resilience. To bridge this gap, there are a need to establish local development consultation platform in development projects to handle routine appropriate place and highly needed areas. These need collaboration of different stakeholders to strengthen public-private partnerships to ensure consistent of agricultural inputs and veterinary supplies, which are crucial for sustaining pastoral livelihoods and climate challenges mitigation (FGD and KII, 2025).

Finally, the researcher observation on community settlements and perception on climate change adaptation lacks monitoring and evaluation guideline. Without proper feedback systems, gaps remain unaddressed, and lessons are not fully integrated into future interventions. The researcher suggested the need for introduction of regular assessments to identify weaknesses, improve program design, and ensure that institutional interventions effectively complement the adaptive strategies and capacity of local communities.

8.2. Suggesting Ways to cope effectively the impact of climate change

Pastoralist communities can cope effectively with the impacts of climate change by using different ways, such as climate-resilient agricultural practices, conserving natural resources, and diversifying livelihoods. In this study, about 47.1% of the sample respondents suggested that training and awareness giving is the best way to cope effectively with the impact of climate change on pastoralists. This means that developing and changing the life of pastoralists needs building their knowledge and skills to adapt to the impact of climate change. For instance, training and awareness giving are the most frequently suggested strategies because enhancing knowledge, awareness, and capacity building are the best ways to cope with climate change. Whereas, about 22.1% of respondents suggested that transforming to alternative livelihoods is the best way to cope with the impacts of climate change (Figure 22). This means that households recognize the need to diversify their income sources beyond traditional pastoralism.

Therefore, pastoralists need other livelihood alternatives to reduce the dependence on highly vulnerable livestock-based livelihoods, which are affected by climate variability, such as droughts, erratic rainfall, and resource scarcity. This finding is consistent with the suggestion expressed during focus group discussions, where participants emphasized that FGD at Korahey zone stated on the value of training/awareness, where when the households had received training on early warning systems or rangeland management felt more confident adjusting their herding diversification. Key informants similarly noted that consultation development agent, elder, or local official on the role of awareness creation in adaptive behaviour.

Consequently, about 18.2% of respondents reported that resource diversification is the best way to cope with the impacts of climate change. The implication of this finding is that a considerable number of households recognized the importance of using resource diversification by applying multiple income generation activities to reduce the dependence on climate-sensitive activities and strengthen resilience against future climate trends. Whereby, about 12.5% of respondents responded that all of them (training and awareness creation, resource diversification, and transforming to alternative livelihoods) are the best ways to cope with the impacts of climate change (Figure 22). These diverse livelihood strategies are important for pastoral communities to adapt effectively, as they recognize the need for a multi-faceted and prioritized approach. However, implementing such climate adaptation options at the community level is often challenging due to limited resources, manpower, skills, and knowledge. This finding aligns with the study of (Ntombela et al., 2024) on pastoral coping and adaptive management strategies to climate change in communal areas. It highlights strategies such as income diversification, supplementary feeding, and livestock mobility, which are consistent with the approaches. However, pastoralists often face a hierarchy of barriers when implementing these strategies, including limited access to grazing lands, land degradation, and the erosion of traditional knowledge for managing livestock and rangeland resources. Therefore, policy development should address these barriers while strengthening existing adaptation strategies to reduce the vulnerability of pastoralists in dryland regions to climate change.

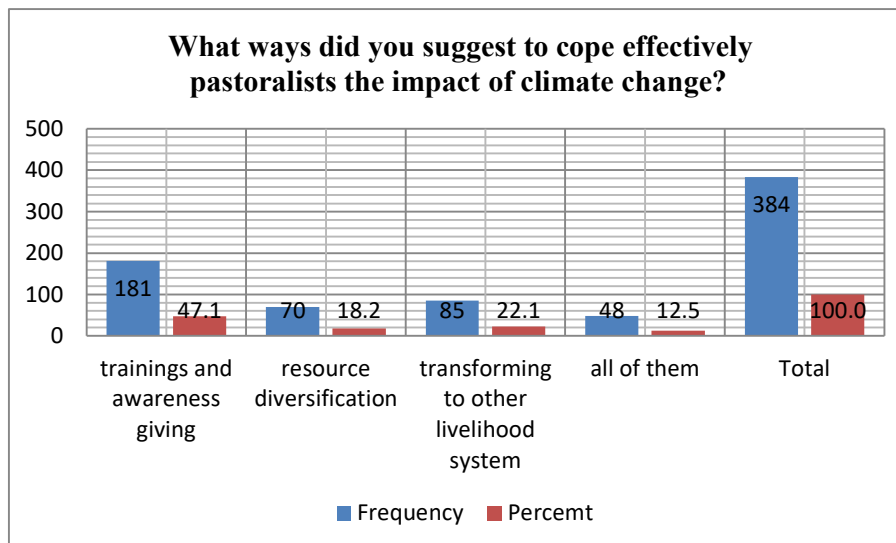


Figure 22: Suggesting Ways to cope effectively the impact of climate change

Source: Own survey result (2025).

Theoretical Interpretation: - These findings meaningfully interpreted through three complementary theoretical lenses.

From the perspective of the Sustainable Livelihoods Framework (SLF), the prominence of training/awareness (47.1%) and alternative livelihoods (22.1%) reflects households' efforts to build and reallocate their livelihood assets human capital (knowledge and skills), financial capital (diversified income), and social capital (information networks) in response to climate-induced vulnerability. The SLF's emphasis on the interaction between vulnerability context (drought, erratic rainfall, resource scarcity) and livelihood strategies is directly visible in respondents' shift away from livestock-only livelihoods toward more diversified asset portfolios. The fact that 12.5% of respondents favoured a combined approach further illustrates the SLF's central premise that resilient livelihoods are built on multiple, interacting capital assets rather than a single strategy.

Capability Theory (Sen) offers a complementary lens by reframing the dominance of training and awareness as a demand for expanded capabilities the substantive freedom of pastoralists to choose and pursue valued ways of living, rather than mere asset accumulation. Respondents' emphasis on knowledge and skill building suggests that the constraint on adaptation is not solely material scarcity but a deficit in functional capability: households need the conversion factors (education, information, institutional support) that allow available resources to translate into real adaptive choices. Viewed this way, the relatively lower preference for resource diversification alone (18.2%) may indicate that without prior capability building, households perceive diversification as a goal they lack the capacity to pursue independently.

Afrocentricity contributes a contextual and epistemological lens, foreshadowing the institutional barriers erosion of traditional knowledge, limited access to grazing land that recur throughout these findings. An Afrocentric reading would caution against interpreting "training and awareness" narrowly as the introduction of external, technocratic knowledge; rather, effective training should integrate indigenous pastoral knowledge systems (e.g., traditional drought forecasting, mobility-based rangeland management) as a foundation rather than a replacement. This is consistent with respondents' and key informants' concern that adaptation strategies are most viable when they build on, rather than displace, existing community knowledge and institutions.

Taken together, these three frameworks suggest that effective policy support should expand pastoralists' capabilities (Sen) by strengthening their livelihood assets (SLF) in ways that are rooted in, rather than external to, local epistemologies and institutions (Afrocentricity). Policy development should therefore address structural barriers restricted grazing access, land degradation, and weakening traditional knowledge systems while reinforcing the adaptation strategies pastoralists themselves identify as most relevant, in order to reduce the long-term vulnerability of dryland pastoral communities to climate change.

8.2.2. Key Strategies Enhancing Pastoralists' Capacity to Climate Change

Pastoralists' climate resilience requires a holistic approach that combines natural resource management, improved services, diversified livelihoods, strong institutions, and supportive policies. These strategies need integration, to become pastoralists better equipped to withstand climatic shocks, protect their livestock, and secure long-term livelihoods. In this study, about 38% of respondents suggested that livelihood diversification is the key strategy for enhancing pastoralists' capacity to cope with climate change impacts (Figure 23). This reflects a strong consensus that relying solely on livestock rearing is no longer viable under increasing climate variability. Therefore, pastoralist households need alternative and supplementary livelihood options such as crop cultivation, livestock splitting, small businesses, and labor-based activities to strengthen their resilience against drought and livestock losses.

Furthermore, approximately 28.9% of respondents noted that access to information and water security initiatives are critical for improving adaptive capacity. This highlights the importance of empowering pastoralists with timely information, including early warnings, and ensuring reliable access to essential resources such as water. The findings underscore the value of predictive information systems: accurate weather forecasts and early alerts on droughts or disease outbreaks enable pastoralists to make proactive decisions regarding herd movement and livelihood planning, thereby minimizing risks and losses. Moreover, it shows that about 10.2% of respondents participated in water harvesting and conservation practices (Figure 23). This finding reflects the reality that drought is one of the primary climate-related challenges affecting pastoralism and water availability. Techniques such as constructing

small dams, building water pans, and practicing rainwater harvesting are viewed as vital for securing reliable water sources and reinforcing household resilience during dry periods.

Moreover, about 13.3% of respondents reported involvement in community-based natural resource management initiatives. This suggests that top-down approaches are often less effective and greater sustainability can be achieved when pastoralist communities actively participate in decisions regarding grazing lands, development projects, water points, and forest resources. Such participatory approaches foster local ownership, ensure culturally appropriate and context-specific interventions, and promote long-term commitment to resource management. Additionally, about 7% of respondents reported having access to veterinary services and using resilient livestock breeds. This highlights the limited availability of veterinary support and improved breeding practices, despite their crucial role in safeguarding pastoralists' core assets. Strengthening animal health services and promoting drought-tolerant livestock breeds can substantially reduce animal losses during climate shocks, allowing households to maintain their livelihoods under changing climatic conditions.

Consequently, only about 2.5% of respondents reported receiving support through policy interventions aimed at enhancing pastoralists' coping capacity (Figure 23). This means that such interventions were perceived as the least effective among the listed strategies. However, this does not imply that policy is unimportant; rather, it indicates that existing policies may be viewed as ineffective, overly centralized, or slow to reach pastoralist communities. Respondents suggested practical, on-the-ground actions such as livelihood diversification and water harvesting is more immediate and impactful than broad policy frameworks. This underscores the need for more responsive, inclusive, and locally grounded policy measures to support pastoralist adaptation more effectively. This finding is consistent with the finding of (Walker et al., 2022) who noted that understanding how adaptation and coping strategies affect pastoral women's well-being is essential to strengthening climate resilience for both communities and the landscapes they depend on. While these strategies influence various social and cognitive dimensions of well-being, they did not significantly predict livestock loss.

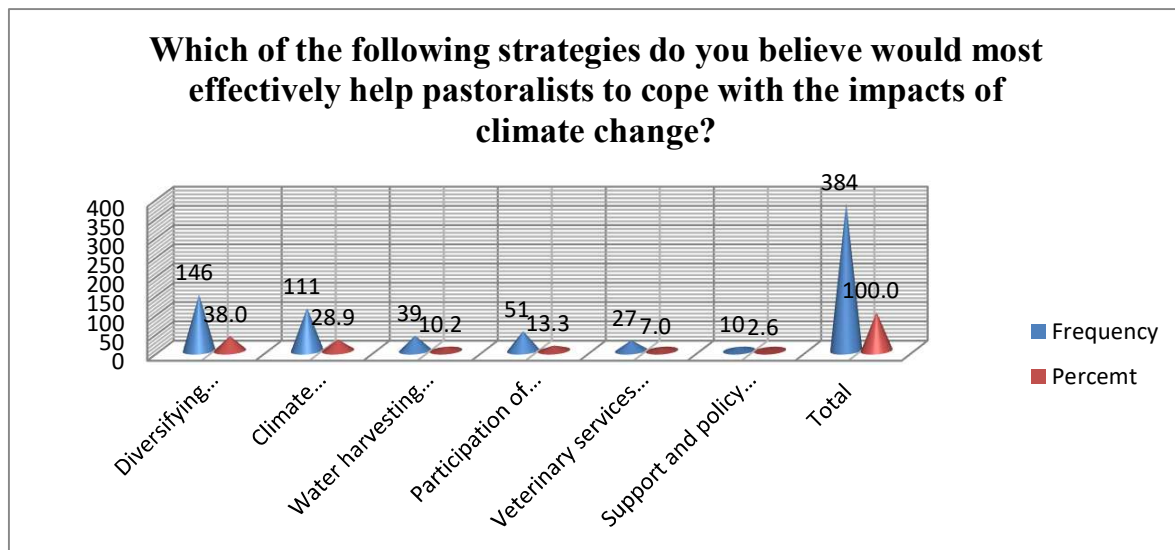


Figure 23: Key Strategies Enhancing Pastoralists Capacity to Climate Change Impacts

Source: Own survey result (2025).

8.3. Integration of Indigenous and Scientific Knowledge to Adapt Climate change

Integrating indigenous and scientific knowledge enhances the effectiveness of climate change adaptation by combining local experience with evidence-based practices. Indigenous knowledge provides context-specific insights into weather patterns, resource management, and survival strategies that have been tested over generations. When aligned with scientific data and modern technologies, this integration fosters more resilient, sustainable, and culturally appropriate adaptation solutions for pastoralist communities. In this study, approximately 67.4% of participants expressed the belief that integrating traditional and scientific knowledge can significantly enhance their resilience to climate change (Table 10). This finding reflects a strong recognition of the complementary value of both knowledge systems and underscores the need for their combined application in climate change adaptation. Traditional knowledge is rooted in lived experience, local ecological understanding, and cultural practices can offers valuable guidance on sustainable resource management, early warning indicators, and adaptive behaviors that are well attuned to local environmental conditions. When combined with scientific approaches characterized by systematic observation, experimentation, and predictive modeling, the two epistemologies can jointly contribute to more holistic and context-sensitive adaptation strategies.

The integration of indigenous and scientific knowledge systems refers to a systematic hybrid architecture that blends localized, intergenerational ecological tracking with the technological precision of modern meteorology to formulate robust climate adaptation strategies. In practice, this means harmonizing traditional, culturally embedded environmental indicators such as pastoralist observations of flora, fauna behavior, and astronomical cycles with empirical scientific tools like satellite-driven remote sensing and

computer-modeled weather forecasts. Because rapid climate acceleration increasingly pushes environmental shifts past the predictive bounds of historical memory, relying purely on inherited practices leaves communities vulnerable. By combining traditional farming or grazing strategies with scientific early warning mechanisms and innovative mobile platforms, adaptation policies achieve greater accuracy while retaining local trust and cultural legitimacy. Ultimately, integrating these two distinct paradigms ensures that modern, top-down climate interventions are grounded in contextual realities, preventing maladaptation and boosting the long-term resilience of pastoralist and agro-pastoralist communities.

Conversely, about 32.6% of respondents did not believe that integrating traditional and scientific knowledge improves resilience to climate change (Table 10). Their skepticism stems from several factors, including limited exposure to scientific information, a lack of formal education in climate science, and deep-rooted cultural beliefs that prioritize traditional knowledge over modern methods. Moreover, institutional barriers such as the absence of platforms for knowledge exchange between scientists and local communities also can hinder the effectiveness of integration. Additionally, distrust in external scientific institutions, perceived inaccessibility of scientific data, and previous experiences where scientific interventions failed to respect indigenous knowledge systems contribute to this resistance. This study aligns with the findings of (Salifu, 2020), who emphasized that local institutions and indigenous knowledge hold significant value in understanding environmental changes and guiding community responses. These local perceptions and traditional practices form a vital foundation for community-based climate change adaptation and natural resource management. Despite challenges posed by global change, cultural erosion, and social transformation, traditional knowledge continues to play an important role in weather forecasting, agriculture, and the management of rangeland resources. In doing so, it sustains community livelihoods and enhances the resilience of landscapes to climate variability and change.

The divergence in perspectives observed in this study by highlighting the importance of inclusive knowledge governance, where traditional custodians and scientific experts actively collaborate in co-producing and co-implementing adaptation solutions. Addressing these epistemological gaps requires not only the technical integration of knowledge systems but also strong social and institutional mechanisms that promote mutual respect, knowledge co-creation, and community empowerment. Such approaches are essential for developing climate adaptation strategies that are both effective and culturally grounded.

Table 11: Integrating Indigenous and Scientific Knowledge in Climate Adaptation

Variable Nature	Frequency	Percent
Yes	259	67.4

Do you believe that combining traditional knowledge with scientific knowledge can improve your resilience to climate change?	No	125	32.6
	Total	384	100.0

Source: Own survey result (2025).

These divergent perspectives on knowledge integration can be productively read through the lens of Afrocentricity, Capability Theory, and the Sustainable Livelihoods Framework. From an Afrocentric standpoint, the 67.4% who endorse integration are not asking traditional knowledge to be validated by science, but rather affirming that indigenous epistemologies rooted in generational ecological observation and cultural practice constitute a legitimate and equally authoritative starting point for adaptation, into scientific tools can be incorporated. The 32.6%, who remain skeptical, meanwhile, can be understood through an Afrocentric reading as expressing a justified caution of their distrust reflects a history in which external scientific interventions have repeatedly failed to respect or co-design with indigenous knowledge systems, rather than as they prefer to stay local knowledge usages.

Capability Theory reframes this divergence as a question of conversion factors: pastoralists' ability to benefit from scientific knowledge depends not merely on its availability but on functioning institutional platforms, education, and trust that allow such knowledge to be converted into real, usable adaptive capacity. Nevertheless, the absent these, scientific inputs remain inaccessible regardless of their technical merit, which explains why limited exposure and lack of formal training correlate with skepticism. The Sustainable Livelihoods Framework then situates both knowledge systems as forms of human and social capital: indigenous knowledge represents an existing, locally embedded capital stock built over generations, while scientific knowledge offers an additional asset that, when properly bridged through institutional mechanisms, strengthens rather than substitutes for that stock. Consequently, these theories suggest that effective knowledge co-production is not a technical exercise in merging two information systems, but an institutional and epistemological project: one that must expand pastoralists' capabilities, build on their existing livelihood assets, and respect indigenous ways of knowing as foundational rather than supplementary.

In general, effective climate adaptation in pastoralist and agro-pastoralist systems needs bottom-up policy to shift from top-down program design toward participatory planning that respects kinship-based decision structures with primary stakeholders. This governance base gives the other adaptation measures legitimacy and makes it more likely communities will adopt and sustain them. Within this participatory framework, co-produced knowledge links local and scientific systems. Elders' long-cycle forecasting needs to combine with scientific meteorological data. This integration improves the credibility of climate information among community members and makes forecasts more locally relevant and more likely to be acted on.

That co-produced information must then reach people in accessible ways. Mobile-friendly early warning systems, delivered through radio and mobile alerts, reach communities despite low literacy. Trusted intermediaries, such as elders and religious leaders, relay and interpret these warnings through existing social networks, so that the information is credible as well as accessible. Finally, early warning translates into resilience through drought-tolerant livelihood assets. Communities that receive timely, trusted information can make anticipatory decisions, such as destocking, migrating, or changing planting dates, and these decisions are supported by adapted assets such as camels and Somali goats, and early-maturing crop varieties suited to pastoral mobility.

8.4. Constraints and Challenges for Implementation of Adaptation Strategies

Implementation of adaptation strategies among pastoralist communities faces several constraints, including limited access to financial services, climate-resilient technologies, inadequate institutional support, poor infrastructure, and weak coordination between stakeholders. Cultural beliefs and lack of awareness also pose challenges to adopting modern adaptation techniques. These constraints collectively reduce the communities' capacity to cope with climate change impacts. In this study, about 78.6% of respondents reported that multiple factors such as pastoral mobility, knowledge gaps, diverse decision-making structures, and cultural or belief-related constraints are the major challenges to the implementation of adaptation strategies (Table 11). This indicates that communities face intersecting and overlapping barriers, reflecting the complexity of implementing climate adaptation measures where social, cultural, and informational constraints occur simultaneously. Moreover, 14.6% of respondents identified knowledge gaps as a notable standalone constraint, highlighting the need for improved access to both scientific knowledge and traditional knowledge to support adaptation strategy. This knowledge gap refers to the absence, insufficiency, or unequal distribution of information, awareness, or technical understanding that pastoralists' communities have about climate change adaptation strategies.

Approximately 3.9% of respondents also pointed to diverse decision-making structures as a primary challenge. At the household level, decision-making often involves collective participation among family members such as fathers, mothers, and adult children. While this inclusive approach fosters shared responsibility, it can also delay timely decisions, hindering the prompt implementation of adaptation actions during urgent climate-related events. The necessity of reconciling multiple perspectives can slow down adaptive responses of climate change among communities.

Additionally, around 1.8% of respondents reported that cultural and belief systems is first priority plays an important role in constraining adaptation strategies (Table 11). Operationally in this study cultural attitudes refer to the deeply held beliefs, values, norms, and worldviews that shape how a community interprets, evaluates, and responds to new adaptation strategy even after that adaptation is known and

benefitable. These findings reflect internal community dynamics in which long-standing traditions, cultural norms, and resistance to technologies due to cultural and belief issues. Only 1.0% of respondents identified pastoral mobility as the main constraint. Since pastoralists are highly mobile in search of water and pasture for their livestock, implementing fixed or location-specific adaptation strategies becomes challenging. This study aligns with the findings of (Baffour-ata et al., 2021) who reported that farmers perceived declining rainfall and rising temperatures. In response, they adopted a range of on-farm and off-farm strategies including the use of traditional agro ecological knowledge, planting improved crop varieties, and engaging in temporary migration to cope with climate change impacts within their communities.

Overall, the findings emphasize the importance of integrating traditional knowledge with scientific approaches to strengthen climate resilience. However, such integration must acknowledge the range of implementation barriers, including knowledge gaps, sociocultural dynamics, and governance complexities. Addressing these multifaceted challenges were required inclusive, context-specific strategies that respect local knowledge while promoting evidence-based adaptation.

Table 12: Constraints and Challenges Faced During Implementation of Adaptation Strategies

Variable Nature		Frequency	Percent
What are the constraints or challenges you faced during implementation of adaptation strategies?	Pastoral Mobility	4	1.0
	Knowledge gaps	56	14.6
	Diverse decision making	15	3.9
	Cultural and belief factors	7	1.8
	All options	302	78.6
	Total	384	100.0

Source: Own survey result (2025).

Theoretical Interpretation: - These constraints interpreted through Afrocentricity, Capability Theory, and the Sustainable Livelihoods Framework, each illuminating a different dimension of why implementation falters even when adaptation strategies existed. From an Afrocentric perspective, the cultural and belief-related constraints reported by respondents should not be read simply as "resistance to modern techniques but as evidence that adaptation interventions are frequently designed without consulting primary beneficiary. Nevertheless, most intervention are top down mechanism which does not know the Pastoralist real problems; where interventions fail to engage existing kinship-based and collective governance structures, they are experienced as external impositions rather than legitimate tools, reinforcing reluctance to adopt them. Capability Theory reframes the dominant 78.6% finding the intersecting burden of mobility constraints, knowledge gaps, and diverse decision-making structures as a demonstration that pastoralists' adaptive capability is shaped not by the absence of will or awareness, but by a lack of conversion factors: institutional support, infrastructure, and financial access that would

allow potential adaptive knowledge to become unsounded. The Sustainable Livelihoods Framework situates these same constraints within its vulnerability context and institutional/policy transforming structures which are poor infrastructure, weak stakeholder coordination, and limited financial services. The structures and processes that should mediate access to livelihood assets, meaning that even households with adequate human and social capital (knowledge, kinship networks) cannot convert these into resilient livelihood outcomes due to lack of institutions functionality. These frameworks indicate that overcoming implementation barriers requires more than disseminating information or technology; it requires building institutional structures that are simultaneously capability-expanding (Sen), asset-enabling (SLF), and culturally legitimate within pastoralist decision-making systems (Afrocentricity).

Conclusion

The findings from this chapter presented a complex and multifaceted nature of climate change impacts on pastoralist communities. Both qualitative and quantitative evidence reveal that while pastoralists have developed a range of coping strategies such as seasonal migration, herd diversification, and water conservation but they constrained by systemic barriers including poor infrastructure, limited access to climate information, and socio-cultural factors. This means that adaptation is effective when it involves a holistic approach that combines traditional ecological knowledge with scientific innovations by implementing early warning systems and drought-tolerant livestock and crops.

Government interventions, although present, need to be more targeted, inclusive, and responsive to the specific needs of pastoralist communities. Training, awareness creation, and livelihood diversification are the most suggested strategies for enhancing resilience and adaptation among pastoralist communities. However, persistent challenges such as knowledge gaps, diversity decision-making, and cultural resistance continue to hinder the success of adaptation initiatives. Remarkably, community members recognize that no single strategy is sufficient to integrate participatory framework and sustainable adaptation mechanism.

Therefore, to ensure sustainable adaptation to climate change, it is imperative to strengthen institutional support systems, invest in decentralized infrastructure, promote inclusive knowledge-sharing platforms, and foster regional cooperation. The future policies and interventions should prioritize capacity-building, communities' ownership awareness creation, and the co-creation of solutions that align with cultural values and environmental realities of pastoralist communities. Implementing such policies and interventions needs comprehensive and context-sensitive approaches can support the long-term sustainability and resilience of pastoralism in changing climate.

Chapter Nine: Conclusions and Recommendations

9.1 Conclusions

Climate change is a dynamic phenomenon that influences the ecology, society, and economy both negatively and positively. This study, grounded in a rigorous mixed-methods approach and informed by a pragmatic research paradigm, illuminates the multifaceted realities of climate change adaptation among pastoralist communities in the Somali Regional State of Ethiopia. The overarching conclusion drawn from the methodological rigor, theoretical grounding, and empirical findings reveals that climate change is an immediate, pervasive, and multidimensional challenge for ecological, social, economic, and cultural that profoundly shapes the sustainability of pastoral livelihoods. The findings consistently affirm that pastoral communities are neither passive victims nor solely vulnerable populations but active agents whose adaptive practices, resilience, and indigenous knowledge offer critical insights into sustainable adaptation pathways. The evidence demonstrates that recurrent droughts, erratic rainfall, water scarcity, and degraded rangelands constitute the dominant climate-induced stressors undermining pastoral production systems. These environmental challenges have direct implications for food security, income diversification, social stability, and inter-clan relationships. While pastoralists continue to rely on traditional coping mechanisms including migration, herd diversification, and the prudent use of indigenous climatic knowledge the cumulative stress of worsening climatic variability, coupled with demographic pressures, poverty, and institutional deficiencies, has eroded the efficiency of such strategies.

From a socio-economic perspective, the study highlights that demographic characteristics such as age, education, gender, household size, and income sources significantly shape adaptation behavior. Statistical analyses, and binary logistic regression, reaffirm that education, livelihood type, and prior adaptation experience strongly significantly influence adaptation to climate change. These results underscore that adaptation is a learned, cumulative process embedded in social capital, knowledge-sharing, and experiential learning. The role of Indigenous Knowledge Systems (IKS) remains indispensable, serving as both a cultural repository and a locally tested resource base for navigating environmental uncertainty. Yet, without adequate institutional and infrastructural support, indigenous systems alone cannot sustain long-term resilience. Institutionally, the research identifies critical gaps in the provision and coordination of external interventions. Although government agencies, NGOs, and development partners have initiated climate adaptation programs such as awareness creation, safety nets, and drought response their reach remains uneven, short-term, and insufficiently aligned with local contexts. Access to financial services, extension support, and climate information and infrastructure facilities remains limited, thereby reinforcing inequality and vulnerability. The results suggest for a paradigmatic shift from reactive, top-down interventions toward integrated, participatory, and community-

owned adaptation frameworks that merge scientific innovation with indigenous expertise. The theoretical synthesis of Afrocentricity, Capability Theory, and the Sustainable Livelihoods Framework (SLF) proved fundamental in conceptualizing adaptation as both a culturally embedded and capability-enhancing process. Collectively, these frameworks emphasize that sustainable adaptation is not merely about surviving climatic shocks but about expanding pastoralists' capabilities to live dignified, autonomous, and resilient lives within their ecological and cultural landscapes.

Ultimately, the study concludes that building resilience among pastoralist communities in the Somali Region requires systemic transformation anchored in equity, knowledge integration, and participatory governance. This transformation demands strengthening institutional capacity and coordination among government and non-government stakeholders to ensure responsiveness, inclusivity, and sustained impact. It further calls for the integration of Indigenous Knowledge Systems with scientific climate data to enhance the credibility, ownership, and contextual relevance of adaptation strategies. Equally important is the need to expand access to education, credit, and climate information services, empowering households with the necessary knowledge and resources for proactive decision-making and adaptive action. Promoting livelihood diversification and gender-sensitive interventions was reduced dependency on climate-sensitive sectors while fostering social equity and economic stability. Moreover, continued investment in long-term, community-based adaptation planning that reflects pastoralists' cultural values, ecological realities, and socio-economic aspirations is essential to ensure that adaptation efforts must be sustainable and locally grounded.

Finally, the collective evidence across all components of this dissertation underscores that effective climate change adaptation among pastoralist communities is a dynamic, iterative, and socially embedded process. It requires not only technical and institutional interventions but also epistemological transformations that respect indigenous systems of knowledge, expand human capabilities, and sustain self-centered approaches to resilience. By bridging the divide between scientific and local knowledge by aligning community insights with policy frameworks. In addition, it need a significant scholarly and practical foundation for designing sustainable, equitable, and culturally grounded adaptation strategies that safeguard the future of pastoralism in Ethiopia and beyond.

9.2. Recommendations

Based on the study's findings and the overarching conclusion on climate change adaptation among pastoralist communities in the Somali Regional State of Ethiopia. The following recommendations were forwarding to the different stakeholders to enhance resilience, promote sustainable adaptation, and bridge the divide between policy intentions and pastoral realities.

1. Policy and Institutional Issues

- ✚ Government institutions at the federal and regional levels should establish a unified policy platform coordinating climate adaptation, livestock development, and natural resource management. This framework must align national climate strategies with localized pastoral needs, ensuring coherence guideline with service providers such as government institution, NGO, and community themselves.
- ✚ Existing local institutions should strengthen to intervene climate change, pastoral development, and disaster risk management by allocating independent pastoral development budget. Establishing a Pastoral development budget at the Regional Government should focus planning, implementation, and accountability across sectors such as agriculture, water resource management, and social protection.
- ✚ Formal institutional mechanisms should recognize, document, and integrate pastoralists' traditional ecological knowledge into planning and decision-making. Local elders and traditional leaders should actively participate in policy formulation, early warning committees, and adaptive management planning.
- ✚ Given the study's evidence that female-headed and widowed households are among the most vulnerable, adaptation policies must incorporate gender-sensitive resource allocation, livelihood diversification programs, and microcredit access targeted at women and youth.

2. Community Empowerment and Capacity Development

- ✚ A community awareness creation on early warning system, meteorological data and indigenous recognition should be developed. Regular training and information dissemination using local languages and media (such as radio and mobile alerts) can help households anticipate and respond to climatic shocks effectively.
- ✚ Capacity-building programs of pastoral communities should focus on literacy, livelihood diversification, and sustainable rangeland management.
- ✚ Extension agents should aware pastoralist to diversify the livestock by selling and paying house, or establishing other business from the town to survive during drought outbreak. It should also train ad aware pastoralists to involve scientific innovations like improved breeds, drought-tolerant crops, and water-harvesting technologies.
- ✚ Pastoralist communities should encourage alternative income-generating opportunities beyond livestock dependence, such as small-scale trade, agro-processing, or eco-tourism. Financial institutions should design culturally appropriate microfinance schemes that cater to mobile pastoralists, reducing their vulnerability to climatic uncertainty.

- ✚ Community should establish village-level Climate Resilience Committees composed of elders, women, youth, and local administrators. Such forums can help co-design and monitor adaptation projects, thereby fostering ownership, accountability, and long-term sustainability.

3. Knowledge Integration and Capacity Advancement

- ✚ Universities, research institutions, and development organizations should support collaborative trainings documenting indigenous climate indicators, mobility patterns, and grazing systems. These insights should inform a hybrid adaptation model that merges traditional ecological knowledge with modern forecasting and management practices.
- ✚ Expand meteorological stations and remote-sensing networks across pastoral zones to generate reliable, real-time climate information. Partnerships between the Ethiopian Meteorological Institute, universities, and regional bureaus can strengthen data quality, accessibility, and utilization for planning.

4. Regional and International Collaboration

- ✚ Given the transboundary nature of rangelands and pastoral movements, Ethiopia should strengthen collaboration with neighboring countries such as Somalia and Kenya to design joint climate resilience programs, harmonize mobility corridors, and manage shared natural resources peacefully.
- ✚ The Somali Regional State should actively mobilize resources from international climate funds including the Green Climate Fund (GCF) and the Global Environment Facility (GEF) for large-scale resilience projects that prioritize pastoral livelihoods, sustainable land restoration, and renewable energy initiatives.

5. Implementation Considerations for Sustainable Resilience

- ✚ Federal government should focus future strategies to transcend short-term emergency relief by fully integrating environmental restoration, livelihood security, and social inclusion. Fostering cross-disciplinary collaborations among sociologists, ecologists, and economists is essential to ensure that interventions remain balanced, contextually appropriate, and ecologically sustainable.
- ✚ Adaptation policies and programs should focus ongoing assessment to accurately measure their effectiveness, scalability, and long-term viability. Embedding community feedback loops and participatory monitoring systems will guarantee adaptive learning, transparency, and accountability across all levels of implementation.
- ✚ Public investments should prioritize the development of infrastructures and physical capital communities. Expanding water-harvesting structures, strengthening localized veterinary

networks, and building accessible market facilities are critical steps to securing and enhancing pastoralist livelihoods.

- ✚ Government initiatives should actively encourage sustainable economic diversification alongside climate-resilient pastoralism. This necessitates advancing selective breeding programs that prioritize drought- and disease-tolerant livestock specifically adapted to shifting local climatic conditions.

These recommendations emphasize the need for a paradigm shift from fragmented, reactive responses toward integrated, knowledge-driven, and community-centered adaptation strategies. By embedding indigenous practices within formal governance structures, enhancing institutional and human capacities, and fostering inclusive engagement, the Somali Region and Ethiopia at large can transform climate adaptation from a survival mechanism into a pathway toward sustainable, equitable, and dignified pastoral development.

6. Suggestions for Future Studies

- ✚ academic research should examine the socio-economic, gender, and institutional dimensions of adaptation, with attention to long-term impacts of interventions. Longitudinal studies tracking how households evolve adaptive strategies across climatic cycles can provide valuable feedback for policy refinement.
- ✚ **Longitudinal studies on adaptation outcomes:** Future research should employ longitudinal designs to track how pastoralist households' adaptation strategies evolve over time and to assess the long-term effectiveness of these strategies in reducing vulnerability to climate change, cross-sectional snapshot captured studies.
- ✚ **Political, economic, and socio-cultural dimensions:** Since this study deliberately excluded political, economic, social, and ethnic factors from its scope, future studies should investigate how these dimensions shape or constrain pastoralists' access to adaptation resources and their capacity to implement effective coping mechanisms.
- ✚ **Climate change mitigation and policy formulation:** While this study focused on adaptation, future research should examine mitigation strategies and policy interventions specific to pastoral areas, including how national and regional climate policies can be better tailored to the realities of mobile pastoral livelihoods.
- ✚ **Comparative studies across pastoral regions:** Further research could compare adaptation mechanisms and their effectiveness across different pastoral communities in Ethiopia (e.g., Afar, Oromia, and Somali regions) or across border regions in the Horn of Africa, to identify which strategies are context-specific versus broadly generalizable, and to inform more targeted policy design.

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Appendix 1: Data collection tool(s) (including questionnaire/ interview guide/checklist)

UNIVERSITY OF SOUTH AFRICA

Climate Change Impacts, Adaptation Strategies and Institutional Interventions among Pastoralist Communities of the Somali Region, Ethiopia

Opening speech

Good morning or afternoon, sir or madam, I am so glad I met you, and I appreciate your dedication to meeting me, keeping our appointments, and devoting your valuable time. The purpose of this interview is to learn about adaptation to climate change among pastoralist communities in the Somali Region of Ethiopia for academic purposes only. It has no administrative or political values and/or will not be used for decisions that might affect your personal life. Furthermore, participation of this study is completely voluntary. Be aware that if you decide to participate, you may stop participating at any time, and you may decide not to answer any specific question.

So, dear respondent, be confidential and open in your responses. Dear respondent, your genuine response to questions is very important in achieving the goal of the study. Please stop me if you need more clarification on any of the following questions.

Part I: HOUSEHOLD SURVEY QUESTIONNAIRE

Respondents Characteristics

Name of Zone ----- district _____ Kebele _____

Name of data collector _____

A. Socio-economic characteristics of respondent.

2. Sex of respondent Male ☐ Female ☐

3. Marital status of respondent Single ☐ married ☐ divorced widowed ☐

4. Age of the respondent (in year)

5. Education status of respondent (level/grade).....

6. Family size of respondent in number.....

7. Occupation of household head

8. Number of Livestock (TLU).....

8. What is your main income source?

Agriculture ☐ pastoralism (livestock) ☐ salary ☐ labor ☐ Trade ☐

If other specify _____

9. What is your total annual income in ETB

10. 1. How long have you been in this location? 1, less than 5 year 2, 6 – 14 years 3, 15- 24 years 4, 25 year and above

B. Household survey on Climate Change/climate variability

Dear Respondents, the following table presents indicators of climate change/climate variability. Its Purpose is to know the perception on whether each indicator observed or not in your locality. Hence you are kindly requested to respond to each question by putting √ mark on the option provided.

No	Indicator of Climate Change	Yes	No
1	Do you observed the drought occurrence in your locality recently?		
2	Is there any Floods Occurrence recently in your area?		
3	Does Rainfall variability occurred over recent decade as compared in the past?		
4	Does Livestock disease Outbreak recently happened in your district?		
5	Does Human disease Outbreak recently happened in your locality?		
6	Is there water scarcity for your livestock and drinking in your area?		
7	Did you observed Range/grass land based conflict in your area		

C. Climate change and its impacts on pastoralist production system

1. Do you have access to early warning information on climate change?

1. Yes

2. No

2. If your answer is yes in Q1, from where do you get? 1 Government 2 NGOs 3

Both 4, Others if any

3. What are the major impacts of climate change on your production and productivity?

No	Impacts of climate change	Yes	No
	Can Cause Water shortage?		
	Can Cause rangeland degradation		
	Can Cause decline on forage quantity and quality		
	Can Cause Livestock death		
	Can Cause reduction of livestock prices		
	Can Cause poor livestock health		
	Crop failure		
	Can Cause an increase of food prices		
	Poor human health		
	Can Cause food shortage (famine)		
	Can Cause loss of income		
	Can Cause recourse based conflict		
	Others if		

4. Which factor affects your animal husbandry from the following as a result of climate change?

No	Factors	Yes	No
	Loss of grazing land due to bush encroachment		
	Recurrent severe drought		
	Livestock diseases		
	Scarcity of water		
	Other (specify)		

5. What are the extents of climate change on agricultural production? (Multiple responses are possible)

1 reduce productivity 2 decrease soil fertility 3 increase pest and crop diseases 4 other (if any) -----

6. What are the extents of climate change on pastoralist communities? (Multiple responses are possible)

1 high risk on human and animal health 2 decreased labour productivity
3 increased Food insecurity 4 reduced household income 5 increased poverty 6 all

7. What are the observed impacts of climate change on natural resource in your localities?

1 Soil erosion 2 decreased pasture 3 shortage of water for livestock and human 4
deforestation 5 decreased range land productivity 6 all

8. What effect climate change? (Multiple Response) 1, drought 2, Strong Wind
3, Shortage of Rain 4, High Temperature 5, Low precipitation 6, all

4. What preparation did you make before drought at household level? (Multiple Response)

1) Borrowing others 2) Stored food and grass 3) Stored water
4) Irrigation 5) Managed what we had 6) aware members on how to cope

9. What is the extent level of climate change in your district?

Low 2) Medium 3) High

D. Adaptation strategies to climate change among pastoral communities

1. Do you have any idea about climate change policy? 1. Yes 2. No, If yes, please explain to me how do you see it and how effective is it-----

2. What coping mechanism did you use in order to adapt climate change?

1. Abortion of livestock 2, Migration to other area 3, Livestock selling 4, Requesting support, 5, If other specify_____

3. Did you adopt resilience mechanism to reduce the effect of climate change?

1) Yes 2) No, if yes specify_____

4. Do you made any long-term preparations (adaptive strategies) to reduce the extent of climate change

1. Yes 2. No.

5. If your response on question number above is yes, which adaptation measures did you use from the option indicated in the following table?

No	Pastoralist adaptive strategies	Yes	No
1	Herd diversification		
2	Storage of fodder		
3	Mobility		
4	Livestock off-take		
7	Saving arrangements		
8	Household splitting		
9	No adaptation		
	IKS intervention on climate change		
1	Do local knowledge has equal value with SK		
2	Can local people identify the problems of CC		
3	Does Indigenous knowledge can intervention climate change		

Do you know any policies that enhance pastoral community awareness of climate change? 1, yes 2 no

From the adaptation option identified in question number 2 above which one did you adopt frequently?

1, Herd diversification 2 storage of fodder 3 mobility 4 livestock off-take

saving Scheme 6, household splitting

Do the extent of climate change on pastoralist communities is high? 1, yes 2, no

Do Pastoralist have their own symptoms to now the coming season will have enough rain or not 1, yes 2 no

What ways did you suggest to cope effectively pastoralists the impact of climate change? 1, trainings and awareness giving 2, resource diversification 3, transforming to other livelihood system if other specify_____

9. What are the constraints or challenges you faced during implementation of adaptation strategies:-

1. Mobility, 2.Livestock off-take 3. Development of water structures 4. Diversification of herd composition

10. Is there are any institutional interventions to climate change in your locality? If yes what are they?

No	Institutional interventions to cope climate change	Yes	No
	Credit services providing		
	Safety net		
	Extension service providing		
	Training and orientation in government and NGO		
	If any others		
	Do you ever attend awareness training about protecting the environment		

Part II. Checklists to Focus group discussants (Elderly Groups from the Community)

1. How do you characterize the weather of this area (temperature and precipitation)?
2. Is there any variability of temperature and rain fall in your area over the past years?
3. What do you think to be the causes of climate change?
4. What are the observed indicators of climate change?
5. What are the main impacts of climate change, on the livestock and the environment?
6. Who are the most vulnerable livelihood sectors to climate change/ variability?
7. What mechanism is used the local peoples cope impacts of climate change?
8. Is spirituality has role in adaptation to climate change?
9. What adaptation measures do you use to adapt the impacts of climate change?
10. Are you noticing any change in the cultural activities as a result of climate change?
11. How are Households that are involved in farming (Smallholder farmers) in this area adapting to and dealing with the effects of climate change

Part III, Interview Questions to Key informants

Did you observed change for the last decades in temperature and rain fall?

What is the role of government in pastoral community?

How do you assist community members/farmers?

What is the existing pastoralist adaptation and coping mechanisms in this area?

What coping mechanism did pastoral communities use on climate change?

To what extent are you aware for the climatic situation of your region?

What are the effectiveness of adaptation and coping strategies of pastoralists

As a service provider what challenges are you facing in the fight against climate change?

Do institutional interventions complement pastoralists' adaptation and coping mechanisms?

Do you think supports provided from the government encourage pastoral communities to cope up with climate related problems?

Which strategy do you think more efficient for reducing effect of climate change

1. _____ 2. _____
3. _____ 4. _____
5. _____ 6. _____