

**IMPACTS OF CLIMATE VARIABILITY AND ADAPTATION
STRATEGIES OF PASTORAL COMMUNITY, KORRAHE ZONE,
SOMALI REGIONAL STATE, ETHIOPIA**

MA THESIS

MAHAMUD MAHAMED ABDI

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Mahamud Mahamed Abdi

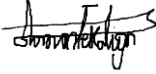
April, 2025

Haramaya University, Haramaya

HARAMAYA UNIVERSITY

POSTGRADUATE PROGRAM DIRECTORATE

We here by certify that we have read and evaluated this thesis entitled ‘**Impacts of Climate Variability and Adaptation Strategies of Pastoral Community, Korrahe Zone, Somali Regional State, Ethiopia**’, prepared under our guidance by **Mahamud Mahamed Abdi**. We recommend that it to be submitted as fulfilling the thesis requirement.

<u>Solomon Tekalign (PhD)</u> Major Advisor	 _____ Signature	<u>16 September 2024</u> _____ Date
<u>Sitotaw Haile (PhD)</u> Co-advisor	_____ Signature	_____ Date

As members of the Board of Examiners of the MA Thesis Open defense Examination, we certify that we have read and evaluated the Thesis work prepared by Mahamud Mahamed Abdi and examined the candidate. We recommend that the Thesis be accepted as fulfilling the Thesis requirement for the Degree of Master in Climate Change and Disaster Risk Management

_____ Name of Chair Person	_____ Signature	_____ Date
_____ Name of Internal Examiner	_____ Signature	_____ Date
_____ Name of External Examiner	_____ Signature	_____ Date

Final approval and acceptance of the thesis is contingent up on the submission of its final copy to the Council of Graduate Studies (CGS) through the candidate’s School Graduate Committee (SGC).

DEDICATION

This work is dedicated to my beloved parents who have contributed a lot to this work and who also shaped my life from the beginning to the stage I am today.

BIOGRAPHICAL SKETCH

The author, Mahamud Mahamed Abdi, was born on 24th of July 1992 in Kabridahar city, Korahe zone, Somali Regional State, Ethiopia. He attended his primary education (1-4) at Shekh Abdiwahab Primary School, Nur Ugas for his second primary education (5-8) and Ahmed-Gurey for his secondary and preparatory school (9-12).

After his successful completion of grade 12 entrance exam on 2011, Mahamud was luckily placed to Haramaya University, where he has received his bachelor in Natural Resources Management in 2014. After finishing his bachelor, he got employed by SoRPARI (Somali Region pastoral and Agro Pastoral Research Institute) as a rangeland researcher. He later also served as a monitoring and evaluating TA in PSNP at Kabridahar district.

On early 2021 he once again had the luck to be a student of HU after he got registered on department of Climate Change and Disaster Risk Management. Upon successfully completing course period, he got employed by Kabridahar University as a lecturer and got registered his second master's degree program in Soil Science at Kabridahar University on 2023 with self- sponsorship, and graduated from it on July 2024. Mahamud is now finalizing his MA in Climate Change and Disaster Risk Management, at Haramaya University.

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ACRONYMS AND ABBREVIATIONS

AU	African Union
AGRA	Alliance for a Green Revolution in Africa
ASALs	Arid and Semi-Arid Lands
AMO	Atlantic Multi-decadal Oscillation
CSA	Central Statistical Agency
CCA	Climate Change Adaptation
CIIs	Climate Impact Indices
CV	Coefficient of Variation
DPPB	Disaster Prevention and Preparedness Bureau
EEA	Ethiopian Economic Association
ESS	Ethiopian Statistical Service
FDRE	Federal Democratic Republic of Ethiopia
FGDs	Focus Group Discussion
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
IPCC	Intergovernmental Panel on Climate Change
MDGs	Millennium Development Goals
NAPA	National Adaptation Program of Action
NMHS	National Meteorological and Hydro meteorological Services
NMSA	National Meteorological Service Agency
NAO	North Atlantic Oscillation
SDGs	Sustainable Development Goals
SLM	Sustainable Land Management
UNFCCC	United Nations Framework Convention on Climate Change
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Program
WB	World Bank

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ABSTRACT

Climate variability has become a major concern locally and globally that has negative impacts on the sustainability of livelihoods as well as socio-economic and environmental welfare. Local pastoral community's adaptation strategies need all-inclusive support to safeguard their livestock based crucial livelihood option. The purpose of this study was to explore impacts of climate variability and to identify adaptation strategies of the pastoral community of Korahe Zone. The study was conducted in three kebeles of Kabridahar district, Somali region. In this study a mixed research design was applied. A total of 284 sample data collected from three selected kebeles. Qualitative data were collected from 4 key informants and 7 focus groups discussions. The climate variability trend was assessed using standardized precipitation index (SPI), Likert rating scale, and multinomial logit model. Historical climate data over the past 30 years recorded by National Metrological Agency from Kabridahar stations were examined using descriptive analysis (frequencies, mean and standard deviation). The climate trend and variability analysis findings over the last 30 years shown that generally there is a decreasing trend of rainfall while temperature is increasing. As a result, the pastoral communities have been suffering to hunt their main livelihoods; livestock pasture and water. The impact of climate variability in the study area has reduced livestock number and mobility, degraded pasture and water depletion at watering points. The primary adaptation strategies employed to mitigate the impact of climate change are herd splitting, livestock mobility, and selling. The study found that herd splitting and increased livestock mobility are the most effective strategies. Therefore, it is recommended that local pastoral communities be sensitized to the certainty of climate change and variability, its impacts, and the importance of strengthening positive adaptation strategies. Additionally, governments and development actors need to work to address the factors that contribute to barriers to climate variability adaptation in the study area, dealing with the root causes to find long-lasting solutions.

Keywords: *adaptation strategy; Climate variability; impacts of climate; Pastoral Community*

1. INTRODUCTION

1.1. Background of the Study

Climate variability has become a major concern that has negative impacts on the sustainability of livelihoods as well as socio-economic and environmental well-being (Singh, R. K., *et al.*, 2020). Such global warming would alter the natural climate and environmental systems, leading to increased frequency of extreme weather events such as droughts, storms, flooding, rising sea levels, reversal of ocean currents and changes in precipitation patterns (Zegeye H., 2018). The global climate change and the associated weather extremes continued posing a considerable challenge in the world mainly in developing countries. However, developed countries have not resisted its devastating effects, and they are not committing their pledges to reduce Greenhouse gas (GHG) emission (Stoddard, I., *et al.*, 2021).

It is now increasingly becoming obvious that behind the ongoing research and debate on climate change, many parts of Africa are already facing dire consequences of erratic climatic conditions (McMichael, A., 2017) that are likely associated with regional climatic changes. Given that most African economies are basically twisted on predominantly rain-fed agriculture, this changing climate is expected to pose unprecedented challenges on them. More challenges even lie in understanding low frequency multi-decadal and centenary climate variability in the vastness and uniqueness of the complicated African terrain and climate systems over eastern Africa (van der Plas, G., 2020).

According to Kobe, F. T. (2023), over the past 50 years, there has been a warming trend in the annual temperature of the country. The minimum temperature is increased by approximately 0.4°C per every ten years and it is projected that the mean annual temperature will increase with the range of 0.9 to 1.1°C by 2030. Hence, it has a devastating effect on humans and environmental functions. For instance, the impact of climate change affected the endemic species of the country. Ethiopia's climate is naturally characterized by both highly diverse and highly variable. However, the climate is dramatically changing in recent years (Mokria *et al.*, 2017). Both climate variability and change have been occurring in Ethiopia. The temperature

(maximum, minimum, mean) is increasing, but the rainfall does not show any definite trend—it shows high variability (Addisu et al., 2015; Mokria et al., 2017).

Ethiopia is particularly susceptible to the negative consequences of climate change because, among other things, it depends more heavily on natural resources for subsistence, has a low capacity for adaptation, and heavily depends on rain-fed agriculture (EPCC, 2015). Smallholder rain-fed subsistence farmers and pastoralists are thought to be the most sensitive to climate variability and change in terms of their means of subsistence, and thus require interventions to modify their systems in order to adapt to the changing climate (Amogne *et al.*, 2018). A variety of policies, strategies, and programs, including those related to the environment, agriculture and rural development, water resources management, national policy on disaster prevention, and agriculture and food security, are in place in Ethiopia and are relevant to lowering the country's susceptibility to climate variability and change as well as agriculture and food security.

Pastoralism contributed a lot to the economy of the Africa. In Ethiopia, the livestock sub-sector accounts for 20% of Ethiopia's GDP, with the national herd inhabiting Ethiopia's vast lowland periphery covering 60% of the total land area (Ayele, T., *et al.*, 2020). About 10 million pastoralists rely on animal husbandry as a key source of wealth and subsistence (Samuel, 2016). Pastoral areas in Ethiopia are characterized by frequent drought with high livestock mortality which often results in threatening viability of pastoral livelihood, famine and deaths in human population (Solomon, 2016).

The frequency of droughts in Somali region, particularly in the recent decades, is an indication of the prevalence of the variation in climate. There were 19 drought events which occurred in Ethiopia in the period 1900–2002, which is almost once in 6 years in the period 1900–1987 (14 drought events) and roughly in 3 years in the period 1988–2002 (5 drought events) (Cherinet, A., *et al.*, 2022). Since 1876, about 22 droughts with an average cycle of every 6 years are occurring in Ethiopia. The frequency and magnitude of droughts in Somali region have been increasing in space and time (Haile, G. G., *et al.*, 2020). It is therefore, important to

have a good understanding of the potential impacts of predicted future climate trends to improve livestock productivity.

Given the inevitable impacts of climate change, adaptation strategies are critical (Callahan, C., 2023). Building adaptive capacity is essential for improving resilience, sustainable development, and economic well-being. This requires action across various sectors and at all levels of government and society. The urgency for adaptation stems from the already observed impacts of climate change, the slow progress on mitigation efforts, and the disproportionate burden developing countries face (Eriksen, S., *et al.*, 2021). For Ethiopian pastoralists, adaptation is not a choice, but a necessity (Kemal, A. W., *et al.*, 2022).

1.2. Statement of the Problem

The pastoral communities in Korrahe Zone, located in the Somali Regional State of Ethiopia, have long depended on traditional livestock-based livelihoods, which are intricately tied to the region's climate and environmental patterns. However, in recent decades, the region has experienced increasing climate variability, including unpredictable rainfall patterns, prolonged droughts, and extreme temperatures (Mohammed, B. T., 2022). These climatic changes have led to a heightened vulnerability of pastoralist livelihoods, disrupting food and water security, exacerbating resource conflicts, and threatening the sustainability of pastoral systems that have historically been resilient (Mohammed, B. T., 2022).

Pastoralists are very vulnerable to ecological disturbance due to increasing climate variability. They are unable to adequately feed their animals in times of extreme weather conditions of floods and droughts thereby causing a disruption in their major source of livelihood (Mekuyie, M., *et al.*, 2018). Given the range of negative repercussions of current climate hazards on the livelihoods of these communities, the implications of climate change must be taken into account to ensure long-term survival and sustainability of these communities (Solomon, 2016).

Despite traditional coping mechanisms, the severity and frequency of climate-related impacts necessitate the development and implementation of more effective and sustainable adaptation strategies. This study aims to assess the specific impacts of climate variability on the pastoral

communities in the Korrahe Zone and to identify and evaluate adaptation strategies that can enhance their resilience and sustainability in the face of ongoing climatic challenges.

This research therefore seeks to assess the impacts of climate variability on the pastoral communities of Korrahe Zone and to identify the adaptation strategies employed to mitigate these effects. By understanding the interplay between climate change, vulnerability, and adaptation, this study aims to provide evidence-based recommendations for enhancing the resilience of pastoral communities and ensuring sustainable livelihoods in the face of ongoing environmental change.

1.3. Objectives of the Study

1.3.1. General Objective

The overall objective of this study is to assess the impacts of climate variability and adaptation strategies of pastoral community, Korrahe Zone, SRS, Ethiopia.

1.3.2. Specific Objectives

- To evaluate temperature and rainfall variability on local pastoral community in the study area from 1990-2020.
- To investigate impacts of climate variability on pastoral community in the study area.
- To identify adaptation strategies of the pastoral community to the impacts of climate variability.
- To explore factors that determine pastoral adaptation strategies

1.4. Research Questions

- What is the climate variability in the study area?
- What are the major impacts of climate variability in the study area?
- What are the adaptation strategies of the local pastoral community to the impacts of climate variability?
- What are the factors that determine the pastoralists' adaptation strategies?

1.5. Significance of the Study

The impacts of climate variability and change are already felt through extended drought periods, unpredictable dry spells, floods, and storms, leaving no doubt about the scientific projections of the phenomenon, especially in developing countries (Kongsager et al., 2016). The findings of this study are expected to be a valuable resource for future researchers who intend to conduct similar studies, as it will reveal ways to assess and identify the impacts of climate variability and its appropriate adaptation strategies. Hopefully, this work will contribute to the existing literature on national and regional climate variability affecting pastoral communities.

Climate change and variability significantly threaten food security in the Somali regional state, which is highly susceptible to climatic shocks and stress. While research on this topic is limited, primarily focusing on general aspects, there is a lack of specific information on impacts and adaptation strategies for the Korahe zone, particularly the three selected kebeles.

Due to climate change and variability, pastoral communities in the Korahe zone, particularly in the three kebeles selected for this study, are facing significant challenges. Nearby water bodies have dried up, forcing them to travel long distances to find water for their livestock. To sell their livestock and products, these communities must now go farther from the markets, having left their villages in search of food or grazing areas. Adapting to these effects will be crucial for coping with the challenges posed by climate variability.

1.6. Scope of the Study

This study was conceptually focused on climate variability, impacts and adaptation strategies of the local pastoral community in the study area. It is expected to uncover whole section of society that is vulnerable to climate variability. Methodologically, the study employed both primary and secondary data necessary for the study. Metrological data was used to analyze and interpret climate variability. Geographically, the study is confined to one district from the zone, kebridehar, since the zone's whole districts have the same ecological zone.

1.7. Definition of Key Terms

Adaptation: any modification in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007).

Climate variability: refers to variation in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc) of the climate on all temporal and spatial scales beyond that of individual weather events (IPCC, 2009).

Coping strategies; - are short-term ways to adapt and adjust to the stress and they almost inevitably lead to a different state of vulnerability (Adger, 2000)

Impact: the powerful effects that hinders crop growth due to strong influence by climate variability and affect crop production (Kassahun, 2011).

Pastoralists: Pastoralists are people who live mostly in dry, remote areas. Their livelihoods depend on their intimate knowledge of the surrounding ecosystem and the well-being of their livestock (Swift J.1988).

Zone: is a 2nd level subdivision of Ethiopia, below regions and above woredas, or districts (CSA, 2007).

Woreda: Zones are divided into *woredas* (districts).The Woreda Council is the highest government organ of the district, which is made up of directly elected representatives from each kebele in the woredas (Vértesy *et al*, 2022).

1.8. Organization of the Thesis

This thesis is organized into five chapters. Chapter one presents the introduction part (consists of background, statement of the problem, objectives of the study, research questions, significance of the study, scope of the study, and definition of key terms); chapter two provides review of related literature (consists the concept, empirical review, conceptual framework, and policies & strategies); chapter three described the study area, methods and materials (comprises the description of the study area, sampling techniques, sample size, techniques of data collection, techniques of data analysis, and types of data & sources); chapter four gives results and discussions; chapter five presents Summary, conclusion and recommendations of the study and finally references and appendices.

2. LITERATURE REVIEW

This Chapter focuses on reviewing literature or publications on climate variability, impacts and adaptation strategies on pastoralists being guided by the aim and objectives of the present research. Both worldwide positions and national orientations with regard to rural livelihoods and adaptation to climate variability and change are analyzed revealing the inherent knowledge gaps. Specific thematic subjects are discussed which include the concepts, features and indicators of climate variability, pastoralists; socio-economic impacts and adaptation strategies.

2.1. Concepts of Climate Change, Climate Variability, Pastoralists and Adaptation Strategies

2.1.1. Concepts of Climate Change

Increased greenhouse gas concentrations combined with reductions in aerosol pollution have led to rapid increases in human-induced effective radiative forcing, which has in turn led to atmosphere, land, cryosphere and ocean warming (Gulev et al., 2021). This in turn has led to an intensification of many weather and climate extremes, particularly more frequent and more intense hot extremes, and heavy precipitation across most regions of the world (Seneviratne et al., 2021). Given the speed of recent change, and the need for evidence-based decision-making, this Indicators of Global Climate Change (IGCC) update assembles the latest scientific understanding on the current state and evolution of the climate system and of human influence to support policymakers whilst the next Intergovernmental Panel on Climate Change (IPCC) assessment is under preparation.

The world has awakened to the reality that our climate shows alarming signs of changing more rapidly and dramatically than at any time in recorded history (Morales, J. A. 2022). The long-term state of the Earth's climate is regulated by the balance between incoming and outgoing energy, which determines the Earth's energy balance. Any factor that causes a sustained change to the amount of incoming or outgoing energy can lead to climate change (Raimi, M. O., *et al*, (2021).

Effects of climate change has been directly impacting the livestock sector and rangeland resources, directly linked to pastoralists' livelihoods and food security. The loss (death) of livestock has been observed by climate-driven impacts such as recurrent drought, which negatively impacts pastoralists' livelihood security (Ayele, T., *et al*, 2020).

2.1.2. Concepts of Climate Variability

Climate variability may be due to natural internal processes or external forcings, or to the persistent anthropogenic (resulting from or produced by human beings) changes in the composition of the atmosphere or in land use (Morales, J. A. 2022). Since industrial revolution, anthropogenic activities particularly increase in GHGs emissions in to the atmosphere have contributed to rapid and unprecedented climate variability (Adamo, N., *et al*, 2021). The continuous increase in the concentrations of greenhouse gases in the atmosphere threatens to dramatically change the Earth's climate (Nunes, L. J., 2023).

According to IPCC (2014), global surface temperature increases, rainfall patterns become uneven, and heat waves events are the potential consequences of the climate variability and changes. The pastoral communities are particularly vulnerable to climate variability and changes due to their livestock dependence for food and livelihood.

Climate variability is attributed by natural process and human activities in the recent years (Shi, S., *et al*, 2021). It is predicted to have adverse impacts for the world's ecosystems, economies and societies and is recognized as one of the greatest challenges facing human lives and their ecosystem in the 21st century (IPCC, 2007). This has been surely cause changes in weather patterns and an increment in both the frequency and severity of climate induced hazards. Due to its complexity in nature around the globe, climate system needs cooperative and inclusive activities within international and interdisciplinary programs to monitor and predict climate change.

2.1.3. Concepts of Pastoralists

Pastoralism is a form of animal husbandry where domesticated animals (known as "livestock") are released onto large vegetated outdoor lands (pastures) for grazing, historically by nomadic people who moved around with their herds (known as "**pastoralists**"). The animal species involved include cattle, camels, goats, horses and sheep (Schoof, *et al* 2018). Pastoral

production is the major system of production practiced in the lowland regions of Ethiopia where livelihoods are heavily dependent on livestock. Extensive livestock keeping is the backbone of the economies of the lowlands (FAO, 2018b). Livestock is the principal asset of the poor in most pastoral and agro-pastoral communities, though the sector is highly susceptible to extreme climatic events (Fereja, 2016). It is commonly believed that the crisis facing pastoralists in Africa is a result of their production system. Extensive pastoralism, characterized by seasonal or annual mobility of livestock in search of pasture over a large area of rangeland is widely believed to lead inevitably to desertification and land degradation. The pastoral production systems are increasingly failing to provide sustainable livelihood.

Climate extremes are having a significant impact on livestock productivity in Eastern Ethiopia. Increasing frequency and intensity of droughts; changes in water availability; increasing patterns of temperature and rainfall variability, all are profoundly threatening livelihoods of drought-prone areas, and the existence of arid and semi-arid remote regions (Ulrichs, et al., 2019).

The incidence and distributions of livestock diseases are currently increasing, which is assumed that these might have emerged due to climate change. The distribution of vectors and pathogens are positively correlated to wind and its blowing direction (Lubroth, 2012; Yattoo, et al., 2012). Climate change diminishes available feed resources and creates conducive environment to survive, complete cycle and transfer of disease which directly leads to increase the susceptibility of livestock species and distributions to vectors and pathogens (Desalegn, 2016; Lubroth, 2012; Morand, 2015)

2.1.4. Concept of Adaptation Strategies

Adaptation is one of the key concepts in this research. Wheeler *et al.* (2013) and Yegbemey *et al.* (2014) refer to it as any form of adjustment or alteration in ecological, social or economic systems in response to current or projected climatic change and its effects or impacts. Kale (2013) and Kongsager *et al.* (2016) also note adaptation as all kinds of activities focused on a vulnerable system to climate change with the intention to moderate, reduce or eliminate its harmful effects or to exploit opportunities. This calls for creativity in promoting processes, practices and structures which ensure minimum potential damages thus, enhancing maximum benefits from opportunities inherent in climate change. Tompkins *et al.* (2010 cited in Noble *et*

al., 2014:839) further allude to adaptation as a practice to reduce risk and vulnerability; to seek opportunities and build the capacity to cope with the impacts of climate variability and change from the macro level (global or national) to micro level (local or individual) including natural systems. The focus is on the mobilization of capacity through harnessing decisions and actions (Furness, et al., 2016).

Pastoral communities in Ethiopia have become vulnerable to the effects of recurrent climate variability. However, pastoralists have gradually developed mechanisms to survive in a risky environment. The communities lived in drought-prone regions, adapted to fragile environments, and sustainably conserved the natural resources. Pastoralists in the study area are rainfall dependent, and any variation in its pattern affects livestock productivity and survivability (Abdulahi et al., 2020). Some livestock species are more vulnerable than others, depending on their resilience and adaptive capacity. Assessing community perception of climate change and livestock production potential under climatic stress is valuable in addressing livestock herder vulnerability to climate extremes. Therefore, this study examines the variability in climate, its impacts on pastoral community and their adaptive capacity to cope with the climatic stress in eastern Ethiopia.

2.2. Features of Climate Variability and Measurement Indices

2.2.1. Features of Climate variability

Over the years the frequency of the climate variation in terms of temperature and rainfall has been increasing (Chibinga et al., 2012). Climate change is a major threat to sustainable development, particularly in sub-Saharan Africa, that is anticipated to be most vulnerable because of low adaptive capacity and high dependency on climate sensitive resources such as water resources and ecological systems (Bedeke, S. B., 2023). Ethiopia is experiencing the effects of climate change including the direct effects such as an increase in average temperature or a change in rainfall patterns (FDRE, 2011). On an aggregate level, the economy of Ethiopia remain highly vulnerable to exogenous shocks (Demiessie, H. G., 2020) and hence climate change is likely to exacerbate this situation and makes extreme weather events in the country more frequent and intense that in turn enhances water stress (Tongul and Hobson, 2013). The adverse effect of such variability and change is accelerating the already existing pastoral livelihood insecurity.

Asfaw et al. (2018) stated there is seasonal and inter-annual rainfall variability across many areas in Ethiopia. Similarly, Tamiru et al. (2015) analyzed that annual rainfall variability was and reported a high coefficient of variability (25%) in Eastern Ethiopia. Analysis of the 40 years (from 1961–2013) annual total rainfall data from 109 representative ground-based meteorological stations in Ethiopia indicated a coefficient of variation ranging from 20 to 89%, and 17 stations had above 42% coefficient of variation highlighting the extreme variability of rainfall over the country (Addisu et al., 2015). According to (NMSA, 2007; Bewket, 2011; Eshetu, 2011; Addisu et al., 2015; Mokria et al., 2017) temperature (maximum, minimum, mean) is increasing, but the rainfall does not show any definite trend– it shows high variability Since 1950, the annual average maximum and minimum temperatures of the country have been increasing every decade by about 1 and 0.25°C, respectively (NMSA, 2001).

Somali region as being one of the country's forming regions' spatial and temporal rainfall variability has been increasing. The length of the rainy season(s) and the reliability/predictability of the rainfall amount, frequency, distribution and timing (onset and ending) are decreasing. Reconstructed rainfall since 1811 revealed significant inter annual variations between 2.2- and 3.8-year periodicity, with significant decadal and multi decadal variations during 1855–1900 and 1960–1990; the duration of negative and positive rainfall anomalies varied between 1–7 years and 1–8 years (Mokria et al., 2017).

In his study on annual rainfall variability on Somali Regional State, Solomon T. (2016) identified that there are slight variations in the overall rainfall features: total amount, trends, variability, probability of wet and dry days, percentage of number of rain days, and amount of rainfall.

2.2.2. Climate Measurement indices

There is a general consensus within the climate community that any change in the frequency or severity of extreme climate events would have profound impacts on nature and society. The monitoring, detection and attribution of changes in climate variability usually require daily resolution data (Easterling, D. R., *et al.* 2016). However, the compilation, provision, and update of a globally complete and readily available full resolution daily dataset are a very difficult task. This comes about, in part, because not all National Meteorological and Hydro

meteorological Services (NMHS) have the capacity or mandate to freely distribute the daily data that they collect (Adarsh, K., 2022). Consequently, a Working Group (WG) on Climate Change Detection have been coordinating an international effort to develop, calculate, and analysis a suite of indices so that individuals, countries, and regions can calculate the indices in exactly the same way such that their analyses has fit seamlessly into the global picture (Karl et al. 1999, Peterson and Co-authors 2001).

Climate indices are used more extensively in climate detecting and monitoring. These indices are annual or monthly statistics of modeled or observed climate data. Climate indices fulfill two general purposes. First, they are quantities that can be used to examine climate impacts on, and vulnerabilities of, socio-ecological systems, and second, they can be used to assess simulations of current and future climate conditions for various climate change scenarios (Domínguez-Castro et al., 2020).

Based on daily temperature values or daily precipitation amount, there are a total number of 27 indices considered to be core indices by the World Meteorological Organization. Some are based on fixed thresholds that are of relevance to particular applications. In these cases, thresholds are the same for all stations. Other indices are based on thresholds that vary from location to location. In these cases, thresholds are typically defined as a percentile of the relevant data series.

Temperature Indices: On the basis of time series of air temperature (minimum, average and maximum; daily values) many different temperature indices can be derived. These indices are often used in specific sectors or used for a more general public. The indices give an (indirect) indication of the impacts of the climate or climate change (Hatfield, J. L., *et al.* 2020). The (change) in e.g. the number of ice days (maximum temperature below 0 °C) gives an indication of the accessibility of unpaved roads in Scandinavia during winter; or the number of tropical nights (minimum temperature of 20 °C or higher) can be an indication of heat stress (Hatfield, J. L., *et al.* 2020).

Temperature indices show the extremes of temperature, like the monthly maximum/minimum of daily minimum/maximum temperature; number of frost days (*FD**) implying Count of days

where TN (daily minimum temperature) $<0^{\circ}\text{C}$; number of summer days (SU) Count of days where TX (daily maximum temperature) $>25^{\circ}\text{C}$ and so on.

Rainfall Index (RI): is based on weather data collected and maintained by the National Oceanic and Atmospheric Administration's Climate Prediction Center. The index reflects how much precipitation is received relative to the long-term average for a specified area and timeframe. It includes; heavy precipitation days (R10mm*) Count of days where RR (daily precipitation amount) $\geq 10\text{mm}$; Maximum 5-d precipitation (RX5day*) Highest precipitation amount in 5-day period; PRCPTOT Total precipitation in wet days ($>1\text{mm}$), Monthly maximum of 1-day and consecutive 5-day precipitation, simple precipitation intensity index, annual number of days exceeding a certain precipitation value, maximum length of dry spell, maximum length of wet spell, annual total precipitation exceeds a threshold (percentile), annual total rainfall in rainy days and so on.

2.3. Impact of Climate Variability on Pastoralism and Production System

2.3.1. Social Impacts

Climate variability affects humanity in a number of ways such as causing loss of life, crop failures, food shortages, malnutrition, health issues and mass migration (Below *et al.*, 2011).

Social impacts such as population migration, impacts on health and schooling of children, hopelessness and sense of loss, conflicts in society for water, and malnutrition due to changed food preferences are the most known. During climate variability and drought times, water level goes down and springs and streams decrease significantly and some even dry up. In addition to failure in livestock and crop production, sanitation has been lose attention under the prevalence of drought conditions. This is so because of personal hygiene such as washing of body, cloth, etc. require the availability and supply of water (FAO, 2014). The prevalence of drought forces people to look for opportunities for survival including abandoning their home and migrating to camps where they see some temporary help to rescue their life. Those who are unable to move or cope up with the drought are doomed to perish. As drought persists human and livestock death toll increases compounded by poor sanitation and deteriorating

natural environment. On the other hand drought shock increases the prevalence of diarrhea among the children.

In many parts of the region, the effects of drought on ecosystems have begun to compromise the traditional livelihoods and lifestyles of indigenous peoples who depend on them. The increased drought risks to agriculture, pastoralism, property, infrastructure, and ecosystems are likely to have negative impacts on health by impeding access to safe water sources and sufficient food (FAO, 2014). The capacity to cope up with drought impacts has declined because of the increasing human and livestock population pressure resulting in serious natural resources degradation. Though climate variability can be a natural disaster, land degradation has made Ethiopia vulnerable to drought and famine. Since the 1983-1984 famine, the policy response to this threat has been a series of adhoc emergency appeals on a near annual basis for food aid and other forms of emergency assistance which are then delivered either as payment for public works or as a direct transfer. While these measures succeeded in averting mass starvation, especially among those with no assets, they did not banish the threat of further famine, nor did they prevent asset depletion by marginally poor households affected by recurrent droughts. As a result, the number of individuals in need of emergency food assistance rose from approximately 2.1 million people in 1996 to 13.2 million in 2003 before falling back to 7.1 million in 2004 (World Bank, 2010).

The high proportions of households that receive emergency food aid are those that face unpredictable annual food deficits caused by livestock and agricultural production constraints and poverty. These people are also exposed to recurrent shocks, usually triggered by climate variability, that raise their vulnerability further, by forcing them to dispose of their assets to survive. This results in a gradual deterioration of their food security status over time, which decades of large-scale food aid deliveries have done little to prevent. Instead, dependency on food aid has steadily increased over time, as has the number of chronically food insecure Ethiopians (Subbarao and Smith, 2003).

2.3.2. Economic Impacts

Developing countries are most vulnerable to climate change impacts due to their population dependence on economic activities that are highly exposed and extremely sensitive to climatic

variability and deteriorating environmental conditions (Tesema D. & Musa B. 2020; World Bank, 2010). Similarly, many Sub-Saharan African economies are highly vulnerable to climate variability due to over-dependence on rain-fed agriculture and livestock production (Masinde M. 2014; & Tesema D. & Musa B. 2020). The variations in climate are not new phenomenon in Ethiopia; there is now widespread public perception and scientific evidence in some parts of the country that it has become more frequent (World Bank 2010). Recurrent droughts have deteriorated the ecosystem, eroded the livelihood assets of pastoralists and thereby jeopardized the livelihoods of the pastoralists. Furthermore, it has severely emaciated livestock thus declining their market values, increasing food prices due to food shortage and unfavorable terms of trade.

Reviewed empirical evidence shows that, pastoralist in Ethiopia, in addition to livestock rearing which form their dominant livelihood base, they engaged in various economic activities which include crop farming, petty trade, hand craft activities, wood and charcoal sale and casual labor. Even if they are engaged in diversified livelihoods, their degree of participation is constrained by different factors such as capital shortage, poor entrepreneurial skill, and inaccessibility of the markets. Moreover, changes in climatic factors such as temperature, precipitation and the frequency and severity of extreme events like droughts directly affected livestock yields in pastoral areas (Tariku, et al. 2021).

2.3.3. Environmental Impacts

Climate variability causes huge damage to the environment and is regarded as a major cause of land degradation, aridity and desertification (Below *et al.*, 2011). Pastoral areas in Ethiopia are characterized by frequent drought with high livestock mortality which often results in threatening viability of pastoral livelihood, famine and deaths in human population (Solomon, 2016). Increasing pressures due to natural and man-made shocks that are leading to imbalance between these populations and the resources they depend on to sustain themselves and ongoing climate change is expected to increase the unpredictability of rainfall, leading to more frequent droughts and floods (Smith *et al.*, 2015). These factors exacerbated livelihood challenge among pastoralists as it is hardly to understand pastoralists' livelihood system independent of natural resources.

Climate change and variability in Ethiopia poses particular risks to poor farmers and pastoralists who have an immediate daily dependence on climate sensitive livelihoods and natural resources. In addition to the physiological effects of higher temperatures on individual animals, loss of animals as a result of droughts and floods, or disease epidemics related to climate change may thus increase. Indirect effects may be felt via ecosystem changes that alter the distribution of animal diseases or the supply of feed. Moreover, the spatial distribution and availability of pasture and water are highly dependent on the pattern and availability of rainfall. Changes in the patterns of rainfall and ranges of temperature affect feed availability, grazing ranges, feed quality, weed, pest and disease incidence (Tiruneh and Tegene, 2018). Climate change characterized by changing rainfall patterns and temperature increases has been affect poor Ethiopian people whose survival depends on rain-fed agriculture through farming and/or pastoralism (Ludi et al., 2011). According to Venton et al., (2012), the frequency of droughts and floods has increased in many areas of Ethiopia in recent years, and these people are already struggling to cope with the impacts of current climate variability and poverty. NAPA (2007) cited in Reid et al., (2013) identifies pastoralists as amongst those most vulnerable to climate change impacts and states that “drought is the single most important climate related natural hazard impacting the country.

2.4. Empirical Studies

In their study to examine Perception and adaptation of pastoralists to climate variability and change in Morocco's arid rangelands, (Snaibi, W. et al 2021) found a considerable decrease in annual rainfall and an increase in temperature and frequency of droughts and high winds. There were significant differences ($\text{Chi square} = 7.603$, $p = 0.022$, $df = 2$) between small, medium and large pastoralists in the frequency adoption of adaptation strategies, especially between small and large pastoralists ($U \text{ statistic} = 16.000$, $p = 0.009$). The distribution of most adaptation actions also differed significantly between these two groups. Wealthier pastoralists have adopted a greater range of strategies, while poorer pastoralists have less diverse adaptation portfolios, and are more likely to adopt less advantageous strategies such as casual labor. The adoption of adaptation practices was significantly influenced by equipment, educational level, household size, herd size, training received, CC perceptions and agro ecological setting.

Habte M. et al. (2022). In a study to assess the effects of climate variability on livestock productivity and pastoralist's perception in southern Ethiopia, noted increasing patterns of temperature (82.8%) and drought intensity (84.8%). Majority of respondents perceived decreasing trends of rainfall and feed availability. Similarly, the trend analysis of rainfall showed declining trends of annual (-4.7 mm/year), autumn (-4.5 mm) and winter (-0.54 mm). The rainfall anomaly index resulted in 13 driest years (1991, 2016, 2017, 1992, 1999, 2015, 1998, 2010, 2000, 1988, 2009, 2007 and 2012) within 32 years (1986-2017). Of which, 46.2% (6 driest years) were recorded during 1986-2006 (within 21 years) while about 53.8% (seven driest years) noted during 2007 – 2017 (within 11 years), indicating increasing trends of drought years in the last decade.

As many reviewed empirical evidences show, pastoralists in Ethiopia have engaged on various economic activities which include livestock rearing, crop farming, petty trade, hand craft activities, wood and charcoal sale and casual labor. Moreover, changes in climatic factors directly affected natural resources, livestock yields, caused animal and human disease epidemics, and loss of animals in pastoral areas (Tariku D., et al. 2021)

According to a study made in the Somali region, (Solomon, 2016) identified that there are remarkable changes: both number of rain days and annual amount of rainfall received increased from Gode (103days and 1365.6mm) to Jigjiga {185days and 1565.1mm) and latter falls towards Shinile (135days and 1274.2mm) respectively. Eleven to twelve out of eighteen years (i.e. 60% to 70% of the years) rainfall records were close to normal. Another study in Meta district of Eastern Ethiopia showed that the area has experienced increased annual minimum and maximum temperature by a factor of 0.140°C and 0.0050°C in the past three decades, respectively and decreased annual rainfall by a factor of 0.792 mm during the study period.

In the study area, (Kemal A. W. et al 2021) showed in their study that household pastoralists adopt different climate change adaptation strategies in their locality; from this herd diversification (10.7%), storage of fodder (14.4%), mobility (23.7%), Livestock off-take (12%), saving scheme (8.8%) and household and herd splitting (15.3%) are the major pastoralists' adaptation strategies to climate change. accordingly, the multinomial logit model they used in the study showed that sex, age, family size, access to climate information, access

to credit services, access to extension services and livestock ownership were identified as the major determinants factors of climate change adaptation strategies in Korahey zone.

2.5. Conceptual Framework

Many conceptual theories have been developed to understand climate change impacts and adaptation methods. The majority of earlier studies gave typical disagreement about the appropriate concept for climate change impacts, risk, vulnerability, adaption and mitigation (Owusu et al. 2015; Jethi et al. 2016). This assumption is established on community- based adaptation framework. The concept of community-based adaptation is founded on the premise that climate change adaptation methods/processes should be guided and based on the communities' needs, expertise, priorities, and adaptation capacities (Jethi et al. 2016).

The conceptual framework for the present study is, therefore, based on the hypothesis that climate change impacts assessment and adaptation strategies should be focused on the communities' adaptive capabilities. This study is based, therefore, on the hypothesis that climate change adaptation should be oriented to increase communities' welfares and capabilities to cope with climate variability.

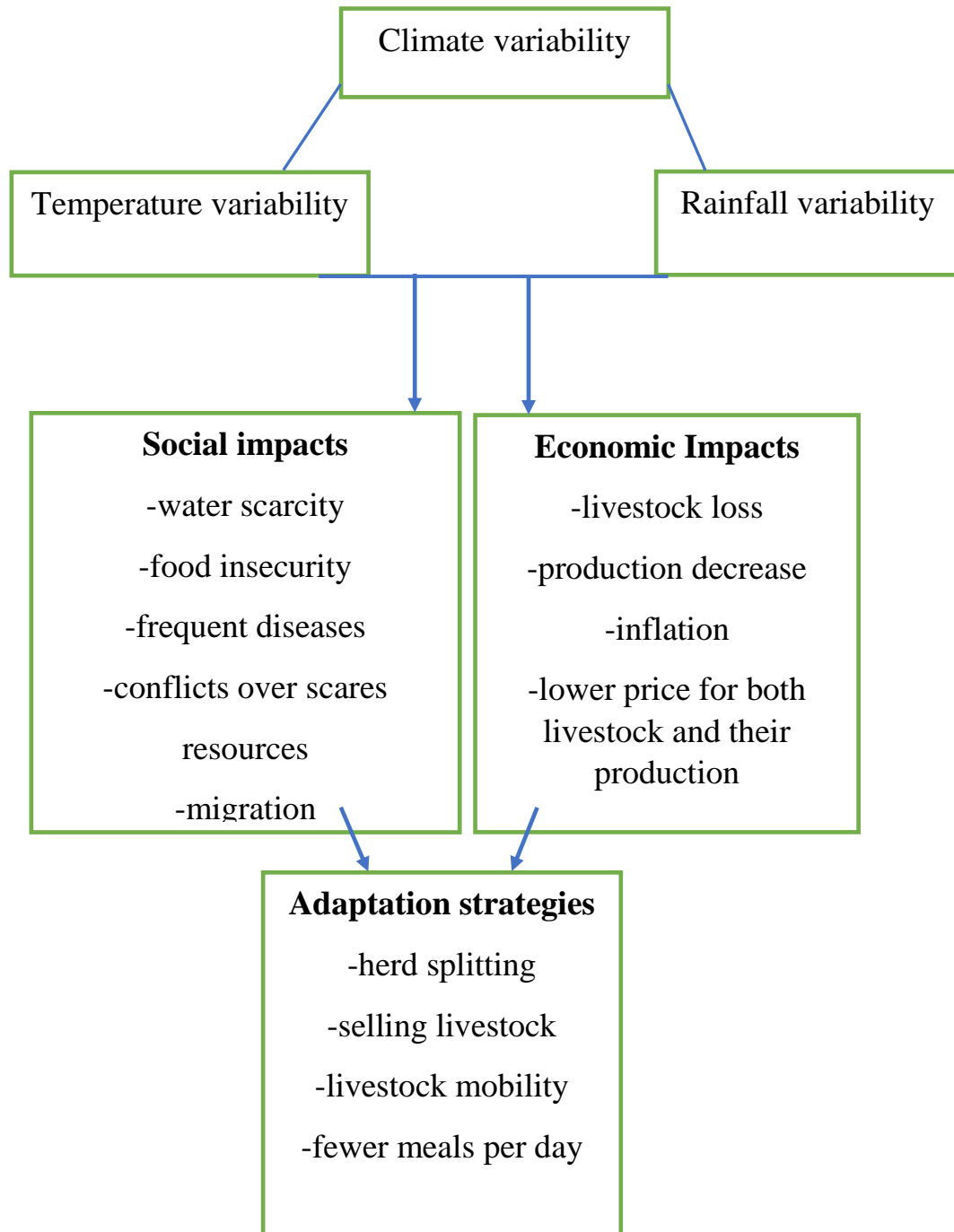


Figure 1. The relationships between climate variability, impacts and adaptation strategies of the pastoralists

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted in the Somali regional state specifically, Korahey zone. Korahey is one of the 11 zones of the Somali region of Ethiopia. It is bordered by Gode zone to the southwest, Fiq to the northwest, Degah-bur to the north, Werder to the east, and the Republic of Somalia to the southeast. The zone comprises ten (10) districts of which the largest city is Kebridahar. Geographically, Korahe zone is found between 6°28' to 7°58'N Latitude to 43°53'-45°00' E longitude, respectively.

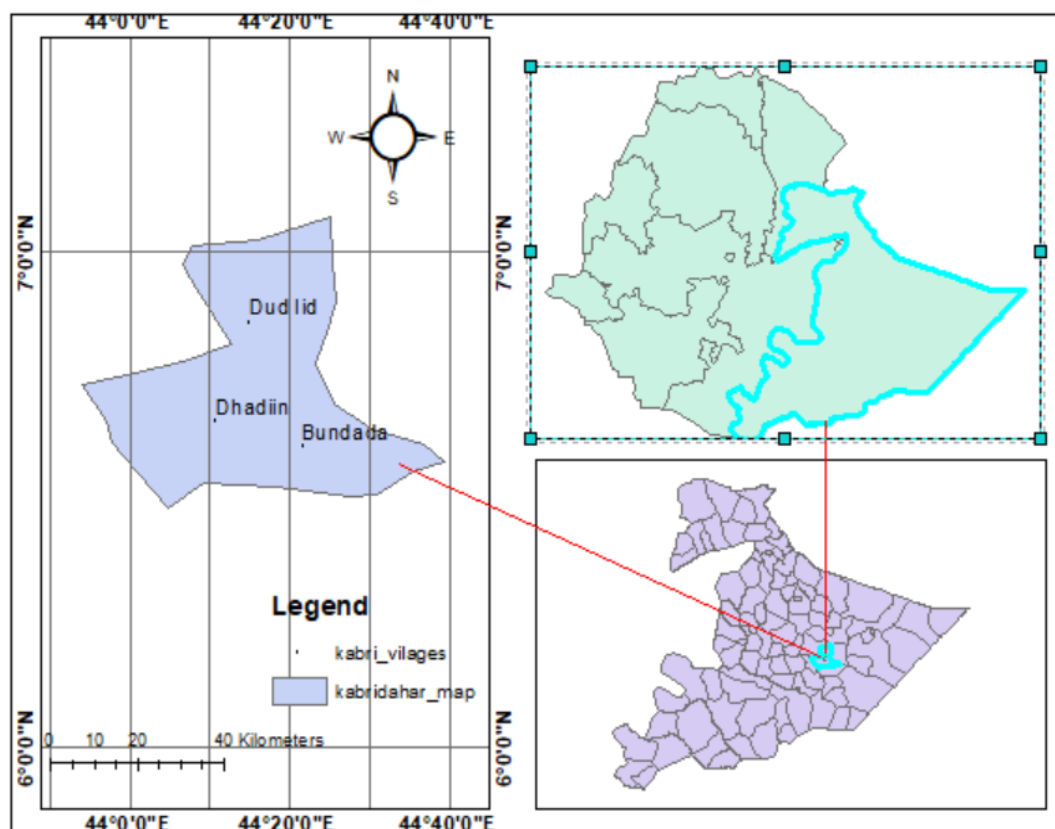


Figure 2. Map of the study area

3.1.1. Topography and soil

The zone is characterized by topography of predominantly lowland plain with a few foothills. The altitude of the zone ranges from 456 to 1042 meters above sea level which is found within the southeastern lowlands of Ethiopia. The lowest elevation of the study area is found along

the Fafen River which is estimated to be about 456 meters above sea level (Abdulahi et al., 2020).

3.1.2. Climate and drainage

The climate of the zone is characterized as tropical semiarid. A vast area of the district experiences high temperature and low precipitation with mean annual temperature ranges between 20.75°C - 31.25°C. The annual rainfall of the Korahey varies between 295 mm and 595.6 mm (NMA, 2007). According to Abdulahi et al. (2020), the area has a bimodal rainfall pattern with two main rainy seasons in which the first being “Gu” which occurs from mid-April to the end of June. The second rainy season occurs from early October to late December and is locally known as “Deyr”.

Mean daily maximum °C (°F)	33.8 (92.8)	35.0 (95.0)	35.4 (95.7)	34.2 (93.6)	32.2 (90.0)	32.1 (89.8)	31.3 (88.3)	31.7 (89.1)	33.0 (91.4)	32.1 (89.8)	32.7 (90.9)	33.5 (92.3)	33.1 (91.6)
Mean daily minimum °C (°F)	18.7 (65.7)	19.5 (67.1)	21.0 (69.8)	21.7 (71.1)	20.9 (69.6)	20.3 (68.5)	21.0 (69.8)	20.6 (69.1)	21.2 (70.2)	20.7 (69.3)	19.5 (67.1)	18.1 (64.6)	20.3 (68.5)
Average precipitation mm (inches)	2.0 (0.08)	12.0 (0.47)	4.0 (0.16)	149.0 (5.87)	100.0 (3.94)	5.0 (0.20)	0.0 (0.0)	0.0 (0.0)	15.0 (0.59)	114.0 (4.49)	58.0 (2.28)	8.0 (0.31)	467 (18.39)
Average relative humidity (%)	53	51	51	59	65	60	62	60	60	66	62	55	59
Source: FAO ^[8]													

Figure 3. Climate data for Kebri Dahar, elevation 450 m (1,480 ft), (1971–2000)

3.1.3. Vegetation and wild Animals

The study area was covered by dense indigenous forests. However, the vegetation cover has been removed partly for cultivation, domestic use like making huts off it, coal, urbanization, restricted area for the livestock to use as a pasture later in times of drought. An extensive deforestation due to the population growth and recurrent drought turned the grassland and bush land an overgrazed plain. Thus, like other parts of the country, natural vegetation of the area has been influenced by human activities. Some of the common wild animals which are found in the zone include: -Hyena, monkey, Tiger, Lion, deer, ostrich, leopard, fox, elk etc.

Korahey Zone is well known for its endowment with huge potential of natural resources, the natural gas field of Calub lies in this zone, making petrochemical extraction potential area in the country (Abdulahi *et al.*, 2020).

3.1.4. Population characteristics

Based on the 2022 population projection conducted by Ethiopian Statistics Service (ESS). Kabridahar has a total population of 200,228 of whom 109,409 are men and 90,819 women. The largest ethnic group reported in Korahey was the Somali (99.22 percent) in which their livelihood was predominantly based on livestock production. There are significant variations in the distribution of the zonal population by districts. The largest proportion of the region's population is found in Kabridahar districts with 43.6 percent followed by Dobo-Woin with a percentage share of 22.43 percent and Shilabo and Shekosh with corresponding proportions of 18.42 and 15.6 percent. The largest ethnic group reported in Korahey is the Somali (99.22 percent) in which their livelihood is predominantly based on livestock production.

3.1.5. Socio-economic features

The Somali people are traditionally semi-nomadic, having lived subsistence lifestyles as agro-pastoralists or nomadic livestock herders. Somali nomads typically live in domed structures (*agal*) made of branches, mats and/or animal skins that can easily be taken down and moved to another area. According to the Regional Disaster Prevention and Preparedness Bureau (DPPB), the rural livelihoods of the Somali Regional State can be classified into three broad livelihood zones include pastoralism, agro-pastoralism and farming. Pastoralism in the region is the most practiced livelihood, sharing about 60% of the region's rural population. In these zones, land is communally possessed and different sub-clans traditionally exercise control over the territories they recognize as their areas of origin as governed by clan settlement history. Continuous movements from place to place in search of water and forage for their livestock are their long-existed lifestyle. The pastoralists in the zone are 100% ethnic Somalis with the same language (Somali) and religion (Islam).

As far as the economic activity of the zone is concerned, pastoralism is the dominant mode of livelihood systems. The livelihood of the overwhelming majority of pastoral people depends on rearing of livestock. Despite its lion share in the economy, pastoralist's livelihoods have

remained rain-fed with traditional methods of livestock rearing. Wealth in pastoralists' area is determined by the quantity of domestic animals specially goats, sheep, camels and cattle. The pastoralists are subjected to selling their livestock to buy food grains and other industrial products. Milk and ghee are sold by pastoralists only when they are near villages or urban area. According to Tenaw Z. T. (2021), zones like; Korahe, Dollo and Jarar; berkad (artificial water reservoir) possession is significant as there are very scarce natural water sources. In the drought periods, water is sold, particularly in berkad-dependent areas.

The deprived groups of people in all livelihood zones depend on the better-off households in that they provide labor (like caring livestock) and in response they obtain rewards. Poor households usually engaged in various sources of income generating activities as they have fewer livestock than the better-off households. The collection and sale of firewood, charcoal, gums and engagement in petty trading and unskilled labour activities are additional sources of income for the poor pastoral communities.

3.2. Research Design

The study employed a descriptive research design which is a good way of approaching research as it enables to counteract the weaknesses in both qualitative and quantitative research. The mixed research approach minimizes some of the limitations of using a single method because quantitative or qualitative research methods are not sufficient to address the complex social phenomena when they are treated independently (Creswell, 2003). Accordingly in this study, the mixed- method approaches that simultaneously combine the qualitative and quantitative techniques were applied at both data collection (focus group discussion, key informant interview and structured questionnaires') and analyses techniques to obtain information about the impacts of climate variability and the adaptation strategies of household pastoralists.

3.3. Types and Sources of Data

This study employed both primary and secondary sources of data. The primary data was gathered from questionnaires, focus group discussion (FGDs), key informants' interviews and field observations. The secondary data was gathered mainly from metrological data as well as

through an extensive review of existing literature and official reports. In addition to this, secondary data were collected from various published and unpublished sources of the governmental and the non-governmental organizations. Moreover, books, journals, internet sources, research reports, archives and records were employed for acquiring necessary information.

3.4. Sampling Techniques and Sample Size Determination

The study employed multi stage sampling technique. In the first stage, among other zones in the Somali region, the Korahey zone is targeted purposively as a study area because it is one of the most disadvantaged zones from the effects of climate change in the region and because of its predominantly pastoralist livelihood system. In the second stage, from the total districts (10) of the Korahey zone, 1 district namely, Kebridehar was selected purposively because all districts are more or less affected by climate change in a similar way and are in one ecological zone. Moreover, due to the transportation and human resources expenses, a self-sponsored student wouldn't be easy to collect data from the whole zone. From the 10 first-staged kebeles of the district, three Kebeles namely, dhadhin, bundada, and duudciid were selected purposively based on their accessibility and representativeness and because of their pastoral abundancy. Finally, from the selected Kebeles, sample households were selected randomly for household interviews, for questions mainly related to the climate variability, major impacts and the appropriate local adaptation strategies they use against those impacts as well as the determinant factors.

In order to make representative samples size; first the list of all eligible household heads respondents residing in each of the three sample kebeles was prepared. From the total household heads residing in these kebeles, residents, sample pastoral households were selected systematically for questionnaire and to make the study easy using simple random sampling. The study also applied a simplified formula provided by Yamane (Yamane, 1967 cited in: Indris, 2012) to determine the required sample size at 95% confidence level, degree of variability=0.5 and level of precision= 5% (0.05)

The total population in the three Kebeles selected for the study was 383 (Dhadhin 122, Buundada 184, Duudciid 77) and the data were obtained from three Kebeles statistical reports. To determine the sample size of the population for this study, the following formula was used.

$$n = N/(1 + N(e^2)) \quad (1)$$

Where: n = is the sample size, N = is the population size (total household heads size), and e = is the level of precision.

Table 1. Selected Kebeles with the sampled population size

S/N	Kebele	Target Population	Sample size of respondents	Samples Size (%)
1	Dhadhin	122	93	33
2	Bundada	184	126	44
3	Dudciid	77	65	23
	Total	383	284	100

Population size in the three kebeles varies and therefore Proportional to the Population Size (PPS) technique was employed using this formula (sample size/population size) \times stratum size.

3.5. Methods of Data Collection

Both quantitative and qualitative data was collected through questionnaire, key informants' interviews, focus group discussion (FGDs), and field observations. This method of data collection helps the investigator to combine the strength and amend some of the inadequacies of any one of the sources of data.

3.5.1. Questionnaires

Questionnaire is one of the principal tools used to gather data from respondents. It was prepared in English and translated in to Somali language in which both open and closed-ended format of questions had been incorporated and distributed to predetermined 284

respondents to collect quantitative and qualitative data. Pilot study was undertaken in a kebeles inside of the study area before distribution of the main questionnaire and help the investigator to get socio-economic information in the targeted kebeles and to modify the instrument based on the experience gained during the pretest. The instrument was helped the respondents to select responses from the provided alternatives and also it provided them with opportunities to express their long experiences, opinions and views regarding climate Variability and adaptation strategies of pastoralists. Besides, the investigator was used the instrument because it would easy to administer, less expensive and provided a wide coverage of data.

Enumerators were recruited and trained to have better knowledge on the questionnaires. The questionnaires were pre-tested before the actual data collection, and appropriate components were modified and corrected as per the feedback obtained. Respondents were interviewed following face-to-face survey method using the door-to-door approach.

3.5.2. Focus group discussion (FGDs)

Focus group discussion is essential to generate data on group dynamics and allows small group respondents to be guided by skilled moderator, to focus on the key issues of the research topic. To describe the previous and the present situation of the study area, to know the present perceptions and the future intention of the community view randomly selected 3 FGD, 1 from each kebele which had 8 members in the group which makes the whole FG members 24 in all the sample population comprising the elderly people men and women, rich people men and women, medium people men and women, poor men and women, model farmers and adult. Data were collected through Focus Group Discussion include extent of vulnerability, impacts of Climate Variability and adaptation strategies.

3.5.3. Key informant interview

Key informant interviews (KIIs) were carried out with a selection of kebeles and knowledgeable and experienced specialists from different organizations. KIIs were defined in this study as elders or experienced farmers who have lived in the area for a considerable

amount of time and have a thorough awareness of local pastoral communities, livelihood systems, and the impacts and adaptation methods of climate variability. The interviews included development agents (DAs), Kebele administrative workers, and elderly individuals.

Ten KIIs were carried out in total: three development agents, four farmers (pastoralists), and two elders. The KIIs were given prepared, semi-structured interview questions, and were expected to verbally supply the required information in face-to-face interviews.

The interviews and discussions with informants proved to be invaluable in providing general context and offering the researcher a wealth of knowledge about the community. These interactions facilitated an in-depth understanding of climate variability, major impacts on the livelihoods of pastoralists, their adaptation strategies, and the overall socioeconomic realities of pastoralist households.

3.5.4. Field observation

Field observation is a way of gathering data by watching, events, or noting physical characteristics in their natural setting. It can be overt (everyone knows they are being observed) or covert (no one knows they are being observed and the observer is concealed). The benefit of covert observation is that people are more likely to behave naturally if they do not know they are being observed. When observation is used in qualitative research, it usually consists of detailed notation of activities, events, and contexts surrounding the events and activities (Creswell, 2003). Therefore, the investigator was making use of overt observation.

3.6. Methods of Data Analysis

3.6.1. Descriptive analysis

Historical climate data over the past 30 years recorded by National Metrological Agency (NMA) from Kabridahar stations was examined using descriptive analysis (frequencies, mean and standard deviation) and graphical representations to highlight any changes in precipitation and temperature patterns. Descriptive statistics like percentages and frequencies was also be used to analyze the household's adaptation strategies to climate change.

Standardized precipitation index and coefficient of variation was used as description of rainfall variability (Ayalew et al., 2012). Standardized precipitation Index is used to examine the nature of the trends and enable to determine the dry (negative values) and wet (positive values) years in the record using the formula given below.

$$SPI = \frac{x - \bar{x}}{\sigma} \quad (2)$$

Where SPI is standardized precipitation index, x is precipitation, \bar{x} is mean of precipitation and σ is standard deviation. Coefficient of Variation (CV) was also be calculated to evaluate annual and seasonal variability of the rainfall and its characteristics. CV is calculated by dividing the standard deviation of the event to its mean.

$$CV = \frac{\sigma}{\mu} * 100 \quad (3)$$

Where CV is coefficient of variation, σ is standard deviation u is mean of precipitation.

3.6.2. Multinomial Logit Specification

pastoralists are more likely to adapt a mix of adaptation strategies to deal with a magnitude of climate induced risks and constrains than adapting a single strategy. Analytical approaches that are commonly used in adaptation decision studies involving multiple choices are the multinomial logit (MNL) and multinomial probit (MNP) models. The limitation of most of the studies on use options of climate variability adaptation strategies are that they do not consider the possible inter-relationships between the various adaptation strategies (Yu et al., 2008). For instance, Nhemachena and Hassan (2007) were employed the multivariate probit model to analyze factors influencing the choice of climate variability adaptation options in Southern Africa.

Faced to adverse climatic variability, farmers options to adapt a mix of strategies as a way of mitigation rather than relying on a single strategy to exploit complementarities among alternatives. Adaptation will also be path dependent with earlier accepted strategies informing decisions on subsequent practices in the future. It is thus necessary to use a model which estimates the influence of exogenous factors on the adaptation of the strategies simultaneously while allowing for the error terms of each of these strategies will be freely correlated, failure to which lead to biased estimates (Kassie et al., 2013). In this study, the researcher employed

multinomial logit (multinomial logistic regression model) to identify factors affecting the choice of pastoralists' adaptation strategies in response to climate variability.

Hence, the multinomial logit model chosen in this study was estimate the choices the pastoralists make regarding climate change adaptation strategies on what factors influence those choices. The model specification is given as follows. Following the work of Tazeze et al. (2012), for a households' utility of two choices represented by U_j and U_k and β_j and β_k respectively; the linear random utility model could be specified as follows:

$$U_j = \beta_j X_i + \varepsilon_j \quad \text{and} \quad U_k = \beta_k X_j + \varepsilon_k \quad (4)$$

where: U_j and U_k have perceived utilities of adaptation alternatives (strategies) j and k , respectively, is the vector of explanatory variables which influences the perceived the desirability of each option; j and k are the parameters to be estimated, and ε_j and ε_k are error terms assumed to be independently and identically distributed (Greene, 2000).

In case of the climate change adaptation decision if the sample household pastoralist decides to use choice j in particular, then we assume that the perceived utility or benefit from option j is larger than the utility from other alternatives (say, k) depicted as:

$$U_{ij} (\beta_j X_i + \varepsilon_j) > U_{ik} (\beta_k X_j + \varepsilon_k), \quad i \neq j, j \neq k \quad (5)$$

From the above relationship, the probability that household "i" with characteristics "X" choose adaptation option "j" is specified as Equation (6) below. This illustrates the probability that a household used option j from among a set of climate change adaptation options as follows (Oo et al., 2017).

$$P\left(A_i = \frac{1}{X}\right) = (U_{ij} > U_{ik})$$

(6)

Then we can express and simplify Equation (3) as the following;

$$\begin{aligned}
P(\beta_j X_i + \varepsilon_j - \beta_k X_j - \varepsilon_k) &> \frac{0}{X} \\
P(\beta_j X_i - \beta_k X_j + \varepsilon_j - \varepsilon_k) &> \frac{0}{X} \\
P\left(\beta_j X_i + \varepsilon^* > \frac{0}{X}\right) &= F(\beta_k^* X_i)
\end{aligned} \tag{7}$$

Where;

P is a probability function;

U_{ij} , U_{ik} and X_i are as defined above;

$\varepsilon^* = \varepsilon_j - \varepsilon_k$ is a random disturbance term;

$\beta^* = \beta_j - \beta_k$ is a vector of unknown parameters that can be interpreted as a net influence of the vector of independent variables influencing adaptation and

$F(\beta^* X_i)$ is a cumulative distribution function of ε^* evaluated at $\beta^* X_i$. The exact distribution of F depends on the distribution of the random disturbance term ε^* (Tazeze et al., 2012). Several qualitative choice models can be estimated for the above function depending on the assumed distribution of the random disturbance term (Greene & Hensher, 2003).

As pointed out by Belay et al. (2017), the parameter estimates of the MNL model gives us only the direction of the effect of the explanatory variables on the dependent variables. Then the effects of explanatory variables on the probabilities interpreted by deriving the marginal

effects as follows;

$$\frac{\partial P_j}{\partial X_i} = P_j \left(\beta_j - \sum_{k=0}^J P_k \beta_k \right) = P_j (\beta_j - \bar{\beta})$$

(8)

Hence, the marginal effect of marginal probabilities measures the expected change in probabilities where a particular adaptation choice is being made by a unit change of the independent variable from the mean (Greene & Hensher, 2003; Oo et al., 2017).

3.7. Dependent And Independent Variables

3.7.1. Dependent Variables

In this study, pastoral communities' preference for prime adaptation strategy is considered the dependent variable. Therefore, the investigator focused on key informant interviews, focus

group discussions (FGDs), and field observations among selected kebele sample household heads' adaptation strategies practiced to reduce the adverse effects of climate variability on their farming activities. Consequently, it was found that selling livestock and livestock products, herd splitting, rearing drought-resistant livestock, reducing meals per day, livelihood diversification, borrowing cash from institutions, and livestock mobility are the most frequently used strategies in the study area to mitigate the adverse effects of climate change and variability.

3.7.2. Independent Variables

The best independent variables to be used in the study are influenced by the literature review on factors that determine pastoral community decisions to adapt to climate variability, previous research findings and the knowledge about the household condition in the study area. The current research considered the following as potential factors affecting farmers' decisions to adapt to climate variability; such as education of the household head, Sex, age, educational status, family size, and income, livestock ownership and weather and climate information on climate variability, access to credit, climate warning system, social capital and perception to temperature (Table 2).

Sex of Household Head (SEX): Sex is a binary variable, with 1 for male and 0 for female. Previous studies have shown both positive and negative influences of sex on Pastoral community adaptation strategy selections; it has dissimilar understanding between male and female heads of household and climate information (Flatø et al., 2017) female-headed households were less likely to use seasonal migration as an adaptation strategy and males are positively correlated to climate information (Getachew et al., 2014; Kemal et al., 2022).

In this study, we anticipated that the sex of the household head would be a significant factor influencing Pastoral community adaptation strategy choices. Therefore, it has hypothesized that sex would have a positive impact on households' decisions to select and use adaptation strategies.

Family Size of the Household (FSIZE): This is a continuous variable measured in numbers. Tolera and Senbeta (2020) found a positive correlation between family size and Pastoral community adaptation strategy selections.

In this study, it is hypothesized that larger households would have more opportunities to pursue various adaptation options. Therefore, it is expected family size to positively impact households' decisions to select and use adaptation strategies.

Age of household head (AGE): Another explanatory factor that is thought to have a significant impact on households' decisions about climate change adaptation is the age of the household. As a result, it positively affects pastoralists' possibilities for adapting to the climate, particularly if it is positively and substantially correlated with the storage of fodder as a climate adaptation strategy at the 10% significance level. Moreover, the likelihood of family mobility will rise by 1% for every year that the head of the household ages. According to Tazeze et al. (2012), the likelihood of a household head adopting various adaptation strategies to the impacts of climate variability increases with age. This is because an older person is expected to gain more knowledge and experience in weather forecasting.

Educational Status of Household Head (EDU): This refers to the educational level of the respondent/head of household. It is coded as 0 if the individual cannot read or write and 1 otherwise. The educational status of the pastoral community significantly influences the choice of adaptation strategies (Tazeze et al., 2012; Snaibi et al., 2021).

In this study, it has been expected educated and experienced pastoral community to have more knowledge and information about climate variability and be better equipped to respond. Consequently, education status would positively impact households' decisions to select and use adaptation strategies.

Access to Credit (CREDIT): The binary variable Access to Credit (CREDIT) has a value of 1 when access is granted and 0 when it is not. According to Herrero et al. (2016), pastoral communities experiencing drought have discovered that having access to finance has a favourable and significant impact on their ability to react to climate unpredictability and purchase food to feed their animals.

In this study, we anticipated that access to affordable credit would increase pastoral community financial resources and their ability to implement various adaptation options. Therefore, we hypothesized that access to credit would positively impact households' decisions to select and use adaptation strategies.

Access to Weather Information (ACCWEAINFO): This refers to major climate change information, including early warning signals, weather forecasts, pest attacks, input management, cultivation practices, pest and disease management, and prices. It is a binary variable, with 1 for access and 0 otherwise. Climate information had a positive influence on the decision to invest in use drought resistance of livestock's (Tiyumtaba, 2016). According to Deressa et al. (2014), also found a positive correlation between access to climate information and the adoption strategy for the risk of drought problems.

In this study, it has been expected that the pastoral community who had access to climate information to be more likely to adopt various adaptation options. Therefore, access to climate information would positively impact households' decisions to select and use adaptation strategies.

3.8. Validity and Reliability of Data

3.8.1. Validity of data

In this study, the validity and reliability of the data was checked through various methods. In the internal validity of the research, the investigator was ensure the internal consistencies of respondents both during the time of data collection and analysis and interpretation of the collected data. Internal validity helps to confirm the meanings of the data provided by the respondents that the investigator has to endorse. Internal validity can also be established by a constant checking and comparison across different sites, times, cases, and individuals (Lewis and Richie, 2003).

In the external validity of the research, the researcher was try to use data triangulation or qualitative cross validation by collecting converging data and procedures of analysis and relying on diverse theories. The three forms of triangulation that are important for this research are triangulation of sources (that is, comparing data from different qualitative methods indicated earlier), triangulation through multiple analysis (for example, using different analysis to compare and check data collection as well as interpretation) and theory triangulation (that is, illustrating experiences and the research participants' subjective

understanding of the experiences in light of multiple theoretical propositions). This is called theory-based generalization or theory-based external validity (Lewis and Richie, 2003).

3.8.2. Reliability of data

Reliability in research refers to the consistency of the measurement and shows how trustworthy the score of the test is. It can be measured by comparing the consistency of the procedure and its results. Therefore, the collected data was checked again and again using various methods and sample groups to make sure the information is reliable and the result is valid. In order to increase the reliability, the study was use an appropriate questionnaire to measure the competency level, ensure a consistent environment for participants, make the participants familiar with the criteria of assessment and analyze the research items regularly to avoid poor performance.

3.9. Ethical Considerations

The investigator considered the informant's consent before interview begins, and was not explore serious or sensitive issues before the establishment of a good relationship. The rapport was through; clarification of the purpose, telling them provision of information was totally depending on their willingness, assuring confidentiality of their shared information, guaranteeing that every response which comes from them was highly respected, and by telling them no need of writing their names. This strong rapport is hopefully expected to help the investigator get the consent and willingness of the participants, which was surely be very crucial to get the necessary information which was in turn highly contribute to the validity and reliability of the work.

4. RESULTS AND DISCUSSION

4.1. Demographic and Socio-Economic Characteristics

4.1.1. Demographic Characteristics

Figure 4 presents the background profiles of the sample households that participated in this study. As previously mentioned, the study sampled household respondents from three kebeles: Bundada, Duudciid, and Dhadhin. Consequently, key background characteristics of household respondents, including Sex, age, educational status, family size, and income, were highlighted. The Sex distribution shows that 79.4% of respondents from Bundada kebele were male, while 20.6% were female. In Duudciid kebele, 73.8% of respondents were male and 26.2% were female. Whereas from Dhadhin kebele, 81.7% of respondents were male and 18.3% were female (Figure 4).

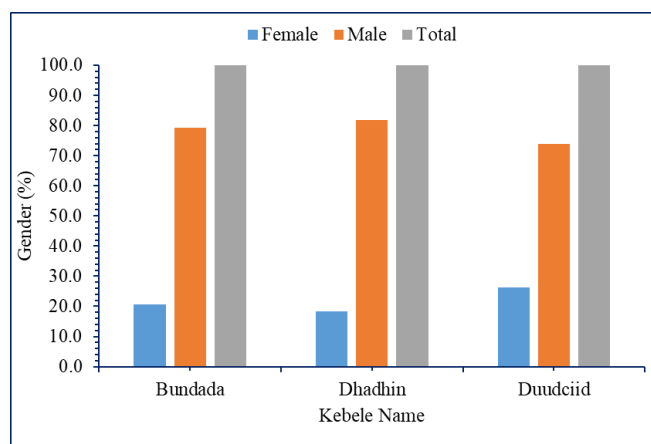


Figure 4. Sex distribution of each kebele participating respondents

According to Omolo & Mafongoya (2019), vulnerability to climate change is influenced by age, Sex, education, and disability. Particularly, elderly women, disabled individuals, and youth are most vulnerable (Fineman, 2012). Moreover, researchers reported that awareness on Sex and climate variability impacts provides a gap to plan adaptation strategy (Aryal et al., 2022).

Age and educational status

The age of sample household heads is 51 to 60 years in 34.13% of Bundada kebele households, while respondents under 50 years old comprise the minimum age group. Those aged 61-70 years old account for 33.33% of households in the same kebele. Among selected agro-pastoral communities in Dhadhin and Duudciid kebeles, the maximum age group (34%) is between 61 and 70 years old. Regarding education status, approximately 92.9%, 95.7%, and 90.8% of residents in Bundada, Dhadhin, and Duudciid kebeles, respectively, cannot read or write. Despite this, there is a small but existent group of agro-pastoral communities in Bundada kebele with complete secondary education.

Studies reported age and education status as one of the backbones of mitigating the impact of climate change and adaptation strategy. For example, communities that cannot read and write have less access to information on climate change (Dumenu & Obeng, 2016), are less likely to understand scientific evidence, reliant on traditional industries that contribute to emissions whereas educated communities.

Table 2. Age and education status of the study kebele respondents

Age Range	Bundada		Dhadhin		Duudciid	
	N	Marginal Percentage	N	Marginal Percentage	N	Marginal Percentage
<= 50	14	11.11	9	9.68	5	7.69
51 to 60	43	34.13	29	31	21	32
61 to 70	42	33.33	32	34	22	34
71 to 80	20	15.87	17	18	14	22
81 to 90	7	5.56	6	6	3	5
Total	126	100	93	100	65	100
Education Status						
Cannot read and write	117	92.9	89	95.7	59	90.8
Primary (1-8)	7	5.6	4	4.3	6	9.2
Secondary (9-12)	2	1.6	0	0	0	0
Total	126	100.0	93	100.0	65	100.0

Family Size

Information regarding the characteristics of family size in Duudciid Kebele, based on household questionnaire interviews, shows that 35% of respondents have between 4 and 6 or 7 and 9 family members per household (Figure 5). This is followed by 20% with 10 to 12 members, while the smallest family size is 13 to 15 members, representing 2% of households in the Kebele. In Bundada Kebele (Figure 6), 35% of the data indicates family sizes between 7 and 9, followed by 4 to 6 members (34%), with 2% of households having 16 to 18 members. Finally, in Dhadhin Kebele (Figure 7), 36% of families have between 4 and 6 members, followed by 7 to 9 members (35%), while 2% have 13 to 15 members.

In terms of climate change impacts, larger households are generally more vulnerable to climate variability (Thornton et al., 2014). This implies that the indicated average family size in the study area is likely to be associated with increased vulnerability due to climate change occurrences (Ehsan et al., 2022).

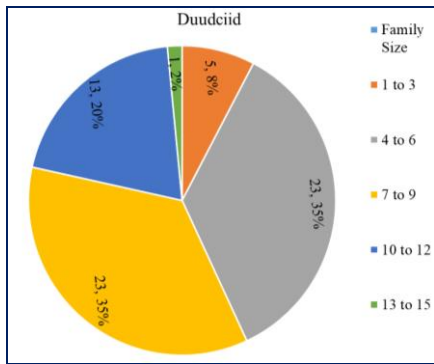


Figure 5. Duudciid kebele family size

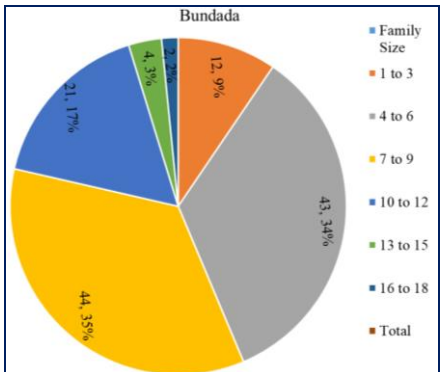


Figure 6. Bundada kebele family size

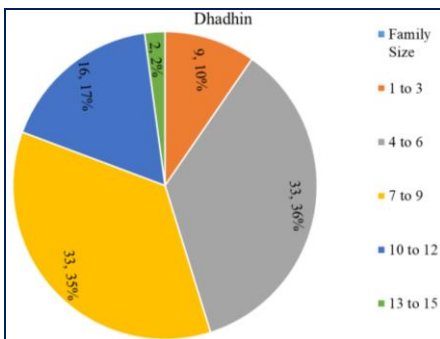


Figure 7. Dhadhin kebele family size

4.1.2. Socio-economic characteristics

The income of sample households in the study kebeles ranged from 2000 to 60000 ETB annually (Figure 8). According to discussions with respondents, income is reliant on livestock and livestock products, which account for 50000 ETB (19%) of income in Bundada, 50000 ETB (21.5%) in Dhadhin, and 5000 ETB (18.5%) in Duudciid kebele. UNDP (2011) reported that income level compromises adaptive capacity and exacerbates climate change vulnerability. The level of income is positively correlated with most adaptation strategies (Zakari et al., 2022), indicating that higher household income is associated with better

adaptation to climate change and variability.

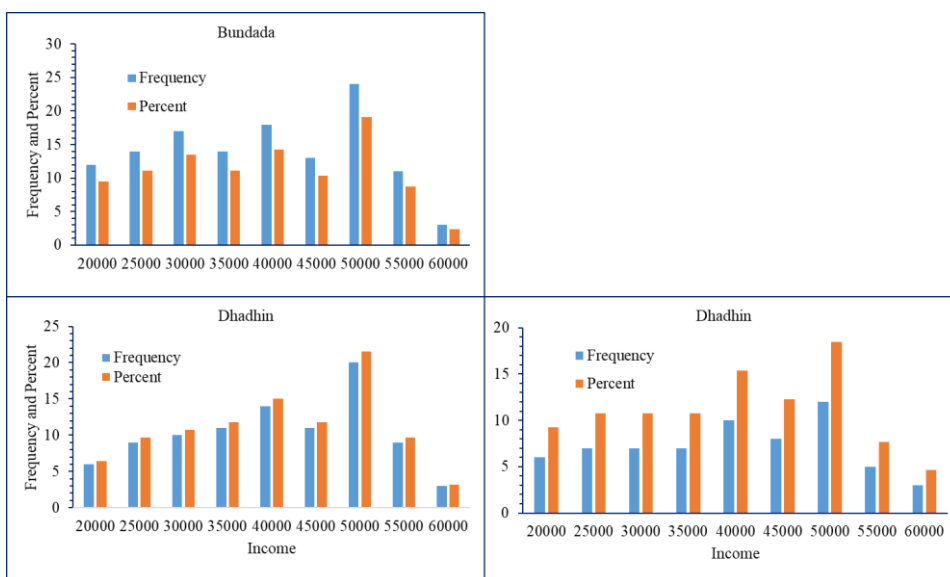


Figure 8. Income level of the respondents of study kebele

Livestock ownership

According to this study and the questioner's responses, all pastoralists possess livestock with varying numbers. In pastoral communities, livestock serves as the primary financial and social asset. The herd composition of sample households in Bundada kebele reveals that 33% of respondents own 11 to 20 camels, while 40% have 1 to 10 cattle. Furthermore, 92% of respondents possess 1 to 10 donkeys, and 60% have more than 50 sheep and goats combined (Table 3). Livestock is positively correlated with most of the adaptation strategies employed by the pastoral communities in the study district.

In Ethiopia the same truth was reported by Megersa et al. (2014) study conducted on pastoral cattle production in southern Ethiopia that can positively influence adoption of livestock diversification.

Table 3. Livestock owners of the study kebeles

Bundada								
Numbers of Livestock	camel		cattle		donkey		sheep and goats	
	N	Marginal Percentage	N	Marginal Percentage	N	Marginal Percentage	N	Marginal Percentage
Less than 1	22	17	50	40	10	8	2	2
1 To 10	40	32	51	40	116	92	4	3
11 To 20	42	33	19	15	0	0	11	9
21 To 30	14	11	4	3	0	0	8	6
31 To 40	4	3	1	1	0	0	8	6
41 To 50	0.0	0.0	1	1	0	0	17	13
Greater than 50	4	3	0.0	0.0	0	0	76	60
Total	126	100	126	100	126	100	126	100
Duudciid								
Less than 1	0	0	59	90.8	4	6.2	0	0
1 To 10	11.0	16.9	6.0	9.2	61.0	93.8	2.0	3.1
11 To 20	26.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0
21 To 30	19.0	29.2	0.0	0.0	0.0	0.0	0.0	0.0
31 To 40	4.0	6.2	0.0	0.0	0.0	0.0	1.0	1.5
41 To 50	2.0	3.1	0.0	0.0	0.0	0.0	6.0	9.2
Greater than 50	3.0	4.6	0.0	0.0	0.0	0.0	56.0	86.2
Total	65.0	100.0	65.0	100.0	65.0	100.0	65.0	100.0
Dhadhin								
Less than 1	5.0	5.4	88.0	94.6	8	9	1	1
1 To 10	21.0	22.6	3.0	3.2	85	91	3	3
11 To 20	36.0	38.7	2.0	2.2	0	0	7	8
21 To 30	14.0	15.1	0.0	0.0	0.0	0.0	7	8
31 To 40	8.0	8.6	0.0	0.0	0.0	0.0	6	6
41 To 50	3.0	3.2	0.0	0.0	0.0	0.0	13	14
Greater than 50	6.0	6.5	0.0	0.0	0.0	0.0	56	60
Total	93.0	100.0	93.0	100.0	93.0	100.0	93.0	100.0

Access to market

According to the respondents of the three kebeles of table 4, those who said “No” responded more than 80 % except Dhadhin which was 84.95 % agreeing they have livestock market

centers and marketing facilities in their kebele. On the other hand, Bundada and Duudciid kebeles pastoral communities walk approximately for 3 hours to reach the market center.

Table 4. The market access of the three kebeles in this study area

Do you have livestock market centers & marketing Facilities in your kebeles?	Bundada		Duudciid		Dhadhin	
	F	%	F	%	F	%
Yes	14	11.11	12.00	18.46	79.00	84.95
No	112	88.89	53.00	81.54	14.00	15.05
Total	126	100	65	100	93	100

Access to weather and climate information

The climate information by pastoralists of the three kebeles selected for this study responded that they have no information on climate variability. Regarding the negative effects, the respondents asked as “*Do you think climate change or variability posed negative effects on your livelihood?*” All the respondents replied “Yes” that they agree with the negative effects of climate variability.

Health Status

According to the respondents, all Kebels have a veterinary service (Table 5). For the veterinary service in each kebele, those who say “yes” is 63.5 % for Bundada, 10.8 % for Duudciid and 9.7 % for Dhadhin kebele while those who said “No” 36.5 %, 89.2 % and 90.3 % for Bundada, Duudciid and Dhadhin kebele respectively.

The respondents have not taken animals to veterinary service in Bundada kebele when they get sick; because 36.5 % of the respondents said that traditional medicine is better, inadequate drugs & facilities, vet personnel are unqualified, and vet personnel are not available most of the time (Table 5).

The respondents about the health centre for their family service and treatment, and whether they use or not, they responded “yes” in Bundada, Duudciid and Dhadhin kebele for 56.3 %, 63.1% and 19.4% respectively (Table 5). Those who said “No” in Dhadhin kebele is 80.6% while the other kebeles responded less than 40 %. The reason they have been not used for their

family treatment was health personnel were unqualified and inadequate drugs and facilities replied 100 % in Duudciid kebele while “I prefer town” was 96.9 % (Table 5). These reasons were replied 38.1 % and 80.6 % by Bundada and Dhadhin Kebele respectively as health personnel are unqualified, inadequate drugs and facilities, health personnel are not available most of the time, I prefer town and traditional medicine is better.

Table 5. Taking animals/humans to veterinary/health service

Do you take your animals to veterinary service when they get sick?	Bundada	Duudciid	Dhadhin
No	36.5%	89.2%	90.3%
Yes	63.5%	10.8%	9.7%
Total	100.0%	100.0%	100.0%
Why don't you take them there, because?			
Traditional medicine is better	36.5%	63.1%	90.3%
Inadequate drugs & facilities	36.5%	100.0%	90.3%
Vet personnel are unqualified	36.5%	44.6%	90.3%
Vet personnel are not available most of the time	36.5%	100.0%	90.3%
Do you use this health center for you and your family health treatment?			
No	35.7%	36.9%	80.6%
Yes	56.3%	63.1%	19.4%
Missed	7.9%		
Total	100.0%	100.0%	100.0%
Why not use the health center for you and your family health treatment?			
Traditional medicine is better		21.5%	
Inadequate drugs & facilities	38.1%	100.0%	80.6%
I prefer town	38.1%	96.9%	80.6%
health personnel are unqualified	38.1%	100.0%	80.6%
health personnel are not available most of the time	38.1%	48%	80.6%

4.2. Climate Variability

4.2.1. Major Indicators of climate variability

In the study area, the major indicators of climate variability are provided in Table 7. In all three kebeles, the increase in temperature and reduction in rainfall share 100 %. In Duudciid and Dhadhin kebele, flood increased due to climate variability by 44.6 % and 80.6%; and 1.5 % of Duudciid kebele respondents' other issues like disease observed due to climate variability. This finding has similar information regarding climate variability challenges to Ayal and Muluneh (2014) for their study of the pastoralists' perception of the increasing trend

of annual and seasonal temperatures. In the other study report, devastatingly highest perceptions of trends in climatic variables; a large share of households distinguish temperature has been increasing eventually, rainfall has been decreasing with its irregularity of increasing (Ayal and Walter, 2017).

Table 6. Major indicators observed following climate variability in three kebeles of the study area

Major indicators of the observed climate variability	Bundada	Duudciid	Dhadhin
Increase in temperatures	100%	100%	100%
Reduction in rainfall	100%	100%	100%
Change in wind patterns	0%	21.5%	0%
Flood Increased	0%	44.6%	80.6%
Others (New disease)	0%	1.5%	0%

(Field survey, 2024)

4.2.2. Temperature and Rainfall Variability

4.2.2.1. Temperature variability

In the current study, the temperature effect has not followed the seasonal calendars as the seasonal temperature trend indicated (Figure 9). It has presented in monthly time scale. According to the local calendar; the season has been classified as January to March is locally called *Jilal*, April to June is locally called *Gu*, July to September is locally called *Hagaa* and Oct to Dec is locally called *Dyre*. Consequently, the temperature series was investigated for monthly and seasonal temporal trends to provide a temperature variability and change in the three kabeles of Korrahe Zone between 1990 and 2020.

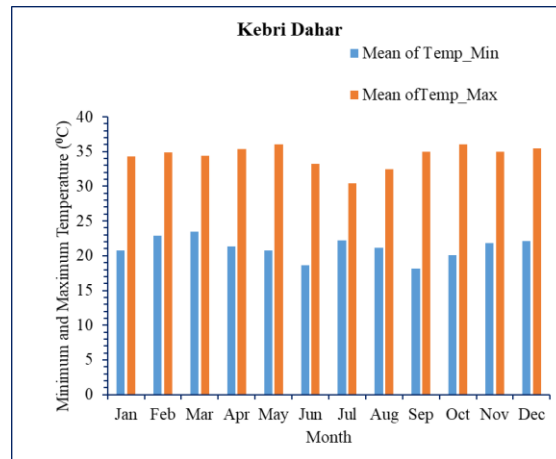


Figure 9. The temperature trend of Kebri Dahar station of Korrahe Zone

In Figure 10, the temperature trend is presented as local calendar definition as stated in between the dashed line for example, *Jilal* January to March; *Hagaa* this time the temperature little bit showed a decreasing trend as compared to the other seasons in Korrahe Zone.

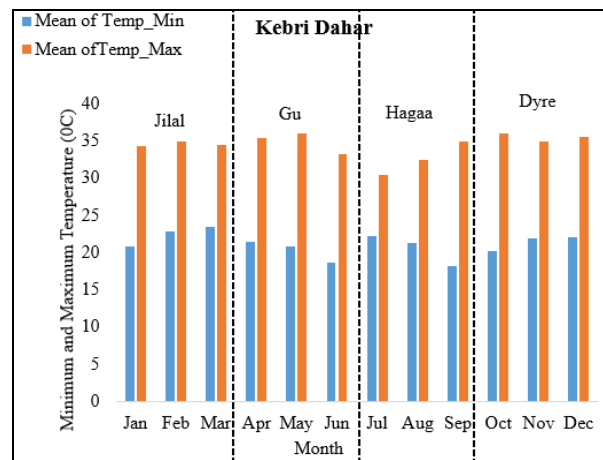


Figure 10. The seasonal classification of temperature trend of Kebri Dahar station of Korrahe Zone

4.2.3.2. Rainfall variability

In the analysis period from 1990 to 2020, the maximum monthly rainfall of 115.77 mm was observed in the study kebeles during October 1999. The basic characteristics of the monthly rainfall time series for the three kebeles are reported in Table 8. Conversely, the minimum rainfall for the district was 0 mm throughout the study period.

Table 7. Rainfall trends of the study area

Rainfall level (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	6.24	11.02	54.03	82.32	51.51	25.94	8.40	11.72	51.68	115.77	72.06	15.28
Average	0.04	0.25	1.09	6.49	4.72	0.62	0.05	0.18	1.51	6.62	2.49	0.20
SD	0.37	1.00	4.23	11.22	8.95	2.81	0.44	1.02	5.43	13.23	7.72	1.16
CV (%)	1029	403	388	173	190	456	951	577	360	200	310	576
Annual	1.12	6.98	33.80	194.62	146.18	18.45	1.43	5.49	45.29	205.35	74.63	6.23

The highest rainfall of 205.35 mm occurred from October to December, followed by 194.62 mm in April and June. The rainfall extremes exhibited from July to September have certainly influenced the seasonal rainfall, as this season showed a significant decreasing trend as presented in Table 9.

Table 8. Rainfall seasonal trends of the study kebeles

Rainfall level (mm)	Gu (April and June)	Dyre (Oct to Dec)	Jilaal (Jan-March)	Hagaa (July - September)
Minimum	18.45	6.23	1.121	1.429
Maximum	194.62	205.35	33.801	45.292
Average	119.75	95.40	13.968	17.403
SD	91.01	101.17	17.424	24.238
CV (%)	76.00	106.04	124.74	139.28

Rainfall seasonality is a double-edged sword for pastoral communities. While it dictates the growth of crucial pastures for livestock grazing and provides drinking water, its irregularity throws a wrench into their entire way of life. Unpredictable rains can lead to insufficient pasture growth, water shortages, and the spread of diseases among livestock, impacting their health, productivity, and ultimately, the income and food security of these communities. Pastoralists have adapted by diversifying their livelihoods, managing grazing practices more sustainably, collecting rainwater, and working together to face these challenges.

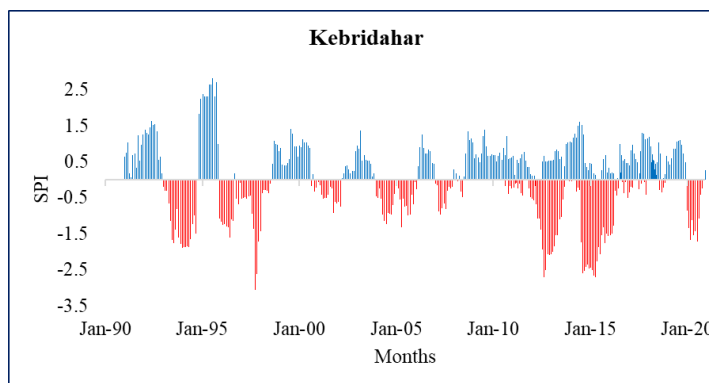


Figure 11. The 12-month of SPI of Kebridahar station

4.3. Major Impacts of Climate Variability

4.3.1. Impact of livestock production

4.3.1.1. Impact on livestock status

Table 10, provides the livestock status of the study area over the last 30 years. According to the data, livestock status has decreased in all three kebeles; where Duudciid experienced the most significant decline by 66.2%, Dhadhin by 64.5%, and Bundada by 64.3%.

Respondents' information confirms that climate variability has significantly impacted livestock and their products in the study area. This study report is in line with Mekuyie and Mulu (2021) and Alemayehu and Bewket (2017). This decline has adversely affected the economy of the pastoral communities in the three Kebeles. The findings of this study align with previous research on the negative effects of climate variability on livestock and livestock products in Ethiopia (Bekele, 2017) and East Africa, particularly Kenya (Silvestri et al., 2012).

Climate change disrupts the delicate balance for livestock, impacting their health and productivity in several ways. Changes in precipitation patterns lead to reduced grass growth, lower nutritional value, and increased drought risk, leaving animals with less and poorer quality food. This, coupled with intensified competition for resources due to climate stress, puts further strain on available forage and water. The scarcity of drinking water directly affects livestock health, while contaminated sources can spread diseases. High temperatures further exacerbate the situation by reducing appetite and productivity, leading to weight loss

and lower milk production. Extreme heat events can even cause death in susceptible animals. Warmer temperatures also favor the survival and reproduction of disease-carrying insects, increasing the prevalence of vector-borne illnesses among livestock. The emergence of new diseases becomes a possibility as well. Ultimately, these factors translate to economic losses, with decreased livestock value and potential loss of livelihoods for pastoral communities who depend heavily on their animals.

Table 9. Livestock status of the study kebeles

Livestock status	Dhadhin		Duudciid		Bundada	
	N	Marginal Percentage	N	Marginal Percentage	N	Marginal Percentage
increased	33	35.5	22	33.8	45	35.7
decreased	60	64.5	43	66.2	81	64.3
Total	93	100.0	65	100.0	126	100.0

4.3.1.2. Impacts on sources of water

Climate variability is squeezing the life out of rivers and ponds worldwide. Reduced rainfall and scorching temperatures are causing increased droughts and evaporation, shrinking these water bodies. Due to rising temperatures further reducing the flow of water into rivers and streams has been declined and eliminated in the study area. Land use changes and deforestation worsen the situation by reducing water infiltration and increasing sediment buildup in rivers and ponds, diminishing their capacity to hold water. A consequence of climate change can also impact coastal freshwater resources. The severity of these impacts varies by region, nevertheless, the overall trend is similar in the three Kebeles climate change is a major threat to the size and health of water, with cascading consequences for ecosystems, pastoralists, and pastoral community of the study area.

The following bar graph presents the water sources in Duudciid Kebele from 1994 to 2024. For understanding the impacts of climate, this is assessed based on a year's difference as provided in Figure 12. However, the water sources from Kebele to Kebele are different for instance, in Bundada from 1994-2004 and 2005-2015 the community used a river and well, but from 2015- 2024 they have been used a borehole. On the other hand, the Dhadhin kebele

community has used wells for water sources in all study periods of the last 30 years. The Dhadhin Kebele pastoral community's distance to the water point is 500 m; as the results of their water sources are dependent on them to use well. The distance for the Duudciid Kebele pastoral community was 15 km from 1994-2004 and 2005-2014 while decreasing to 1 km from 2015-2024 as they are focused on borehole water use. The distance for Bundada kebele pastoral community is from 500m-1km from 1994-2014 while it increased to 1 to 2 km from 2015-2024 as they are relying on using the river, well and borehole in this study period.

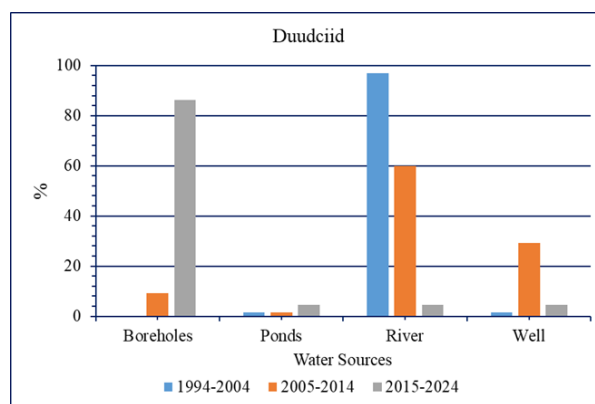


Figure 12. Types of water resources in the Duudciid kebele in the study periods

The graph shows the percentage of different water sources used in Dhadhina kebele over three time periods: 1994-2004, 2005-2014, and 2015-2024 (Figure 13). In the first two periods, boreholes were the primary water source, but their usage decreased significantly from 1994-2004 to 2005-2014. Pond water source usage remained relatively low throughout the study periods. River usage increased dramatically from 2005-2014 to 2015-2024, becoming the primary source in the latter period. The Well sources usage remained relatively consistent throughout the study periods, with a slight increase in the 2005-2014 period.

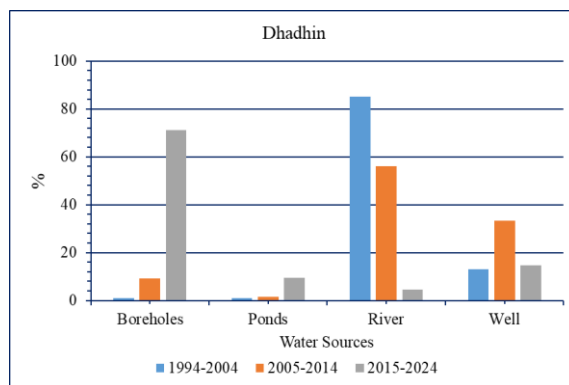


Figure 13. Types of water resources in the Dhadhina kebele in the study periods

Figure 14 shows the percentage of different water sources used in Bundada kebele over three periods including 1994-2004, 2005-2014, and 2015-2024. In the first period (1994-2004), boreholes were the primary water source, but their usage decreased significantly in the subsequent periods due to over-extraction and declining water levels. Pond usage remained relatively low throughout the study periods, as ponds are often unreliable and susceptible to drying up during droughts. River usage increased dramatically from 2005-2014 to 2015-2024, becoming the primary source in the latter period. This shift can be attributed to increased rainfall and the construction of irrigation infrastructure along the river. The well water source usage remained relatively consistent throughout the study periods, with a slight increase in 2005-2014. However, well water is often contaminated and requires treatment before consumption, which can be challenging for pastoral communities with limited resources (Mobie, 2008).

The changing water sources in Bundada kebele reflect the impacts of climate variability on the pastoral community. Irregular rainfall patterns, droughts, and floods have made it increasingly difficult for pastoralists to rely on traditional water sources like boreholes and ponds (Kedir et al., 2015). As a result, they have had to adapt their livelihoods and water sourcing strategies to depend more heavily on rivers and wells. This shift has both benefits and challenges, as it can improve access to water but also increase vulnerability to water quality issues and conflicts over water resources (Postel, 2003).

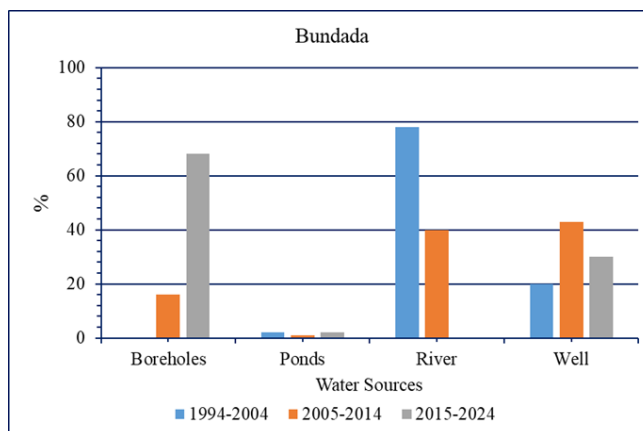


Figure 14. Types of water resources in the Bundada kebele in the study periods

4.3.1.3. High frequency of livestock disease

In the study area, livestock have been decreasing due to drought events. According to respondents who participated in this study, climate change has been one of the factors; in addition, the respondents said that increasing drought produces diseases in their livestock.

Table 10. Natural hazards in the study kebele due to climate variability

Natural hazards	Duudciid		Bundada		Dhadhin	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Disease	43	66.2	81	64.3	60	64.5
Drought	7	10.8	8	6.3	12	12.9
Drought and disease	15	23.1	37	29.4	21	22.6
Total	65	100.0	126	100.0	93	100.0

4.3.1.4. Impact on livestock pasture

More than 90 % of the respondents in all Kebeles, the availability of pasture is occasional (Table 12). The non-respondents said never while some respondents responded regular availability of pasture. The data reveals a concerning trend in pasture availability across the three kebele. While occasional access to pasture is the norm, regular availability remains notably scarce. Bundada, in particular, faces the most challenging situation with only 6.3% of respondents reporting regular access. Duudciid, with 3.1% regular availability, is in a similar difficulty. Dhadhin, though marginally better, still falls short of consistent pasture access, with

only 5.4% of respondents reporting regular availability. These findings collectively underscore the limited and unpredictable nature of pasture resources in these Kebeles, which could have significant implications for livestock grazing and the livelihoods of local communities.

Table 11. The Pasture Availability in study kebele

Pasture Availability	Bundada		Duudciid		Dhadhin	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Never	0	0.0	0	0.0	0	0
Occasionally	118	93.7	63	96.9	88	94.6
Regularly	8	6.3	2	3.1	5	5.4
Total	126	100	65	100	93	100

4.3.2. Economic Impacts

4.3.2.1. Livestock price during normal time

Prices during normal days or non-drought times are reported in Figures (13-15) in the three kebeles. During normal days, the price of camel in all kebeles showed increasing trends that is greater than 80 % in the same manner with goats and sheep while cattle have less market value as compared with other livestock prices according to the respondent's information. On the other hand, drought effects significantly observed the price of livestock market; for instance, camel prices except for Dhadhin kebele has almost showed around 2 %. According to some respondents, cattle price is the same, particularly for Dhadhin approximately 30 % similarity.

The graph below shows that the price of livestock in Bundada kebele during normal days or non-drought times has remained relatively stable for all types of livestock, indicating that climate variability has not had a significant impact on the livestock market in the area during non-drought periods. The prices of camels, cattle, sheep, goats, and donkeys have all remained the same.

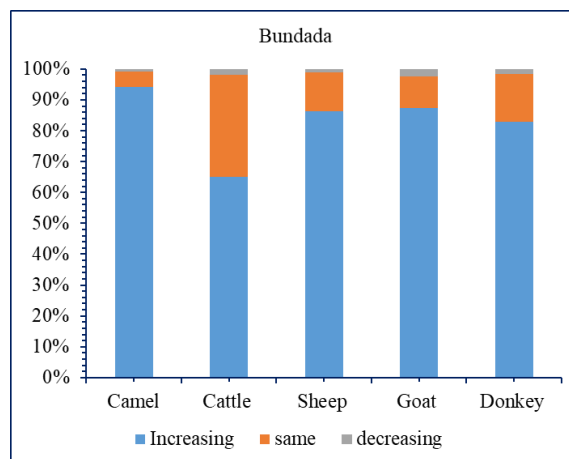


Figure 15 . The price of livestock looks like during normal days or non-drought times in Bundada Kebele

Figure 16 shows that the price of livestock in Duudciid kebele during normal days or non-drought times has remained relatively stable for all types of livestock, indicating that climate variability has not had a significant direct impact on the livestock market in the area during non-drought periods. While climate change can indirectly affect livestock prices through factors such as reduced forage availability and increased disease prevalence, the data suggests that these effects have been minimal in Duudciid kebele during non-drought conditions.

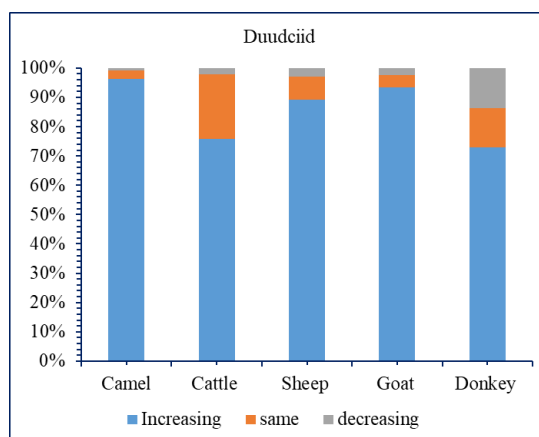


Figure 16. The price of livestock look like during normal days or non-drought times in Duudciid Kebele

Figure 17 below as well demonstrates that the prices of livestock in Dhadhin kebele have remained remarkably consistent throughout periods of normal weather and non-drought conditions. This stability suggests that climate variability has not exerted a substantial direct influence on the livestock market in the region during times of ample rainfall. While climate change can indirectly impact livestock prices through factors such as diminished forage

availability and elevated disease prevalence, the data indicates that these effects have been negligible in Dhadhin kebele during non-drought periods.

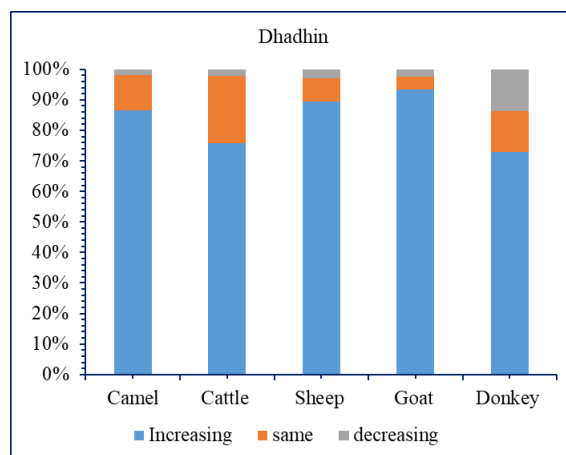


Figure 17. The price of livestock look like during normal days or non-drought times in Dhadhin Kebele

4.3.2.2. Livestock price during drought time

The price of livestock is said to be inconsistent and changes throughout the times. The respondents explained that during drought times, pastoralists are afraid of losing their livestock due to droughts and other hazards. They, therefore rush to sell out for a cheaper price especially cattle owners, because they say cattle is the weakest of all livestock during droughts. Pastoralists also keep selling out their livestock during drought to buy food for survival.

Figure 18 demonstrates that the price of livestock in Bundada kebele during drought times has decreased significantly for all types of livestock, indicating that climate variability has had a substantial negative impact on the livestock market in the area during droughts. This decline in prices is likely due to factors such as reduced forage availability, increased disease prevalence, and decreased demand for livestock products as pastoralists struggle to meet their basic needs (Ayele and Duba, 2020).

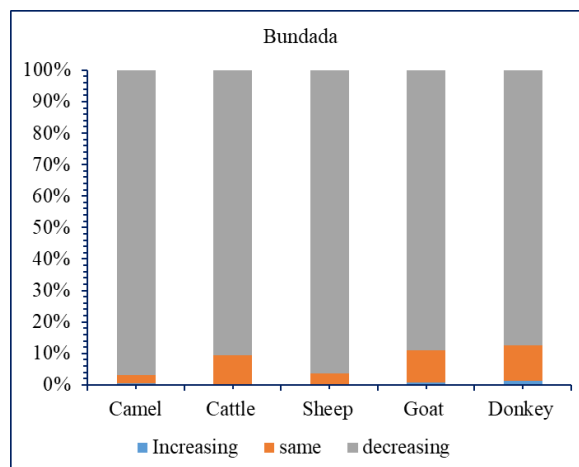


Figure 18. The price of livestock during drought days or drought times in Bundada Kebele

The graph below shows that the price of livestock in Duudciid kebele during drought times has decreased significantly for all types of livestock, indicating that climate variability has had a substantial negative impact on the livestock market in the area during droughts. This decline in prices is likely due to factors such as reduced forage availability, increased disease prevalence, and decreased demand for livestock products as pastoralists struggle to meet their basic needs.

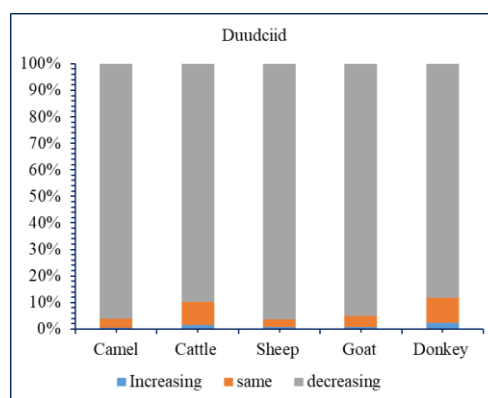


Figure 19. The price of livestock during drought days or drought times in Duudciid Kebele

The prices of livestock in Dhadhin kebele have declined substantially during times of drought, indicating a significant negative impact of climate variability on the local livestock market (Figure 20). This price reduction is likely attributable to several factors, including diminished forage availability, increased prevalence of diseases, and a decrease in demand for livestock products as pastoralists grapple with meeting their fundamental needs. The reduced availability of grazing land and water resources due to drought conditions has led to a decline in the overall health and productivity of livestock, resulting in lower market prices. Additionally, the increased prevalence of diseases, such as foot-and-mouth disease and East Coast

fever (Knight-Jones et al., 2017), can further reduce the value of livestock. As pastoralists struggle to sustain their livelihoods in the face of drought, they may be forced to sell their livestock at lower prices to meet their immediate needs, further exacerbating the decline in livestock prices.

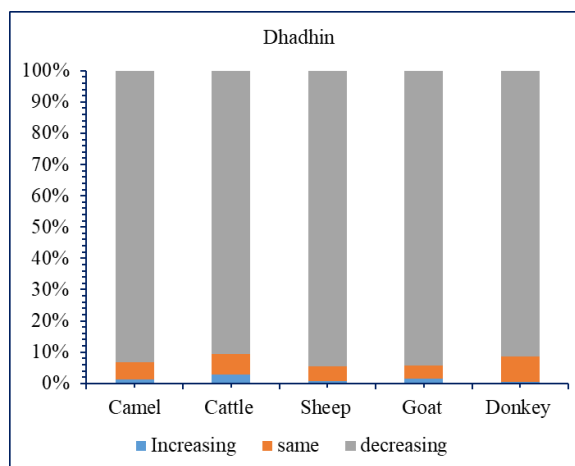


Figure 20. The price of livestock during drought days or drought times in Dhadhin Kebele

4.3.2.3. Impacts on livestock products

Milk and other livestock products have been affected by climate variability. As depicted in Table 13, meat decreased by 46.8 % in Bundada kebele while milk showed a 100 % decrease. The Dhadhin kebele showed the same trend as Bunddada, however, this trend has different characteristics in Duudciid kebele meat decreased by 53.8 % and milk decreased by 100 % while butter showed the same trend by 61.5 % (Table 13).

Livestock products normally decrease during drought time as stated by the FGDs and KII. This is because, products come with pasture and therefore as pasture availability decreases during drought time so do the products as well. Moreover, when there is a rainy season and livestock get green pasture (grass and leaves), their products almost double as expressed by the respondents.

Table 12. Trend of livestock products during drought time of three kebeles in the study area.

Kebele Name	Trend	Meat		Milk		Butter	
		F	%	F	%	F	%
Bundada	Decreases	59	46.8	126	100.0	47	37.3
	Increases	31	24.6	0	0	55	43.7
	Same	36	28.6	0	0	24	19.0
	Not used	0	0.0	0	0	0	0.0
	Total	126	100.0	126	100.0	126	100.0
Dhadhin	Decreases	43	46.2	93	100.0	36	38.7
	Increases	22	23.7	0	0	38	40.9
	Same	28	30.1	0	0	19	20.4
	Not used	0	0.0	0	0	0	0.0
	Total	93	100	93	100	93	100
Duudciid	Decreases	35	53.8	65	100.0	25	38.5
	Increases	0	0	0	0	0	0
	Same	30	46.2	0	0	40	61.5
	Not used	0	0	0	0.0	0	0
	Total	65	100	65	100	65	100

4.4. Adaptation Strategies of the local pastoral community

The adaptation strategies employed by the pastoral communities during climate change are presented in Table 14. The adaptation strategy to adapt to climate variability impact those agreed were 73 % in Bundada, 71 % in Duudciid and 60.9 % in Dhadhin kebele; and their reason were selling of livestock and livestock products 98.4 % in Bundada, 96.9 % in Duudciid and 88.3 in Dhadhin kebele. Borrowing cash from institutions was less than 30 % in all kebeles whereas livestock mobility was 97.6 % in Bundada, 98.5 % in Duudciid and 89.3 % in Dhadhin kebele.

Table 13. Adaptation strategies used to adapt to climate variability impact of study area

Have you ever used any adaptation strategy to adapt with climate variability impact?	Bundada	Duudciid	Dhadhin
Yes	73.0%	71.0%	60.9%
No	26.98%	29.01%	39.11%
If your answer is 'yes' which one?			
Selling of livestock and livestock products	98.4%	96.9%	88.3%
Herd splitting	56.3%	52.3%	49.5%
Rearing of drought-resistant livestock	69.8%	64.6%	62.1%
Fewer meals per day	98.4%	96.9%	57.3%
Livelihood diversification	65.1%	61.5%	57.3%
Borrowing cash from institutions	25.4%	26.2%	22.3%
Livestock mobility	97.6%	98.5%	89.3%

Selling livestock and livestock products is a crucial adaptation strategy for pastoral communities facing climate variability. It provides income generation, risk management, food security, and flexibility. By selling animals during drought or disease, pastoralists can generate funds to purchase essential goods and services (Mohamed et al., 2020), maintain a sustainable herd size, and ensure enough livestock for subsistence. This strategy allows adaptability to changing market conditions and climate-related challenges (Wiréhn, 2018). Over 90% of Kebeles agreed on the importance of this strategy (Table 14).

Herd splitting is a significant adaptation strategy for pastoral communities facing climate variability (Butt et al., 2009). By dividing a large herd into smaller, more manageable groups, pastoralists can improve resource management, reduce vulnerability to climate shocks, increase resilience, and maintain flexibility in responding to changing circumstances (Reda, 2016). This strategy allows for more effective utilization of available resources, reduces the risk of overgrazing and resource depletion, and enhances the ability of pastoral communities to adapt to changing environmental conditions.

Rearing drought-resistant livestock is a crucial adaptation strategy for pastoral communities facing climate variability. These breeds are genetically adapted to withstand periods of water

scarcity, reducing mortality rates and ensuring long-term sustainability. Drought-resistant livestock can also provide a vital source of food and income, even during dry periods.

Livelihood diversification is another essential adaptation strategy. By expanding income sources beyond livestock rearing, pastoralists can mitigate risks, stabilize income streams, and improve food security. Common diversification strategies include crop cultivation, off-farm activities, and livestock diversification.

Borrowing cash from institutions can provide immediate financial assistance and support climate-resilient practices (Kadir, 2012). However, it's essential to consider the risks and access to financial services; therefore, based on this fact, all Kebeles used in this study, borrow less than 30%.

Livestock mobility is a crucial strategy for accessing new grazing areas and reducing the risk of animal losses. By moving livestock to areas with better conditions, pastoralists can ensure their herds' survival during climate-related challenges. Livestock mobility enhances the resilience of pastoral communities by enabling them to adapt to changing environmental conditions and maintain their livelihoods.

Cultural practices: Livestock mobility is often deeply rooted in the cultural practices and traditions of pastoral communities, contributing to their sense of identity and connection to their land.

However, these adaptation strategies used in this study can also have challenges, such as conflicts over grazing resources, the potential for disease transmission, herd depletion and long-term vulnerability (Ayal et al., 2018; Moru, 2010;). Hence, strategies require careful planning, coordination, and collaboration among pastoral communities and relevant authorities to apply these adaptation strategies.

4.5. Factors affecting adaptation strategies

The factors affecting pastorals decision of implementing adaptation measures to livelihood. The pastoralists in the study area used livestock and their products, rearing of drought resistant livestock, selling of livestock and livestock products, Herd splitting, fewer meals per day, livelihood diversification, borrowing cash from institutions and livestock mobility were major

adaptation strategies. But, choice of an adaptation option(s) determined by a number of factors. To identify these factors and estimate the effect of explanatory variables on choices of adaptation options, the Multinomial Logit model was used. The general interpretation of a parameter estimates from Multinomial Logit model shows how the probability of the consequence changes when the corresponding variable changes by one unit from its mean while the rest of explanatory variables held constant at their means (Table 15). Other factors which are not controlled in this study may have an influence on choice of adaptation strategy.

Table 14. The Marginal effects of selected variables from multinomial logit model on adaptation strategy

Variable	Rearing of drought resistant livestock	Fewer meals per day	Livelihood diversification	Borrowing cash from institutions	Livestock mobility	Herd splitting	Selling of livestock
Edustat	0.004357	-0.055157	0.100621	-0.077051	0.105833	0.001200	-0.058314
Age	0.003982	0.004357	0.062644	-0.076410	-0.058480	0.000825	0.001200
Gender	-0.058480	-0.068124	0.007400	-0.060642	0.039989	-0.061636	-0.071280
Income	0.100621	0.004087	-0.004714	0.0139104225*	0.003982	0.097464	0.000930
Pasture Avail	0.071531	0.061001	0.071531	-0.001815	-0.079744	0.068375	0.057845
Inf. climate	0.0139104225***	-0.010217	0.019008873***	-0.010793	0.012837825***	0.010754	-0.013374

***; ** and * indicate significance at 1%, 5% and 10% probability levels, respectively

Source: Author survey, 2024

Correlation matrix a Pearson pair-wise correlation matrix presented in Table 16. According to Gujarati (2007), if the pair-wise correlation is in excess of 0.8, then the data has a relationship in stronger manner. From the correlation matrix, no variables had a pair-wise correlation above 0.8, which shows that the data was free from seriously related. For example, climate information (info_climate) poorly related to drought in Duudciid kebele while with family size (famsize) somewhat strong than the others.

Table 15. The correlation matrix of Pearson pair-wise of the variables of Duudciid kebele

	Sex	Age	EduStat	Famsize	Info_climate	Drought	Pasture_avail
Sex	1	.597**	.265**	.463**	.459**	.303**	.417**
Age	.597**	1	.632**	.742**	.646**	.479**	.651**
EduStat	.265**	.632**	1	.671**	.494**	.304**	.419**
Famsize	.463**	.742**	.671**	1	.707**	.446**	.525**
Info_climate	.459**	.646**	.494**	.707**	1	.392**	.468**
Drought	.303**	.479**	.304**	.446**	.392**	1	.446**
Pasture_avail	.417**	.651**	.419**	.525**	.468**	.446**	1

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Table 16. The correlation matrix of Pearson pair-wise of the variables of Dhadhin kebele

	Sex	Age	EduStat	Famsize	Info_climate	Drought	Pasture_avail
Sex	1	0.588**	0.261**	0.456**	0.452**	0.299**	0.411**
Age	0.588**	1	0.623**	0.731**	0.636**	0.472**	0.641**
EduStat	0.261**	0.623**	1	0.661**	0.487**	0.300**	0.413**
Famsize	0.456**	0.731**	0.661**	1	0.697**	0.439**	0.517**
Info_climate	0.452**	0.636**	0.487**	0.697**	1	0.386**	0.461**
Drought	0.299**	0.472**	0.300**	0.439**	0.386**	1	0.439**
Pasture_avail	0.411**	0.641**	0.413**	0.517**	0.461**	0.439**	1

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Table 17. The correlation matrix of Pearson pair-wise of the variables of Bundada kebele

	Sex	Age	EduStat	Famsize	Info_climate	Drought	Pasture_avail
Sex	1	0.596**	0.265**	0.462**	0.458**	0.303**	0.416**
Age	0.596**	1	0.631**	0.741**	0.645**	0.478**	0.650**
EduStat	0.265**	0.631**	1	0.670**	0.493**	0.304**	0.418**
Famsize	0.462**	0.741**	0.670**	1	0.706**	0.445**	0.524**
Info_climate	0.458**	0.645**	0.493**	0.706**	1	0.391**	0.467**
Drought	0.303**	0.478**	0.304**	0.445**	0.391**	1	0.445**
Pasture_avail	0.416**	0.650**	0.418**	0.524**	0.467**	0.445**	1

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Understanding the factors that influence adaptation strategies is crucial for developing effective climate change mitigation and adaptation policies. These factors can be broadly categorized into significant and non-significant, based on their degree of impact on adaptation choices. Significant factors include socio-economic conditions, institutional factors, environmental factors, and cultural factors. Socio-economic factors, such as income, education, and land ownership, can significantly influence an individual's or community's ability to adapt to climate change. Institutional factors, such as government policies, regulations, and institutional support, play a critical role in shaping adaptation responses. Environmental factors, including climate, topography, and natural resources, can influence the types of adaptation strategies that are feasible and effective. Cultural factors, such as beliefs, values, and traditions, can shape adaptation choices. Understanding these factors is essential for designing adaptation strategies that are tailored to local needs and circumstances.

Non-significant factors are Conditional adaptation strategies that may not have a direct and significant impact on adaptation strategies in all contexts, they can become important under certain conditions. For instance, Demographic factors like age, gender, and family size can influence adaptation choices, but their significance varies depending on cultural norms and social structures. For instance, in some societies, women may have limited access to resources and decision-making power, which can constrain their ability to adapt to climate change. Additionally, psychological factors such as perceived risk and vulnerability can also influence adaptation behavior, but their impact may be moderated by other factors like socio-economic conditions and cultural beliefs. While these factors might not have a direct and significant impact on adaptation strategies in all contexts, they can become important under certain conditions.

Many studies have consistently identified socio-economic, institutional, and environmental factors as significant determinants of adaptation strategies, suggesting their general applicability across different contexts. However, the relative importance of these factors can vary depending on specific circumstances. For example, in regions with limited resources, access to information may be a more critical factor than income or education. Moreover, these factors are often interconnected and can influence each other, as demonstrated by the relationship between poverty, education, and information access.

5. SUMMARY AND CONCLUSIONS

5.1. Summary

The study analyzed the demographic and socioeconomic characteristics of pastoral households in three kebeles: Bundada, Duudciid, and Dhadhin. Results showed that the majority of respondents were male and aged 51-60 years old. Most respondents had limited education, with only 7.7% to 9.2% having primary education. Family sizes ranged from 4-6 members, with larger families being more vulnerable to climate change impacts. Livestock ownership was widespread, with camels, cattle, donkeys, sheep, and goats being the most common animals. Household income primarily depended on livestock and livestock products. Climate variability, as indicated by temperature increases and rainfall reductions, has significantly impacted the pastoral communities in these kebeles. Livestock production has suffered, with decreased livestock status, reduced water availability, and increased disease prevalence. This has led to economic losses and reduced access to livestock products. The study also highlighted the lack of information on climate variability among pastoralists. They face challenges such as weak social capital, poor administration, and knowledge gaps in adapting to climate change. Addressing these challenges is crucial for enhancing the resilience of pastoral communities to climate variability.

The study analyzed the adaptation strategies employed by pastoral communities in Bundada, Duudciid, and Dhadhin kebeles to cope with climate variability. The most commonly used strategies were selling livestock and livestock products, herd splitting, rearing drought-resistant livestock, and livestock mobility. Factors influencing adaptation choices include socio-economic conditions, institutional factors, environmental factors, and cultural factors. While demographic and psychological factors may not have a direct impact in all contexts, they can become important under certain conditions. Understanding these factors is essential for designing effective adaptation strategies tailored to local needs.

Key adaptation strategies include selling livestock and livestock products, herd splitting, rearing drought-resistant livestock, livelihood diversification, borrowing cash from institutions, and livestock mobility. These strategies offer various benefits, such as income generation, risk management, food security, and resilience. However, they also face challenges like conflicts over grazing resources, disease transmission, herd depletion, and long-term vulnerability. Effective implementation of adaptation strategies requires careful planning, coordination, and collaboration among pastoral communities and relevant authorities.

5.2. Conclusions

The pastoralist adaptation response to climate variabilities have generally involved the strategies of adjustment in pastoral practices and shifts to non-pastoral livelihoods to market-based income generation to cope-up impact of climate. Despite the existing restrictive pressures, increased pastoral mobility still remains to be a viable strategy of sustainable pastoralism in the present framework of climate-induced risks and pastoral livelihood vulnerability. In a related forward-facing, the Somali pastoralists appear to have gradually moved to practice farming as a result of the increasing need to generate own food source and income at household level. It recognized as well the pastoral communities in the study area are coming to rear more browsers livestock species, camels, sheep and goats those drought-tolerant species than cattle. These adjustments in pastoral practices are apparently quite helpful in the sense that they are found to exhibit significant positive implications for increased pastoral production. In the study kebeles, pastoralists have long years of experience in terms of responding to the impacts of climate change with various adaptation and coping strategies through analysis and evaluation of the local situations, their resource and potential with regard to issues central to their livelihood. However, their efforts were not supported for long with inappropriate pastoral development.

Somali pastoral communities have found it difficult to sustain their livestock-based livelihood, since the climate change impact degraded pasture lands, increases the incidence and severity of livestock diseases and mobility. Impact of climate change and variability on livestock production is multifaceted in its nature notably: reduced livestock number and productivity, reduced pasture availability and down watering points. However, effective livestock adaptation strategies are seriously constrained by lack of institutions that steers or governs

climate issue at the grassroots level, poor service and facilities that support adaptation such veterinary and credit services and lack of infrastructure. Even though, pastoralists were not passive victims, currently practiced climate change adaptation strategies are found far from materialization to of the desired outcome, fast economic growth and development.

The recorded trend and variability of temperature in the last 30 years was found to correspond with pastoralist perception of climate change in reduction of rainfall. The temperature fairly following a general upward trend in the last three decades matches with the pastoralist perception with the rainfall records decrease except the rainy season of the study kebeles received doesn't associate with the pastoralist's insight of climate change, since they perceive rainfall for having declining trend. The inconsistency between meteorological record and pastoral community's rainfall observations, since livestock guardians focus associate the climate patterns with extreme events such as drought in relative to the climate phenomena they observed during that event and interpret qualitatively, while in scientific records, changes are explained using temperature and rainfall in statistical averages and in absolute terms.

This study set livestock are still the key and primary source of pastoral income, with live animal sale and its products constituting the household income as per the household. The study attested the pastoral communities are extremely sensitive to the effect on markets, since they sale they do marketing of their livestock to buy grains and other food and non-food items. The pastoral communities in the district rear more of sheep and goats for their ease in marketability. It is often referred as a "purse of pastoralists". As the pasturelands were increasingly replaced by bushes and shrubs due to bush encroachment and prolonged and recurrent droughts, there is strong tendency from pastoralists to rear browsers, goats and camels than grazers, cattle and sheep. Thus, currently goats are the best preferred livestock species in Korahe district as well camels, goats and sheep are reared more and more by pastoralists for ease in marketability and their leaf through feeding habits.

5.3. Recommendations

As per the findings of this study, the following recommendations were forwarded that would enhance the pastoral community of Korahe zone will improve their security to resist climate impact.

- It is recommended that the concerning bodies enhance pastoralists' access to market
- It is also significant to remind the stakeholders maintain their efforts on water sector to help pastoralists get water in times of drought
- It is indeed paramount to strengthen the pastoral adaptive capacity to climate variability through timely provision of climate forecast for preparedness and based on early information. Local institutions, which importantly contribute the communities, is highly recommended for quick dissemination of information and act at the public level.
- It is also crucial to blend the metrological agency information with local traditional forecasting since experience shows that traditional forecasting matches and sometimes supersedes the instrumental.
- As part of developing the objective adaptive capacity, government and development actors need to promote the use of drought tolerant/resistant livestock and crop species for use by the pastoral communities, since the natural hazards notably rainfall variability, and drought would continue at large scale about the projected rainfall and temperature.
- Moreover, the government and other concerning actors are informed to give a close attention to barriers of the community's adaptation struggles.
- Finally, it is recommended the pastoral communities need also focus on and strengthen forage development and preservation, which is not practiced as such currently in the study area.

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7. APPENDICES

Appendix I. Household survey questionnaire

Dear respondent, my name is Mahamud Mahamed Abdi. I am a student in the Climate Change and Disaster Risk Management Program at the School of Geography and Environmental Studies of Haramaya University. I am conducting research on "Climate Variability, Impact and Adaptation Strategies on Pastoral Communities in the Korahey Zone, Somali Regional State, Ethiopia." It is purely academic research to be conducted to acquire a Master of Science Degree in Geography and Environmental Studies. Hence, your kind cooperation with true answers to the questionnaire will be important to the overall success of the study. Therefore, you have to feel free to complete the questionnaire. I would like to appreciate your cooperation in advance!

General Instructions

- For the close-ended questions make a tick mark X in the box provided or encircle the chosen response!
- You can use the blank space provided for additional information or justification!

PART I: Household Identification

Date _____ Time: Start: _____ Finish _____

Enumerator name: _____ Signature: _____

1.	Household ID. No _____
2.	Woreda: _____
3.	Kebele: _____
4.	Village: _____

PART II: Household demographic information

1. Gender: 1 male _____ 2 Female _____
2. Age: -----years
3. Family Sizes of household; _____
4. Educational status

I. Cannot read and write II. Primary school III. Secondary school IV. Certificate and above

5. What is the estimated annual income of your household? _____ E.T.B.

PART II: Livestock Ownership

6. Do you have livestock? 1. Yes 2. No

7. If 'yes' to Q6, mention the name and number of livestock owned currently:

Name of livestock	Number
1. camel	
2. goat	
3. Sheep	
4. cattle	
5. poultry	
6. Donkey	

8. What do you think about the number of livestock owned by your household during the past 30 years?

1. Decreased 2. Increased 3. No change

9. If your answer for question 8 is '**decreased**' then what was the reason? You can select more than one answer?

Drought	<input type="checkbox"/>	Disease	<input type="checkbox"/>	Other specify:
Flood	<input type="checkbox"/>			
Conflict	<input type="checkbox"/>			

10. How is access to pasture for animals?

1. Regularly available 2. Occasionally 3. Never available

11. can you tell me the status of posture on the following years

Year	Excellent	Very Good	Good	Poor	Very poor	I Don't know
1994-2004						
2005-2014						
2015-2024						

12. Have you ever gotten training on climate variability from any organization, please?

1. Yes 2. No

PART II: Access to weather and climate information

1. Does the development agent provide you any information on climate variability?
 1. Yes
 2. No
2. Do you think climate change or variability posed negative effects on your livelihood?
 1. Yes
 2. No
3. If your answer to question '2' above is 'yes', what are the major challenges that climate change/variability posed on your livelihood? You can select more than one answer if any?

1. Shortage of pasture land	<input type="checkbox"/>	4. Loss of livestock	<input type="checkbox"/>	6. other (specify)
2. Crop yield reduction	<input type="checkbox"/>	4. Flooding	<input type="checkbox"/>	
3. Drought	<input type="checkbox"/>			

4. If again your answer to question '2' is 'yes', why do you think, you are more vulnerable to the impact of climate variability?

1. Lack of information on climate and weather variability	<input type="checkbox"/>
2. Weak social capital	<input type="checkbox"/>
3. Poor administration	<input type="checkbox"/>
4. Others (specify)	

5. What are the major indicators of the observed climate variability?

1. Increase in temperatures	<input type="checkbox"/>
2. Reduction in rainfall levels in all seasons	<input type="checkbox"/>
3. Change in wind patterns	<input type="checkbox"/>
4. Increase in the incidences of floods	<input type="checkbox"/>
5. Prolonged cold season	<input type="checkbox"/>
6. other reason specify:	

6. What are the most frequent Impacts of climate variability on livestock production? You can select more than one answer?

1. Weakened animals due to trekking long distance	<input type="checkbox"/>
2. Death of livestock due to lack of feed and water	<input type="checkbox"/>

3. Increase of pests and diseases	<input type="checkbox"/>
4. Livestock-wildlife conflicts	<input type="checkbox"/>
5. other reason specify:	

7. How would you explain the climate on social impacts in your kebele?

1. Increases 2. Decreases 3. Same

PART III: Health Status

8. Do you have veterinary service in your kebele? 1. Yes 2. No

9. If No, how long it takes to reach to the one that is the nearest to you?

-----Hours/walk

10. Do you take your animals to veterinary service when they get sick?

1. Yes 2. No

11. If No, why don't you take them there, because?

1. The service is expensive	<input type="checkbox"/>
2. Traditional medicine is better	<input type="checkbox"/>
3. Inadequate drugs & facilities	<input type="checkbox"/>
4. Vet personnel are unqualified	<input type="checkbox"/>
5. Vet personnel are not available most of the time	<input type="checkbox"/>
6. Others (specify)	

12. Do you have health service in your kebele? 1. Yes 2. No

13. If no, how long it takes to the nearest health facility from your residential?

_____ hrs/walk on foot

14. Do you use this health center for you and your family health treatment?

1. Yes 2. No

15. If your answer to question 14 above is no, why

1. Because the service is expensive	<input type="checkbox"/>
2. Because the personals are unqualified	<input type="checkbox"/>
3. There are no sufficient facility and drugs at the center	<input type="checkbox"/>
4. I prefer urban health centers than this one	<input type="checkbox"/>
5 Traditional treatment is better	<input type="checkbox"/>
6. The personnel are not available most of the time	<input type="checkbox"/>
7. Others (specify)	

PART IV: Impacts on Natural resources

16. What is/are the water sources and points found in your kebele?

Name of livestock	1994-2004	2005-2014	2015-2024
1. Well			
2 dams			
3. boreholes			
4. Tap water			
5. pond			
6. river			
7. other specify			

17. What is/was the distance of the water point from your house? ____ hrs/km

	Year		
	1994-2004	2005-2014	2015-2024
Travel hrs./ distance in km			

18. Are these water sources sufficient enough to support your water demand in bad climatic conditions (drought, short rainfall, and dry or high temperature times? 1. Yes

2. No

19. If no, how do you fill the gap?

1. Water tankering 2. Reduce livestock watering frequency 3. Reducing the number of

4. Move to other areas in search of water 5. Other (specify)

20. Have you ever experienced conflict while you are moving with your animals in search of water? 1. Yes 2. No

21. If yes, what has been its consequence on the household?

1. Death of animals

2. Raiding of animals

3. Death of household member

4. Death of relatives

5. Migration

6. Other specify:

Part V: Impacts on Economic

22. Do you have livestock market centers & marketing Facilities in your kebeles?

1. Yes 2. No

23. If No, how long it takes to reach for the nearest market

_____ hr/walk and specify the center _____

24. What does the price of livestock look like during normal days and during drought time?

Fill the space by a. Increasing b. decreasing or c. same

Name of livestock	Normal days	Drought time
Camel		
Cattle		
Sheep		
Goat		
Donkey		

25. What does the price of milk and other livestock products (milk, butter, meat etc) look like during normal days and during drought time?

Fill the space by a. Increasing b. decreasing c. same

Name of livestock	Normal days	Drought time
Milk		
Meat		
Butter		
skin		

26. Do you think there is any relationship between changes in the production of your livestock and the rainfall variability? 1. Yes 2. No

Explain your answer (in terms of the relationship)

.....

27. Do you think there is any relationship between changes in the production of your livestock and the temperature variability? 1. Yes 2. No

Explain your answer

PART VI: Major Adaptive Strategies Practiced by Pastoral Community-

1. Have you ever used any adaptation strategy to adapt with climate variability impact?

1. Yes 2. No

2. If your answer is —yes— which one?

1. Rearing of drought resistant livestock
2. Selling of livestock and livestock products
3. Governmental and NGOs aid
4. Relied on remittance
5. Herd splitting
6. Sharing food from their clans
7. Fewer meals per day
8. Migration to other countries
9. Selling of fire wood and charcoal
10. Livelihood diversification
11. Daily laborer in nearby town
13. Borrowing cash from institutions
14. Petty trade
16. Broker
17. Save cash in the bank
18. Livestock mobility
19. Other, please specify_____.

3. Are there any institutional coping mechanisms in your locality? If yes what are they?

No	Institutional coping mechanisms	Yes	No	Provider	
				Government	NGO
1.	Emergency aid				
2.	Credit services				
3.	Safety net				
4.	Water distribution				
5.	Training on livestock health				
6.	Others:				

Appendix II. Check list for Focused group discussion

My name is Mahamud Mahamed Abdi, a student in the Climate Change and Disaster Risk Management Program at the School of Geography and Environmental Studies, Haramaya University. I am working research on Climate Variability, Impact, and Adaptation Strategies among Pastoral Communities in the Korahey Zone, Somali Regional State, Ethiopia. You have been selected to participate in this group discussion, and the aim of the discussion will be for research purposes. I assure you that all information will be kept confidential and not shared with any third parties. I greatly appreciate your cooperation in dedicating your time to this research and contributing to its success.

Kebele _____ Focus group sizes _____

1. Have you heard about climate variability?
2. Who did tell you? Have you heard from Radio? Or from extension workers?
3. Do you think the weather condition is changing?
4. If you say yes, how? Explain
5. Is there any change on water, grazing land, the quality of pasture and arable land over the past years in your village? Please
6. What do you think is the major causes for the changes on the resources mentioned above?
7. Do you observe a change in the rain fall pattern and temperature condition? Which one is increasing? or decreasing?
8. Have you observed any climate extremes (floods and drought) in your locality? How many times occurred for 30 years ago?
9. Without having instrument to measure the change how do you explain by local indicators?
10. What are the socio-economic impacts posed on the local pastoralists by the adverse effects of climate variability?
11. What are the biggest challenges you face when trying to cope up with the effects of climate variability?
12. Are there any institutional coping mechanisms in your locality? If yes who is the provider?
13. What are the locally perceived existing barriers and obstacles to coping and adaptation, and in which way community members consider to overcome them?

Appendix III. Key Informant Interviews

My name is Mahamud Mahamed Abdi, and I am a student in the Climate Change and Disaster Risk Management Program at the School of Geography and Environmental Studies at Haramaya University. I am currently conducting research on "Climate Variability, Impact, and Adaptation Strategies on the Pastoral Community of Korahey Zone, Somali Regional State, Ethiopia." You have been selected to participate in this questionnaire, and all your information will be used solely for research purposes. I assure you that all responses will remain confidential and will not be shared with any third party. I would like to express my sincere gratitude for your time and participation in helping me complete this research.

Instructions: Please answer the following questions to the best of your ability. Your honest responses will be invaluable in understanding how pastoral communities adapt to climate variability.

Personal Information:

1. Age: _____
2. Gender: _____
3. Location: _____
4. Number of years living in this community: _____

Part I: Climate Change

1. What is the agro-ecology zone of your woreda
2. What are sources of rural livelihood used by the local community in your kebele?
3. In your experience, how has the climate changed in your community over the past 30 years? (e.g., temperature, rainfall patterns, droughts, floods)
4. How often do you experience extreme weather events? (e.g., droughts, floods, and heatwaves)
5. What are the main impacts of climate variability on your livelihood and community? (e.g., water availability, pasture availability, livestock health)
6. What changes have you observed on livestock? Do you observe crops and livestock's that were not familiar in the area? What are the most frequently occurring climatic events that affect pastoral production?

7. What do you think about the influence of climate variability on the pastoral production system?
8. What are adaptation strategies used by local community to reduce impacts of climate variability in your kebele?
9. Do you think the enhancement of these coping strategies have contributions in promoting sustainable development?
10. Is there any effort made by local institutions in reducing the impacts of climate variability on society in order to make their life sustainable?
11. What are the major challenges in alleviating the problems of climate variability in your kebele?